



## **Intelligence and Health**

by Daniel Ray Wilmoth

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This thesis/dissertation document has been electronically approved by the following individuals:

Kenkel, Donald S. (Chairperson)

Nicholson, Sean (Minor Member)

O'Donoghue, Edward Donald (Minor Member)

INTELLIGENCE AND HEALTH

A Dissertation

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

by

Daniel Ray Wilmoth

August 2010

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# INTELLIGENCE AND HEALTH

Daniel Ray Wilmoth, Ph. D.

Cornell University 2010

Socioeconomic status is positively related to health. Differences by socioeconomic status in health are closely related to differences in intelligence. This dissertation presents an investigation of the effects of health on intelligence and an investigation of the relationship between intelligence and the behaviors that affect health. One of the most important themes to emerge from this research is that the relationship between socioeconomic status and health may be driven in part by differences in success at self-control. The behaviors people choose affect their health. Some behaviors, such as the use of addictive substances, are influenced by failures of self-control.

Psychologists have repeatedly demonstrated in the laboratory that more intelligent people tend to be better at self-control. Multiple regression analysis of data from a national survey is used to provide evidence that the relationship between intelligence and health is driven in part by differences in success at self-control. Implications for policies to improve the health of those with low socioeconomic status are discussed.

## BIOGRAPHICAL SKETCH

In 2001, Daniel Wilmoth received a Bachelor of Arts degree in economics from the University of Iowa, where he graduated with highest distinction and honors in economics. He spent the next three years as a research assistant in the Health and Human Resources Division of the Congressional Budget Office. That experience inspired him to seek additional training at Cornell University, where he enrolled in the policy analysis doctoral program in 2004 before transferring into the economics doctoral program in 2006. He successfully defended this dissertation in July of 2010.

## ACKNOWLEDGMENTS

The research presented here has benefited greatly from comments by Don Kenkel, Ted O'Donoghue, Sean Nicholson and many others.

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# INTRODUCTION

## Intelligence and Health Economics

Socioeconomic status (SES) is correlated with health. The wealthy and well educated tend to have better health than the poor and poorly educated (Adler et al., 1994; Mackenbach et al., 2008). Differences by SES in life outcomes, including health, are closely related to differences in intelligence (Cutler and Lleras-Muney, 2010; Gottfredson, 2004; Herrnstein and Murray, 1994) and the relationship between intelligence and health has been studied by several economists (Auld and Sidhu, 2005; Cutler and Lleras-Muney, 2010; Heckman et al., 2006; Kenkel et al., 2006). A deeper understanding of the relationship between intelligence and health could provide insight into the nature of the choices that affect health and thereby inform economic models of those choices. It may also prove helpful in designing policies to improve the health of those with low SES.

The relationship between intelligence and health is not a subject that respects academic boundaries. This dissertation will employ ideas from such diverse fields as nutrition, neurobiology, psychology and sociology as well as economics. By incorporating those ideas into this analysis, it was possible to improve substantially on previous work by economists.

Three essays are presented here. The first essay explores the contribution of differences in vitamin D status to the relationship between race and intelligence in the United States. The second essay examines the relationship between intelligence and experimentation with recreational drugs. The third essay investigates the relationship between intelligence and the choice to consume a large amount of alcohol.

One of the most important themes to emerge from the research that will be presented here is that the relationship between SES and health may be driven in part

by differences in success at self-control. The behaviors people choose affect their health. Some behaviors, such as the use of addictive substances, are influenced by failures of self-control (Baumeister et al., 1994; Baumeister et al., 2007; Bechara, 2005; Niaura et al., 1988).

Psychologists have repeatedly demonstrated in the laboratory that more intelligent people tend to be better at self-control (Dempster, 1991; Evdokimidis et al., 2002; Heitz et al., 2005; Salthouse et al., 2003; Schmeichel et al., 2003; Shoda et al., 1990; Friedman et al. (2006) reported mixed results). Insights from that research have never previously been incorporated with research by economists relating intelligence to health, however. Evidence is presented here that the relationship between intelligence and health is driven in part by differences in success at self-control.

This has some important implications for the fields of economics and public policy. First, the close relationship between intelligence and self-control necessitates a more careful conceptualization of cognitive ability and other mental abilities than has been previously employed by economists (cf. Auld and Sidhu, 2005; Cawley et al., 1997; Heckman et al., 2006; Heckman, 2008). Second, the relevance of self-control failures in shaping patterns of alcohol use suggests that the rational addiction model (Becker and Murphy, 1988) ignores some of the most interesting and important aspects of decisions about the use of addictive goods. Finally, these results suggest some policies that may improve the health of those with low SES.

There are at least two ways policymakers could improve popular success at self-control. First, they could make self-control easier. This could be done by regulating environmental cues, such as advertisements, that can trigger cravings (Bernheim and Rangel, 2004). Second, policymakers could help people become better at self-control. A variety of evidence suggests that people can become better through practice (Baumeister et al., 2006; Mischel et al., 1989). Incorporating self-control

tasks into school curricula could therefore improve success at self-control (Diamond et al., 2007). If differences in success at self-control are contributing to the relationship between SES and health, these policies could lead to better health for those with low SES.

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## CHAPTER 1

### RACE, INTELLIGENCE AND VITAMIN D IN THE UNITED STATES

#### Introduction

The average IQ for blacks is lower than the average IQ for whites in the United States; the contribution of genetic differences to this gap is debated (Rushton and Jensen, 2005; Nisbett, 2005; Sternberg et al., 2005).

Sternberg et al. (2005) argued that skin color differs systematically by race but other genetic variations are not easily sorted by race. Vitamin D may be created in the skin using ultraviolet radiation from the sun. Skin pigment absorbs this radiation and reduces vitamin D production, resulting in high vitamin D deficiency rates among infants born to black mothers in the United States (Bodnar et al., 2007; Nesby-O'Dell et al., 2002; Specker, 1994). Research suggests vitamin D plays a role in brain development and function (Garcion et al, 2002; Kalueff and Tuohimaa, 2007; McGrath et al., 2004; O'Loan et al., 2007). Therefore racial differences in skin pigmentation may be contributing to the average IQ gap.

Data from the National Longitudinal Surveys were used to construct four tests of the effect of an early vitamin D deficiency on later IQ. The results are consistent with a detrimental effect that may be contributing to the average IQ gap.

#### Race, Intelligence and Vitamin D

This section reviews the literature on race, intelligence and vitamin D. It is divided into five subsections discussing intelligence, race and intelligence, race and vitamin D, vitamin D and the brain and the possible relationship between race, intelligence and vitamin D.



### *Intelligence*

Scores on tests of different types of cognitive ability are often highly correlated. It is assumed here that such correlations are due to a single underlying characteristic that will be referred to as intelligence. There are other ways to think about intelligence; for a more complete discussion, refer to Neisser et al. (1996). The term IQ will be used to refer to a score on a test of cognitive ability that has been converted to a scale such that it will have a mean of 100 and a standard deviation of 15.

### *Race and Intelligence*

A substantial gap exists between the average IQs of blacks and whites in the United States. Rushton and Jensen (2005) put the gap at about one standard deviation, or 15 IQ points. Nisbett (2005) and Dickens and Flynn (2006) argued that the gap has narrowed to about two thirds of a standard deviation, or 10 IQ points.

A large literature has arisen examining various aspects of the gap. That literature documents a number of interesting and surprising empirical regularities. It will be argued here that a parsimonious explanation for many of these empirical regularities is provided by the hypothesis that differences by race in perinatal vitamin D status contribute to the gap.

The average IQ gap does not appear to be a result of biased tests. Jencks (1998) reported that the gap is bigger on questions and tests that appear to involve less cultural knowledge and that an analysis of scores on one type of vocabulary test used to measure intelligence revealed that young black students learn the same words as young white students, but learn them slightly later. Evidence suggests that for a given test score blacks do not exhibit better academic performance (Herrnstein and Murray,

1994) or job performance (Jenks, 1998) than whites, indicating that the tests do not understate the intelligence of blacks as it relates to those fields.

In an effort to understand the relationship between genetic heritage and intelligence, researchers have studied the relationship between skin color and intelligence among blacks, using skin color as an indication of degree of white ancestry. Studies have repeatedly found a correlation between skin color and IQ in blacks but failed to find such a result for other indicators of white ancestry. For instance, Lynn (2002) found a statistically significant correlation of 0.17 between IQ and skin color among blacks. Shuey (1966) summarized several older studies and found a similar correlation between IQ and skin color but a much weaker relationship between IQ and other physical indicators of white ancestry, such as nose and lip width and curliness of hair. Scarr et al. (1977) constructed a measure based on blood group that was intended to indicate the extent of white ancestry; the measure had a correlation of 0.27 with skin color. They found a correlation of 0.155 between skin color and IQ but no significant relationship between their measure of white ancestry and IQ when controlling for skin color. Loehlin (1973) also failed to find a relationship between intelligence and those blood group genes more common in whites.

Nisbett (2005) summarized some results that suggest that the race of the mother is particularly important in determining a child's intelligence. One particularly interesting study he referenced compared the IQs of German children fathered by black US soldiers to the IQs of German children fathered by white US soldiers and found no meaningful difference.

The relationship between skin color and IQ among blacks and the absence of a relationship between other indicators of white ancestry and IQ among blacks suggest vitamin D deficiency as a possible contributor to the IQ gap. The importance of

mother's race with respect to IQ suggests the perinatal period as a period in which a vitamin D deficiency may influence later intelligence.

### *Race and Vitamin D*

The most important source of vitamin D is synthesis in the skin using ultraviolet radiation from the sun (Bodnar et al., 2007). Skin pigment absorbs the necessary radiation and can drastically reduce synthesis of vitamin D in the skin.

White and black mothers differ in the nutritional environment they provide their fetuses and breastfed infants. White women have higher levels of vitamin D and lower vitamin D deficiency rates. Breast milk contains low amounts of vitamin D and breast milk vitamin D levels are correlated with maternal vitamin D levels (Specker, 1994). Infant vitamin D levels correlate with those of the mother for the first 8 weeks following birth. After the first 8 weeks, vitamin D levels are primarily determined by exposure to sunlight. Specker speculated that for infants with limited sunlight exposure, breast milk vitamin D levels may be an important determinant of the vitamin D level of the infants, noting that infants who have little exposure to sunlight and who have mothers with low vitamin D levels have the highest risk of developing rickets, a condition that can be caused by a vitamin D deficiency.

Nesby-O'Dell et al. (2002) noted that "recent reports of rickets among African American children drew renewed attention to the vitamin D status of those infants and their mothers." Using data from the National Health and Nutrition Examination Survey, they found that black women of child-bearing age have a vitamin D deficiency rate (25(OH)D concentrations of  $\leq 37.5$  nmol/L) of about 42%, while white women of child-bearing age have a vitamin D deficiency rate of about 4%. Those black women consuming the Institute of Medicine's "adequate intake" of vitamin D from supplements (200 IU per day) still experienced vitamin D deficiency at a rate of

about 28%.

Examining a sample of women in the Pittsburgh area, Bodnar et al. (2007) found vitamin D deficiency in about 29% of black women and 5% of white women. About 46% of black neonates were found to be vitamin D deficient and about 10% of white neonates were found to be vitamin D deficient.

### *Vitamin D and the Brain*

The importance of vitamin D was first recognized after it was discovered early in the twentieth century to prevent rickets (Groff and Gropper, 2000). Vitamin D has since been discovered to play a number of other roles, including immune system regulation and the regulation of cell development and differentiation (DeLuca, 2008; Groff and Gropper, 2000).

A growing body of evidence indicates that vitamin D plays a role in brain development and function (Garcion et al, 2002; Kalueff and Tuohimaa, 2007; McGrath et al, 2004). The nuclear vitamin D receptor is present in both neurons and glial cells (Eyles et al, 2005; Garcion et al, 2002). Vitamin D regulates the synthesis of nerve growth factor and other neurotrophins (Brown et al, 2003; Eyles et al, 2003; Garcion, 2002). A transient prenatal vitamin D deficiency in rats has been shown to change the shape of the brain at birth (Eyles et al, 2003) and alter the expression of genes in the adult brain (Eyles et al, 2007).

Vitamin D deficiency has been implicated in several brain disorders in humans, including multiple sclerosis (Cantorna, 2008; Hayes, 2000), schizophrenia (Mackay-Sim et al, 2004; McGrath et al, 2004) and autism (Cannell, 2008; Waldman et al, 2008). As with most evidence concerning the role of vitamin D in humans, evidence linking vitamin D to these brain disorders has primarily been provided by observational studies (Grant, 2009).

Multiple sclerosis is an autoimmune disease of the central nervous system. A variety of evidence links multiple sclerosis to vitamin D deficiency (Cantorna, 2008; Hayes, 2000). Multiple sclerosis patients typically exhibit vitamin D deficiency (Hayes, 2000). The disease is most prevalent in areas that receive low levels of ultraviolet radiation during the winter and migration to or from such areas appears to change the risk of developing multiple sclerosis (Ebers and Sadovnick, 1994). Moving prior to puberty appears to have a larger effect on the risk of developing the disease (Cantorna, 2008). In an animal model of multiple sclerosis, vitamin D was shown to inhibit the progress of the disease (Hayes, 2000).

Schizophrenia is a brain disorder typically characterized by disturbed thought processes and a distorted perception of reality. A variety of evidence links schizophrenia to vitamin D deficiency (Mackay-Sim et al, 2004). Those born to mothers with very low vitamin D levels have a higher risk of developing the disorder (Mackay-Sim et al, 2004; McGrath et al, 2003). The risk of developing schizophrenia varies with season of birth, with those born during the winter and spring facing a higher risk (Torrey et al, 1997). McGrath et al (2004) found a lower risk of developing schizophrenia among males who received a vitamin D supplement during the first year after birth. In rats, a prenatal vitamin D deficiency has been shown to lead to a behavioral alteration that is a key feature of several animal models of schizophrenia (O'Loan et al, 2007).

Autism is brain disorder typically characterized by impaired communication and social interaction. Some evidence links autism to vitamin D deficiency (Cannell, 2008). Autism is more common in areas where exposure to ultraviolet radiation is limited, such as urban areas and areas that receive low levels of ultraviolet radiation during the winter (Cannell, 2008). Children who lived in areas that experienced high levels of precipitation during the first three years after the children were born were

found to have a higher risk of developing autism (Waldman et al, 2008).

### *Race, Intelligence and Vitamin D*

If vitamin D plays a role in brain development, then a vitamin D deficiency early in life could adversely affect later intelligence. In rats, a transient prenatal vitamin D deficiency decreases later exploration of the environment (Becker et al, 2005). In humans, exploration of the environment has a strong positive relationship with intelligence (Raine et al, 2002).

In a section on the implications for human health of evidence linking vitamin D status to brain development, O'Loan et al. (2007) noted the high rates of vitamin D deficiency in black women of reproductive age and suggested that intervention after birth to increase vitamin D levels may prevent some adverse health outcomes for children born to those mothers. Cannell (2008) also noted racial disparities in vitamin D levels and suggested that higher rates of mild mental retardation in black children than in white children may be the result of insufficient vitamin D.

### Data and Methods

Data directly relating perinatal vitamin D status to IQ later in life are not known to be available. The determinants of vitamin D status are well-understood, however. It is therefore possible to use available data as a means of indirectly exploring the relationship between a perinatal vitamin D deficiency and later intelligence.

Four tests of the importance of vitamin D levels for neonates with respect to later IQ are described below. The tests were conducted using data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey.

The NLSY79 collects data on a sample of 12,686 men and women who were between the ages of 14 and 22 when first interviewed in 1979. A wide range of data are collected for the study participants, including information about income and education as well as scores on the Armed Services Vocational Aptitude Battery (ASVAB), which in 1980 was administered to nearly all study participants.

The NLSY79 Children and Young Adults Survey collects information on children born to the NLSY79 women. Data collected include prenatal health practices and infant feeding practices. The Peabody Picture Vocabulary Test (PPVT) and Peabody Individual Achievement Tests (PIATs) are measurements of intelligence administered to the children in the sample.

### *Summary Statistics*

Scores on some subsections of the ASVAB can be combined to create a measure of intelligence, the Armed Forces Qualification Test (AFQT) score. The 1989 scoring scheme as described in Herrnstein and Murray (1994) will be used here. Under this scheme, the basis for comparison is twice the standardized verbal composite score plus the standardized arithmetic reasoning score plus the standardized math knowledge score. For a discussion of the AFQT score as a measure of intelligence, see Herrnstein and Murray (1994).

The sample includes 6,351 children born to 2,866 different mothers. The children were born between 1970 and 2000. The Peabody Picture Vocabulary Test (PPVT) and Peabody Individual Achievement Tests (PIATs) were administered repeatedly beginning in 1986 to assess spoken vocabulary and mathematical and reading ability. The PPVT was administered to children age three and older; the criteria for eligibility for the administration of the PPVT varied with survey year. The PIATs were administered to children age five and older. Beginning in 1994, an

interview replaced the child assessments for adolescents age 15 years and older. For more information, see the NLS Handbook, 2005 (Bureau of Labor Statistics, 2005).

The intelligence of these children was measured multiple times. In order to make use of all of the available data, each unique combination of child, year and test is a potential observation in the tables below and in the analysis that follows. These observations are not independent, so the standard errors for the coefficients presented below will be calculated using the robust estimator. It will be assumed that observations of children born to different mothers form independent “clusters” of observations. In these data there are 2,866 mothers, so there are a total of 2,866 independent clusters of observations.

Three observations with IQ equal to zero are included in the analysis. The next-smallest IQ value is 19; excluding those observations with IQ equal to zero had a negligible effect on the results presented below.

For some observations, the recorded values for mother’s years of education, weeks of age at which infant formula was introduced and weeks of age at which cow’s milk was introduced were so high as to be invalid; those values were treated as missing. The questions used to construct the age at which formula was introduced and the age at which cow’s milk was introduced were not asked after 1990.

A child’s mother was classified as black if the mother’s sole racial or ethnic origin or self-identified primary racial or ethnic origin is black or if a self-identified primary racial or ethnic origin is not specified and the respondent chose black as one of the groups to describe her racial or ethnic origin. A child’s mother was classified as white if the mother’s sole racial or ethnic origin or self-identified primary racial or ethnic origin is a European country or if self-identified primary racial or ethnic origin is not specified, the mother chose a European country as one of the groups to describe her racial or ethnic origin and the mother did not choose black as a group to describe



her racial or ethnic origin. Only observations for which the child's mother is classified as white or black are included in the summaries and used to conduct the tests discussed below.

In the tables below and the analysis that follows, marital status, prenatal vitamin use, smoking during pregnancy, breastfeeding, low birth weight, urban residence and region of residence are described using indicator variables. In each case, the indicator variable takes on a value of one if the observation falls into the category named and zero otherwise.

Table 1-1 summarizes the characteristics of the observations corresponding to white mothers and Table 1-2 summarizes the characteristics of the observations corresponding to black mothers. About 55% of the observations summarized in Tables 1-1 and 1-2 correspond to white mothers.

Table 1-1  
Selected Summary Statistics for Observations Corresponding to White Mothers

<u>Variables</u>	<u>Obs.</u>	<u>Means</u>	<u>Std. Devs.</u>
$IQ_{m,i,t,y}$	39993	104.68	14.57
<i>prenatal vitamin<sub>i</sub></i>	34477	0.96	0.20
<i>breastfed<sub>i</sub></i>	38115	0.58	0.49
<i>age breastfeeding ended<sub>i</sub></i> (wks)	20885	21.97	22.07
<i>age infant formula introduced<sub>i</sub></i> (wks)	25860	5.13	8.85
<i>mother's family income in year before birth<sub>i</sub></i>	36396	40387.96	88162.23
<i>married<sub>i</sub></i>	39993	0.76	0.42
<i>mother's AFQT score<sub>m</sub></i>	38547	201.60	32.36
<i>mother's age at birth of child<sub>i</sub></i>	39993	25.28	4.88
<i>mother's education before birth of child<sub>i</sub></i>	35486	12.87	2.27
<i>child's age when mother returned to work<sub>i</sub></i> (wks)	36590	84.38	152.01
<i>low birth weight<sub>i</sub></i>	37956	0.06	0.24
<i>urban<sub>i</sub></i>	39921	0.77	0.42

Notes: Table 1-1 summarizes data from the National Longitudinal Survey 1979 (NLSY79) and NLSY79 Children and Young Adults Survey. Each unique combination of child, year and IQ test was a potential observation in this table. These observations represented 3,669 children born to 1,761 mothers. Subscripts indicate the dimensions with which the variables vary. The subscript *i* indexes children, *m* indexes mothers, *t* indexes tests and *y* indexes year. The variables *prenatal vitamin<sub>i</sub>*, *breastfed<sub>i</sub>*, *low birth weight<sub>i</sub>*, *married<sub>i</sub>* and *urban<sub>i</sub>* are indicator variables that take on a value of one if they describe the observation and zero otherwise. The variable *low birth weight<sub>i</sub>* takes on a value of one if the child weighed less than 5.5 pounds and zero otherwise. Other variables that will be included in the analysis that follows describe the child's birth order, the age at which cow's milk was introduced and the mother's birth year. The analysis that follows will also include indicator variables for smoking while pregnant and a set of indicator variables describing the mother's region of residence in the year the child was born. Region of residence will be described using indicator variables for residence in the northeastern, north central, southern and western regions of the United States.

Table 1-2  
Selected Summary Statistics for Observations Corresponding to Black Mothers

<u>Variables</u>	<u>Obs.</u>	<u>Means</u>	<u>Std. Devs.</u>
$IQ_{m,i,t,y}$	32844	94.13	16.19
<i>prenatal vitamin<sub>i</sub></i>	25994	0.94	0.24
<i>breastfed<sub>i</sub></i>	31325	0.22	0.41
<i>age breastfeeding ended<sub>i</sub></i> (wks)	6091	16.64	18.15
<i>age infant formula introduced<sub>i</sub></i> (wks)	26347	1.98	6.02
<i>mother's family income in year before birth<sub>i</sub></i>	27339	19029.82	57674.77
<i>married<sub>i</sub></i>	32844	0.28	0.45
<i>mother's AFQT score<sub>m</sub></i>	31926	158.26	28.09
<i>mother's age at birth of child<sub>i</sub></i>	32844	23.06	4.92
<i>mother's education before birth of child<sub>i</sub></i>	26141	11.92	1.97
<i>child's age when mother returned to work<sub>i</sub></i> (wks)	28404	117.27	178.11
<i>low birth weight<sub>i</sub></i>	31123	0.12	0.33
<i>urban<sub>i</sub></i>	32797	0.80	0.40

Notes: Table 1-2 summarizes data from the National Longitudinal Survey 1979 (NLSY79) and NLSY79 Children and Young Adults Survey. Each unique combination of child, year and IQ test was a potential observation in this table. These observations represented 2,682 children born to 1,105 mothers. Subscripts indicate the dimensions with which the variables vary. The subscript *i* indexes children, *m* indexes mothers, *t* indexes tests and *y* indexes year. The variables *prenatal vitamin<sub>i</sub>*, *breastfed<sub>i</sub>*, *low birth weight<sub>i</sub>*, *married<sub>i</sub>* and *urban<sub>i</sub>* are indicator variables that take on a value of one if they describe the observation and zero otherwise. The variable *low birth weight<sub>i</sub>* takes on a value of one if the child weighed less than 5.5 pounds and zero otherwise. Other variables that will be included in the analysis that follows describe the child's birth order, the age at which cow's milk was introduced and the mother's birth year. The analysis that follows will also include indicator variables for smoking while pregnant and a set of indicator variables describing the mother's region of residence in the year the child was born. Region of residence will be described using indicator variables for residence in the northeastern, north central, southern and western regions of the United States.

### *The First Test*

A fundamental concern in constructing these tests was the possibility that the determinants of vitamin D status may be related to later IQ through mechanisms other than vitamin D. In order to address this concern, these tests employ what is sometimes called a “difference-in-differences” estimator.

For example, during the period examined here the Food and Drug Administration required that infant formula contain at least 40 IU of vitamin D per 100 kcal (Anderson et al., 1982; Fomon, 2001; Miller, 1989) while breast milk typically contains very little vitamin D (Specker, 1994). Infants experiencing an extended period of exclusive breastfeeding may therefore face a higher risk of vitamin D deficiency than infants introduced to formula soon after birth. Breastfeeding may

be related to later intelligence through mechanisms other than vitamin D (Anderson et al., 1999), however, so simply examining the relationship between infant feeding practices and later intelligence would provide only limited information about the relationship between a perinatal vitamin D deficiency and later intelligence.

Similarly, skin pigmentation is an important determinant of vitamin D status and skin pigmentation varies by race. Infants born to black mothers may therefore face a higher risk of vitamin D deficiency than infants born to white mothers. Race may be related to intelligence through mechanisms other than vitamin D (Nisbett, 2005), however, so simply examining the relationship between race and intelligence would provide only limited information about the relationship between a perinatal vitamin D deficiency and later intelligence.

While the differences in later IQ between breastfed and formula-fed infants and the differences in IQ between children born to white mothers and children born to black mothers may provide limited information about the relationship between a perinatal vitamin D deficiency and later intelligence, the difference in differences may be more informative. The first test will estimate whether the difference in intelligence between breastfed and formula-fed infants is different for infants born to white mothers than it is for infants born to black mothers. Breastfeeding has a positive average effect on children's later IQ scores (Anderson et al., 1999). An extended period of exclusive breastfeeding can result in a vitamin D deficiency for children born to black mothers, however (Specker, 1994). If an early vitamin D deficiency decreases later IQ scores, then one might expect that an extended period of exclusive breastfeeding will have a less-positive average effect on the IQs of children born to black mothers than it will have on the IQs of children born to white mothers. One implication of this is that one might expect the average IQs of the children born to white and black mothers who began giving their children infant formula in the first

week after birth to be more similar than the average IQs of children whose mothers introduced infant formula after the first six months (26 weeks).

Coefficients were estimated for the following empirical equation.

$$IQ_{m,i,t,y} = a_0 + a_1 * white_m + a_2 * delay_i + a_3 * white_m * delay_i + \bar{a} * \bar{m}_{m,i}' + \varepsilon_{m,i,t,y}$$

Subscripts indicate the dimensions with which the variables vary. The subscript  $i$  indexes children,  $m$  indexes mothers,  $t$  indexes tests,  $y$  indexes year and  $\varepsilon_{m,i,t,y}$ ,  $\varepsilon_{m',i',t',y'}$  are independent for  $m \neq m'$ . The variable  $IQ_{m,i,t,y}$  is an IQ score for child  $i$  of mother  $m$  on test  $t$  in year  $y$ . The variable  $white_m$  equals one if the child's mother is white and zero if the child's mother is black. The vector  $\bar{m}_{m,i}$  includes the mother's AFQT score, the mother's age when the child was born and the mother's birth year. It also includes indicator variables describing the child's birth order, the mother's family income in the year before the birth year, the mother's education level in the year before the birth year, the mother's marital status in the birth year, the child's age in weeks when the mother returned to work, the child's birth weight, the mother's use of a prenatal vitamin and the mother's smoking behavior while pregnant as well as urban residence and region of residence in the birth year.

The variable  $delay_i$  is equal to one if the child was introduced to infant formula after the first 26 weeks and equal to zero if the child began formula in the first week after birth. All other cases are excluded. Because cow's milk is fortified with vitamin D, a small number of cases in which the child began cow's milk before beginning formula are excluded from this analysis. Changing the definition of  $delay_i$  so that it is equal to one only if both cow's milk and formula are delayed past the first 26 weeks had a negligible effect on the results. The variable  $white_m * delay_i$  is the product of  $white_m$  and  $delay_i$ .

If a vitamin D deficiency is contributing to the average IQ gap, then one might expect to calculate a positive value for  $a_3$ , the coefficient on  $white_m * delay_i$ . The coefficient  $a_3$  measures the difference by race in the difference between the IQ scores of infants given formula in the first week after birth and infants introduced to formula after the first six months.

### *A Second Test*

One potential concern about the first test is that it is not known how important a role the infant formula played in the child's diet. For the majority of the children who are both breastfed and given infant formula, the period in which the child is given formula overlaps the period of breastfeeding. It may be that a given child was fed formula only rarely, in which case it would likely have had little effect on the child's vitamin D level.

A different measurement of the effect of an extended period of exclusive breastfeeding may be obtained by limiting the sample examined to those children whose mothers transitioned them from breast milk to formula relatively quickly. The age in weeks of the child at this transition would then be a good measure of the length of the period over which the children of black mothers may have had low vitamin D levels.

A test was conducted in which only observations of those children whose mothers reported the same age in weeks for the child when the child stopped breastfeeding as when the child began formula were included. If delaying the switch to formula creates or prolongs a period of vitamin D deficiency for the children of black mothers but not for the children of white mothers, one might expect the effect on IQ of delaying the switch to be more positive for the children of white mothers than for the children of black mothers.

Coefficients were estimated for the following empirical equation.

$$IQ_{m,i,t,y} = a_0 + a_1 * white_m + a_2 * weeks\ to\ formula_i + a_3 * white_m * weeks\ to\ formula_i + \bar{a} * \bar{m}_{m,i} + \varepsilon_{m,i,t,y}$$

Symbols also appearing in the previous empirical equation have the same definitions here.

The variable *weeks to formula<sub>i</sub>* is the age in weeks of the child when the mother switched from breast milk to formula. Because cow's milk is fortified with vitamin D, a small number of cases in which the child began cow's milk before beginning formula are excluded from this analysis. Altering the definition of *weeks to formula<sub>i</sub>* so that for observations where cow's milk was introduced before formula and in the same week breastfeeding ended *weeks to formula<sub>i</sub>* is equal to the child's age at the switch from breast milk to cow's milk had a negligible effect on the results. The variable *white<sub>m</sub> \* weeks to formula<sub>i</sub>* is the product of *white<sub>m</sub>* and *weeks to formula<sub>i</sub>*. If a vitamin D deficiency is contributing to the average IQ gap, then one might expect to see a positive value for *a<sub>3</sub>*, the coefficient on *white<sub>m</sub> \* weeks to formula<sub>i</sub>*.

### *A Third Test*

In the previous tests, the difference in vitamin D content between breast milk and formula was used to test if a vitamin D deficiency among the children of black mothers was contributing to the average IQ gap. As will be discussed further below, one concern with this sort of test is that breast milk and infant formula differ in ways other than their vitamin D content. As will be discussed further below, a second concern is that the decision by white mothers about infant feeding practices might not

serve as good model for the decision by black mothers about infant feeding practices. The third test addresses these concerns.

Instead of using the difference in vitamin D content between breast milk and formula, this test uses a potential variation in the vitamin D content of breast milk across black mothers. Vitamin D levels change gradually over time (Davies et al., 1997; O’Loan et al. 2007). Nesby-O’Dell et al. (2002) reported a deficiency rate of about 46% for black women of reproductive age who do not use vitamin D supplements and a deficiency rate of only about 11% for those consuming at least 400 IU per day in supplemental vitamin D. All of the prenatal vitamins examined in a 1991 study seem to have been labeled to contain exactly 400 IU of vitamin D (Park et al., 1991; Committee on Dietary Allowances, 1980). Therefore one might expect the breast milk of those black mothers who took a prenatal vitamin to initially have higher vitamin D levels than the breast milk of those mothers who did not and the difference may persist if mothers continue taking the prenatal vitamin while breastfeeding. There may therefore be a more positive relationship between breastfeeding and IQ for those children of black mothers who took a prenatal vitamin than for those children of black mothers who did not.

Coefficients were estimated for the following empirical equation.

$$IQ_{m,i,t,y} = a_0 + a_1 * breastfed_i + a_2 * prenatal\ vitamin_i + a_3 * breastfed_i * prenatal\ vitamin_i + \bar{a} * \bar{m}_{m,i} + \epsilon_{m,i,t,y}$$

The definitions of symbols also appearing in the previous equations remain the same with the exception of  $\bar{m}_{m,i}$ , which no longer includes the prenatal vitamin indicator variables. The variable  $breastfed_i$  is equal to one if child  $i$  was breastfed and zero if the child was not breastfed,  $prenatal\ vitamin_i$  is equal to one if the mother of child  $i$

took a prenatal vitamin while pregnant and zero if she did not, and  $breastfed_i * prenatal\ vitamin_i$  is the product of those two variables. Only observations of children born to black mothers will be used in estimating this equation. If an early vitamin D deficiency is causing lower IQ scores, one might expect to see a positive value for  $a_3$ , the coefficient on  $breastfed_i * prenatal\ vitamin_i$ .

#### *A Fourth Test*

Rickets is a condition affecting bone development that can be caused by a vitamin D deficiency (Wharton and Bishop, 2003). Rickets appeared in northern Europe following industrialization and urbanization (Chesney, 2003) and urban residence continues to be associated with a higher risk of developing rickets (Bachrach et al., 1979; Biser-Rohrbaugh and Hadley-Miller, 2001). Nesby-O'Dell et al. (2002) report a vitamin D deficiency rate of about 47% for those black women of reproductive age living in urban areas and a deficiency rate of about 36% for those black women of reproductive age living in rural areas. Therefore if an early vitamin D deficiency decreases later IQ, one might expect to see a less positive relationship between breastfeeding and IQ for those children of black mothers who live in urban areas than for those children of black mothers who live in rural areas.



Coefficients were estimated for the following empirical equation.

$$IQ_{m,i,t,y} = a_0 + a_1 * breastfed_i + a_2 * urban_i + a_3 * breastfed_i * urban_i + \vec{a} * \vec{m}_{m,i} + \epsilon_{m,i,t,y}$$

The definitions of symbols also appearing in the first two empirical equations are the same as they were for those equations. The variable  $breastfed_i$  is equal to one if child  $i$  was breastfed and zero if the child was not breastfed,  $urban_i$  is equal to one if the mother of child  $i$  reported living in an urban area in the year of the child's birth or in latest year preceding the child's birth for which data were available and zero if she reported living in a rural area, and  $breastfed_i * urban_i$  is the product of those two variables. Only observations of children born to black mothers will be used in estimating this equation. If a vitamin D deficiency is causing lower IQ scores, one might expect to see a negative value for  $a_3$ , the coefficient on  $breastfed_i * urban_i$ .

## Results

If a vitamin D deficiency is contributing to the average IQ gap, then one might expect the relationship between breastfeeding and later IQ to be more positive for children born to white mothers than for children born to black mothers. Figure 1-1 suggests that this is the case.

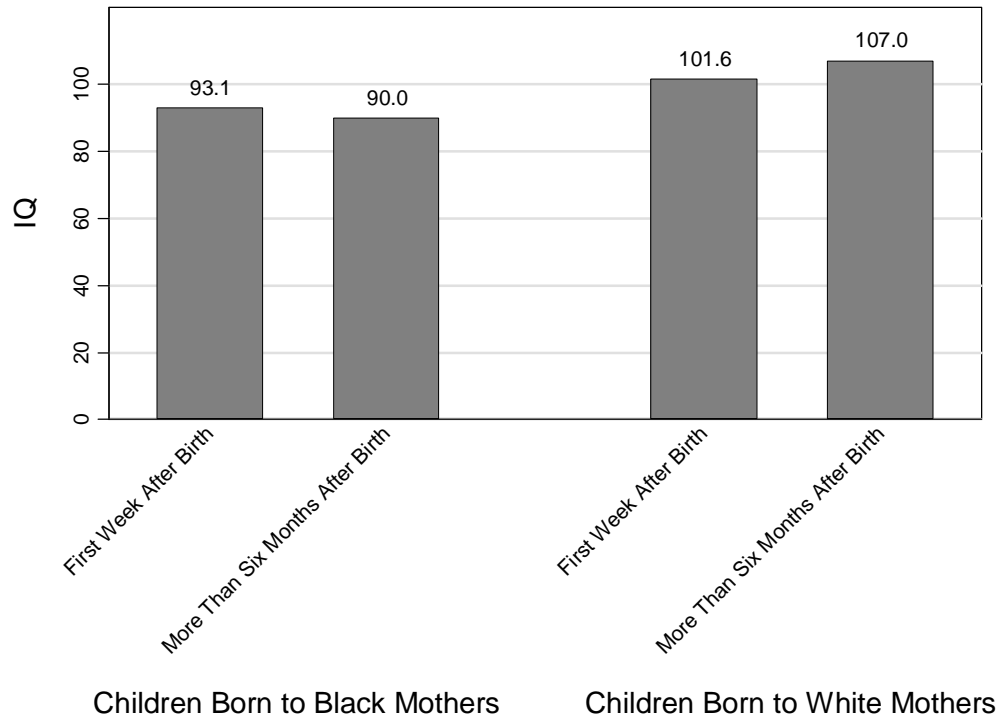


Figure 1-1

**Average IQ and Age at Introduction of Infant Formula by Mother's Race**

Notes: Figure 1-1 is based on data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Each unique combination of child, test and year was a potential observation in the construction of this figure. Only observations for which the child was introduced to formula in either the first week after birth or more than six months after birth were used in the construction of this figure. These observations represented 2,815 children born to 1,614 mothers. These included 1,171 children who were born to white mothers and introduced to formula in the first week after birth, 78 children who were born to white mothers and introduced to formula more than six months after birth, 1,540 children who were born to black mothers and introduced to formula in the first week after birth and 26 children who were born to black mothers and introduced to formula more than six months after birth.

A multiple regression analysis demonstrates that the pattern observed in Figure 1-1 continues to hold after controlling for a wide range of potential confounding variables.

Table 1-3  
Selected Results for the First Test

<u>Variables</u>	<u>Coefficients</u>
$white_m * delay_i$	8.56** (3.50)
$delay_i$	-6.72** (3.42)
$white_m$	2.38*** (0.66)
<hr/>	
Observations	33752
$R^2$	0.18

Notes: Table 1-3 reports coefficients from a multiple regression model estimated using data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the level of mother. Each unique combination of child, year and IQ test was a potential observation in this analysis. Only observations for which the child was introduced to formula in either the first week after birth or more than six months after birth were included in this analysis. These observations represented 2,692 children born to 1,547 mothers. The analysis included 1,110 children who were born to white mothers and introduced to formula in the first week after birth, 73 children who were born to white mothers and introduced to formula more than six months after birth, 1,485 children who were born to black mothers and introduced to formula in the first week after birth and 24 children who were born to black mothers and introduced to formula more than six months after birth. The regression equation also included variables measuring prenatal vitamin use, low birth weight, mother's smoking while pregnant, birth order, child's age when the mother returned to work, mother's AFQT score, mother's family income in the year preceding the birth year, mother's marital status, mother's education in the year preceding the birth year, mother's birth year, mother's age in the birth year, urban residence in the birth year and region of residence in the birth year. Income was described using indicator variables for income less than \$10,000, income between \$10,000 and \$25,000, income greater than \$25,000 and income missing. Education was described using indicator variables for no college education, some college education, four years or more of college education and education missing.

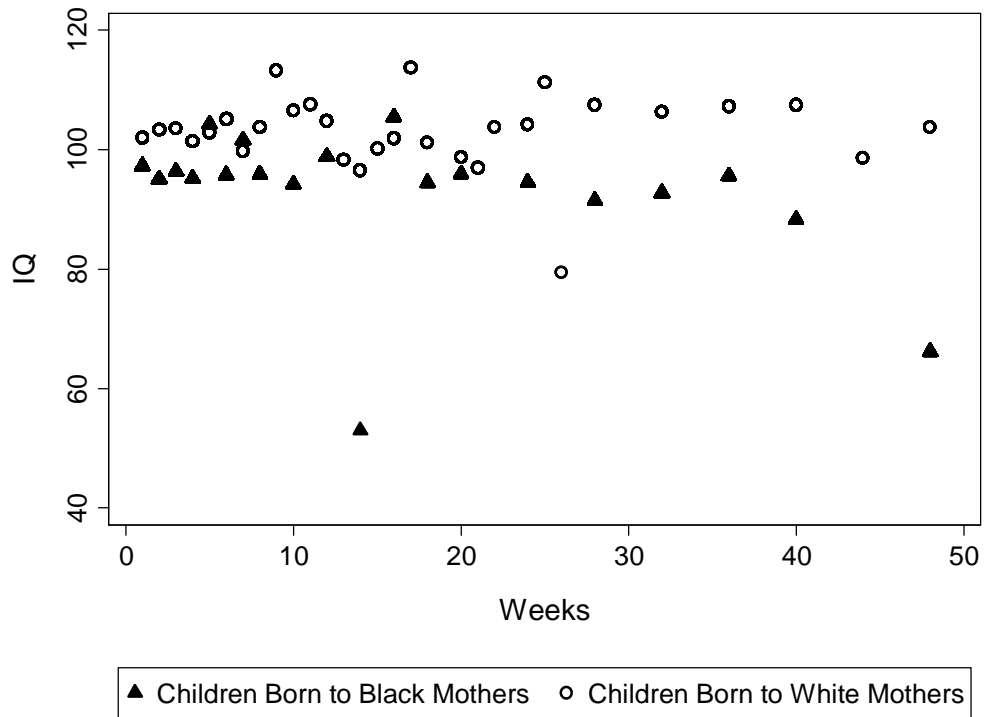
\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

In the first test, the coefficient on  $white_m * delay_i$  is a little less than 9 and statistically significant at the 5% level, indicating that, after controlling for a wide range of potential confounding variables, the IQ gap was about 9 points bigger for those who began formula after the first 26 weeks than for those who began it immediately.

If differences by race in vitamin D status are contributing to the average IQ gap, then one might expect that, among those infants who were transitioned quickly from breastfeeding to infant formula, delays in that transition would be associated with a larger gap. Figure 1-2 suggests that this is the case.



**Figure 1-2**  
**Average IQ and Age in Weeks at Transition from Breastfeeding to Infant Formula by Mother's Race**

Notes: Figure 1-2 is based on data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Each unique combination of child, test and year was a potential observation in the construction of this figure. Only observations of those children who were both given formula and breastfed and who were reported to begin formula and end breastfeeding at the same age in weeks were used in the construction of this figure. These observations represented 534 children born to 424 white mothers and 166 children born to 131 black mothers.

A multiple regression analysis demonstrates that the pattern observed in Figure 1-2 continues to hold after controlling for a wide range of potential confounding variables.

Table 1-4  
Selected Results for the Second Test

<u>Variables</u>	<u>Coefficients</u>
$white_m * weeks\ to\ formula_i$	0.24** (0.10)
$weeks\ to\ formula_i$	-0.21** (0.10)
$white_m$	0.51 (1.68)
<hr/>	
Observations	7740
$R^2$	0.18

Notes: Table 1-4 reports coefficients from a multiple regression model estimated using data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the level of mother. Each unique combination of child, year and IQ test was a potential observation in this analysis. Only those children for whom the same age in weeks was reported for the introduction to infant formula and the end of breastfeeding were included in the analysis. These observations represented 497 children born to 397 white mothers and 161 children born to 126 black mothers. The regression equation also included variables measuring prenatal vitamin use, low birth weight, mother's smoking while pregnant, birth order, child's age when the mother returned to work, mother's AFQT score, mother's family income in the year preceding the birth year, mother's marital status, mother's education in the year preceding the birth year, mother's birth year, mother's age in the birth year, urban residence in the birth year and region of residence in the birth year. Income was described using indicator variables for income less than \$10,000, income between \$10,000 and \$25,000, income greater than \$25,000 and income missing. Education was described using indicator variables for no college education, some college education, four years or more of college education and education missing.

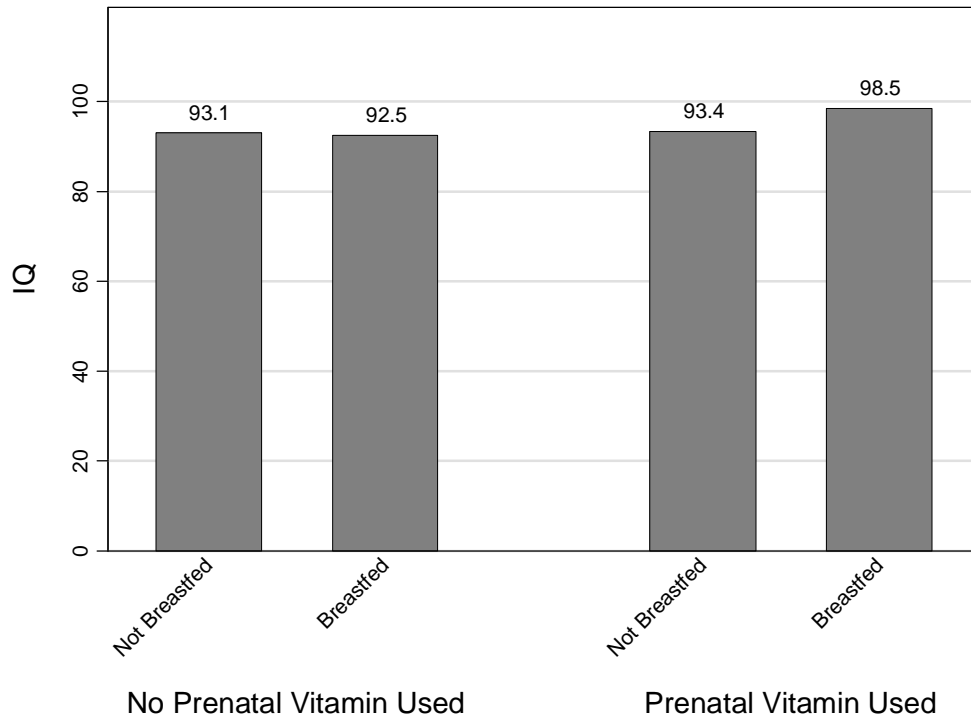
\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

In the second test, the coefficient on  $white_m * weeks\ to\ formula_i$  is about 0.24 and statistically significant at the 5% level, indicating that, after controlling for a wide range of potential confounding variables, each week white and black mothers delay the switch from breast milk to formula is associated with an increase in the average IQ gap between their children of about a quarter of an IQ point.

If differences by race in vitamin D status are contributing to the average IQ gap, then one might expect that among children born to black mothers the relationship between breastfeeding and later IQ would be more positive when the mother used a prenatal vitamin. Figure 1-3 suggests that this is the case.



**Figure 1-3**  
**Average IQ and Breastfeeding by Prenatal Vitamin Use Among Children Born to Black Mothers**

Notes: Figure 1-3 is based on data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Each unique combination of child, test and year was a potential observation in the construction of this figure. Only observations corresponding to the children of black mothers were used in the construction of this figure. These observations represented 2,002 children born to 1,066 mothers. These included 479 children who were breastfed and whose mothers used prenatal vitamins, 16 children who were breastfed and whose mothers did not use prenatal vitamins, 1,399 children who were not breastfed and whose mothers used prenatal vitamins and 108 children who were not breastfed and whose mothers did not use prenatal vitamins.

A multiple regression analysis demonstrates that the pattern observed in Figure 1-3 continues to hold after controlling for a wide range of potential confounding variables.

Table 1-5  
Selected Results for the Third Test

<u>Variables</u>	<u>Coefficients</u>
<i>breastfed<sub>i</sub>*prenatal vitamin<sub>i</sub></i>	6.30** (2.60)
<i>prenatal vitamin<sub>i</sub></i>	-0.94 (0.98)
<i>breastfed<sub>i</sub></i>	-5.30** (2.54)
Observations	24373
R <sup>2</sup>	0.11

Notes: Table 1-5 reports coefficients from a multiple regression model estimated using data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the level of mother. Each unique combination of child, year and IQ test was a potential observation in this analysis. Only observations corresponding to the children of black mothers were included in this analysis. These observations represented 1,936 children born to 1,035 mothers. The analysis included 459 children who were breastfed and whose mothers used prenatal vitamins, 13 children who were breastfed and whose mothers did not use prenatal vitamins, 1,359 children who were not breastfed and whose mothers used prenatal vitamins and 105 children who were not breastfed and whose mothers did not use prenatal vitamins. Subscripts indicate the dimensions with which the variables vary. Only those children born to black mothers were included in the analysis. The regression equation also included variables measuring low birth weight, mother's smoking while pregnant, birth order, child's age when the mother returned to work, mother's AFQT score, mother's family income in the year preceding the birth year, mother's marital status, mother's education in the year preceding the birth year, mother's birth year, mother's age in the birth year, urban residence in the birth year and region of residence in the birth year. Income was described using indicator variables for income less than \$10,000, income between \$10,000 and \$25,000, income greater than \$25,000 and income missing. Education was described using indicator variables for no college education, some college education, four years or more of college education and education missing.

\*\*\* Statistically different from zero with  $p < 0.01$

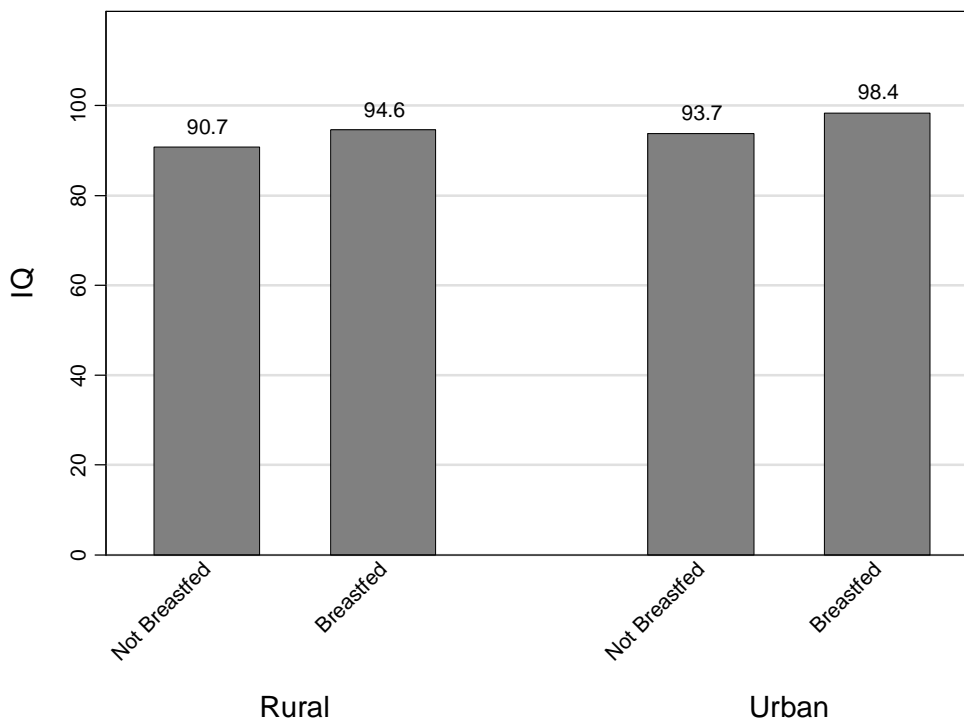
\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

In the third test, the coefficient on *breastfed<sub>i</sub> \* prenatal vitamin<sub>i</sub>* is around 6 and statistically significant at the 5% level, indicating that breastfeeding is associated with higher IQs for those children whose black mothers took a prenatal vitamin than for those whose black mothers who did not.

When the third test is repeated for the children of white mothers, the coefficient on *breastfed<sub>i</sub> \* prenatal vitamin<sub>i</sub>* is calculated to be near zero and not statistically significant. This is what one would expect if the coefficient on *breastfed<sub>i</sub> \* prenatal vitamin<sub>i</sub>* for the children of black mothers is driven by a vitamin D deficiency not prevalent among the children of white mothers.

If differences by race in vitamin D status are contributing to the average IQ gap, then one might expect that among children born to black mothers the relationship between breastfeeding and later IQ would be less positive when the mother resided in an urban area. Figure 1-4 shows the relationship between breastfeeding and later IQ separately for those children born to black mothers living in rural and urban areas.



**Figure 1-4**  
**Average IQ and Breastfeeding by Urban Residence Among Children Born to Black Mothers**

Notes: Figure 1-4 is based on data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Each unique combination of child, test and year was a potential observation in the construction of this figure. Only observations corresponding to the children of black mothers were used in the construction of this figure. These observations represented 2,541 children born to 1,086 mothers. These included 502 children who were breastfed and whose mothers lived in an urban area in the birth year, 74 children who were breastfed and whose mothers lived in a rural area in the birth year, 1,532 children who were not breastfed and whose mothers lived in an urban area in the birth year and 433 children who were not breastfed and whose mothers lived in a rural area in the birth year.



In Figure 1-4, differences in IQ by breastfeeding appear to be similar for mothers living within urban areas and mothers living outside urban areas. A multiple regression analysis demonstrates that the pattern observed in Figure 1-4 continues to hold after controlling for a wide range of potential confounding variables.

Table 1-6  
Selected Results for the Fourth Test

<u>Variables</u>	<u>Coefficients</u>
<i>breastfed<sub>i</sub>*urban<sub>i</sub></i>	-0.45 (1.83)
<i>urban<sub>i</sub></i>	0.90 (0.69)
<i>breastfed<sub>i</sub></i>	1.07 (1.72)
Observations	30363
R <sup>2</sup>	0.11

Notes: Table 1-6 reports coefficients from a multiple regression model estimated using data from the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 Children and Young Adults Survey. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the level of mother. Each unique combination of child, year and IQ test was a potential observation in this analysis. Only observations corresponding to the children of black mothers were included in this analysis. These observations represented 2,455 children born to 1,053 mothers. The analysis included 478 children who were breastfed and whose mothers lived in an urban area in the birth year, 73 children who were breastfed and whose mothers lived in a rural area in the birth year, 1,482 children who were not breastfed and whose mothers lived in an urban area in the birth year and 422 children who were not breastfed and whose mothers lived in a rural area in the birth year. Subscripts indicate the dimensions with which the variables vary. The regression equation also included variables measuring prenatal vitamin use, low birth weight, mother's smoking while pregnant, birth order, child's age when the mother returned to work, mother's AFQT score, mother's family income in the year preceding the birth year, mother's marital status, mother's education in the year preceding the birth year, mother's birth year, mother's age in the birth year and region of residence in the birth year. Income was described using indicator variables for income less than \$10,000, income between \$10,000 and \$25,000, income greater than \$25,000 and income missing. Education was described using indicator variables for no college education, some college education, four years or more of college education and education missing.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

In the fourth test, the coefficient on  $breastfed_i * urban_i$  is negative but near zero and not statistically significant.

The difference in vitamin D deficiency rates between black women living in urban areas and black women living in rural areas is less than a third of the size of the difference in deficiency rates between black women and white women and it is also less than a third of the size of the difference in deficiency rates between black women who take 400 IU per day in supplemental vitamin D and those who take none. The small and statistically insignificant coefficient on  $breastfed_i * urban_i$  may indicate that the difference in vitamin D status between black women living in urban areas and black women living in rural areas is not sufficiently large to identify a relationship between early vitamin D deficiency and later IQ using these data.

The results of the third test give rise to a natural question. Would the patterns observed in the first two tests hold if only those black mothers who took a prenatal vitamin were considered?

In these data, observations for which the mother is black, breastfed her child and did not take a prenatal vitamin are few, and most of these observations do not qualify for the first two tests. The third regression includes only 176 observations representing 12 children of 12 different mothers where the mother was black, breastfed and did not take a prenatal vitamin. All of the black mothers who delayed the introduction of formula for six months also took a prenatal vitamin. There was only one child in these data who was born to a black mother, was switched from breastfeeding to formula in a week and whose mother did not take a prenatal vitamin. Omitting observations corresponding to that child had a negligible effect on the results of the second test. Therefore the results presented in Tables 1-3 and 1-4 are driven by observations of children whose mothers took a prenatal vitamin.

It is not surprising that those patterns would hold for mothers who took a

prenatal vitamin. First, taking a prenatal vitamin may not be sufficient to eliminate a vitamin D deficiency for black mothers (Nesby-O'Dell et al., 2002). Second, the effect of the prenatal vitamin on the mother's vitamin D level would fade if the mother quit taking the vitamin (Davies et al., 1997; O'Loan et al. 2007).

An interesting result from the third test is the small and statistically insignificant coefficient on the variable indicating the mother's use of a prenatal vitamin. Similar results were observed for the other three regressions as well. This may indicate that either vitamin D status is more relevant in the period following birth than in the period preceding it or that the degree of deficiency necessary to influence IQ is rarely reached by mothers but occurs more often in neonates, which would be consistent with the higher vitamin D deficiency rates observed in black neonates than observed in pregnant black women by Bodnar et al. (2007).

#### Concerns and Limitations

The empirical analysis presented here is constrained by several limitations. First, vitamin D status was not measured directly and it was therefore necessary to use the determinants of vitamin D status to indirectly explore the relationship between a perinatal vitamin D deficiency and later IQ. Second, some key groups were not well-represented in these data. Third, the determinants of vitamin D status may be related to later intelligence through mechanisms other than vitamin D. Fourth, the relationship between infant feeding practices and later IQ may be confounded by correlations between infant feeding practices and unobserved characteristics of mothers and children.

One limitation of the first and third tests is the small number of independent clusters of observations for key groups. With respect to the first test, there were only 17 independent clusters of observations representing children of black mothers to

whom formula was introduced after six months. With respect to the third test, there were only 12 independent clusters of observations representing children of black mothers who were breastfed and whose mothers did not take a prenatal vitamin while pregnant. This issue is less of a concern for the second and the fourth tests. In the second test, there were 126 independent clusters of observations for children of black mothers whose mothers reported the same age for the child at the end of breastfeeding and the beginning of formula feeding. In the fourth test, there were 56 independent clusters of observations for the children of black mothers who lived in rural areas and breastfed and 289 independent clusters of observations for the children of black mothers who lived in urban areas and breastfed.

The first two tests show that the relationship between a delay in the introduction of infant formula and later IQ is different for children born to black mothers and children born to white mothers. Another potential concern is that this could be a result of racial differences in the benefits of breast milk with respect to intelligence. In particular, Caspi et al. (2007) present evidence that the benefits of breastfeeding with respect to IQ may vary with genetic differences in long-chain polyunsaturated fatty acid (LC-PUFA) metabolism. Breast milk contains LC-PUFAs not typically found in infant formula during the period examined here.

The evidence presented in Tables 1-3 and 1-4 is inconsistent with this explanation. For concreteness, the results of the first test will be discussed in detail. The results of Caspi et al. suggest that the presence of the relevant LC-PUFAs in breast milk can only increase later IQ. If genetic differences in LC-PUFA metabolism are driving the results of the first test, it must be because breastfeeding has a weakly positive effect for the children of black mothers but has an even more positive effect for the children of white mothers. This would then result in a greater average IQ gap among infants to whom formula was introduced after the first six months than among

infants who began formula immediately. In contrast, if vitamin D deficiency is driving the results of the first test, then it may be that delaying the introduction of formula actually decreases the IQs of children of black mothers.

The coefficient on  $delay_i$  is the difference in IQ between the children of black mothers to whom formula was introduced after the first six months and the children of black mothers who were introduced to formula in the first week after birth. It is close to negative 7 and statistically significant at the 5% level, indicating that most of the increase in the IQ gap associated with a delay in the introduction of formula is because of lower IQs for the children of black mothers who delay the introduction of formula. This allows us to reject differences in LC-PUFA metabolism as the sole explanation for these results.

A similar exercise can be conducted with respect to the second test. In that case, the coefficient on  $weeks\ to\ formula_i$  is the effect of delaying the switch for the children of black mothers. Again, it is negative and statistically significant at the 5% level.

Differences by race in LC-PUFA metabolism clearly could not explain the results of the third test as that test is based on a comparison among the children of black mothers.

Another potential concern is that vitamin D is not the only micronutrient found in both prenatal vitamins and infant formula. The tests used here have little power to distinguish between these micronutrients. However, to explain these results there must be a large racial discrepancy in deficiency levels for the relevant micronutrient, suggesting vitamin D. Furthermore, recall that these tests were motivated in part by a correlation between skin color and IQ among blacks. Genetic variation in skin pigmentation creates variation in vitamin D levels unrelated to diet, so this might be considered further evidence in favor of vitamin D as the relevant micronutrient.

Another potential concern is that infant feeding practices are in many cases chosen by mothers and therefore the associations between infant feeding practices and later IQ may be influenced by the underlying characteristics of mothers that are correlated with their choices. In each of the tests above, this concern was addressed in two ways. First, a wide array of control variables were included in the regression equations. The inclusion of these control variables, to a first order approximation, removes their effects on both breastfeeding and IQ (Greene, 2003). Second, if the infant feeding decisions that the groups of mothers included in the tests above faced are similar, one might expect the difference-in-differences estimator employed here to limit any bias as a result of the correlation of unobserved characteristics with infant feeding practices. The mothers who make similar decisions may tend to resemble each other in the unobserved dimensions.

The usefulness of the difference-in-differences estimator will be more limited if the relationship between unobserved characteristics and infant feeding practices is very different for the two groups. It is possible to use the data to explore whether the relationships between infant feeding practices and the characteristics of the mothers are different.

One way to explore this possibility is to regress infant feeding practices on the observed characteristics of mothers and those observed characteristics interacted with an indicator variable denoting the mother's group. Significant differences by group in the relationship between observed characteristics and feeding behavior may indicate that unobserved characteristics differ by group as well.

One pattern that emerges in such an analysis is that black women with four years of college education or more are less likely to breastfeed for an extended period of time than white women with the same education. While differences in education are accounted for in the multiple regression analysis, these differences may indicate

that the relationships between infant feeding practices and unobserved characteristics differ by race.

Note, however, that controlling for a wide range of potential confounding variables, including mother's intelligence, marital status, education and income, as well as the age of the child when the mother returned to work, did little to alter the patterns observed in Figures 1-1 and 1-2. This suggests that confounding variables are not driving the patterns observed in Figures 1-1 and 1-2 and in Tables 1-3 and 1-4. Differences by race in the relationship between the unobserved characteristics of mothers and infant feeding practices clearly could not explain the results of the third test as that test is based on a comparison among the children of black mothers.

Another potential concern is that the empirical equations used in the first two tests assume that the relationship between IQ and control variables such as income and education is the same for the children of black mothers and the children of white mothers. To test this assumption, for each observation IQ was predicted based on the race of the mother, the control variables used in the first two tests, and race interacted with those control variables. The coefficients on the interaction terms were then jointly tested for statistical significance. The hypothesis that the coefficients on the interaction terms were all equal to zero could not be rejected, suggesting that this assumption is not a problem.

Because of the limitations of the data analyzed here, the results presented here may be the product of coincidence. Further study to confirm a relationship between neonatal vitamin D deficiency and later IQ might include experiments; experimental data could have several advantages over the observational data analyzed here. While there are ethical concerns associated with creating vitamin D deficiencies in neonates, experimental study could nevertheless be conducted by, for example, randomly assigning neonate vitamin D supplementation promotion efforts. A similar technique

has been used to study the relationship between breastfeeding and later intelligence in a primarily-white population (Kramer et al., 2008).

While the results presented above suggest a large detrimental effect of early vitamin D deficiency on later IQ, vitamin D deficiencies brought about by extended periods of exclusive breastfeeding cannot explain the entirety of the average IQ gap; less than one third of the children of black mothers in the United States are ever breastfed (Forste et al., 2001). Note also that these results do not explain the global patterns in IQ described by Rushton and Jenson (2005); such patterns are beyond the scope of this paper.

## Discussion

Developing a better understanding of the sources of the average IQ gap is one of the most important issues in the social sciences. Scores on intelligence tests are correlated with many important life outcomes, including academic performance and job performance. Differences by race in life outcomes are closely related to differences in IQ. Developing a better understanding of the sources of the average IQ gap is an important step in understanding and addressing racial differences in life outcomes.

Gottfredson (1997) asserted that intelligence is “the most powerful single predictor of overall job performance” (p. 83). Neisser et al. (1996) reported that the correlation between children’s IQ and grades is about 0.50 and the “relationship between test scores and school performance seems to be ubiquitous” (p. 81). They reported that the correlation between IQ and total years of education is about 0.55, stating that “test scores are the best single predictor of an individual’s years of education” (p. 82).

Herrnstein and Murray (1994) used data from the NLSY79 to argue for



relationships between intelligence and life outcomes such as poverty, unemployment, marriage, divorce, the bearing of children outside of marriage and crime. They went on to argue that many observed inequalities in average life outcomes between whites and blacks are due in part to differences in average intelligence. Jencks and Phillips (1998) argued that

... if racial equality is America's goal, reducing the black-white test score gap would probably do more to promote this goal than any other strategy that commands broad political support. Reducing the test score gap is probably both necessary and sufficient for substantially reducing racial inequality in educational attainment and earnings. Changes in education and earnings would in turn help reduce racial differences in crime, health, and family structure, although we do not know how large these effects would be. (pp. 3-4)

If it should be the case that the average IQ gap is due in part to racial differences in perinatal vitamin D status, then a portion of the gap could be eliminated simply and cheaply through following the current recommendations of the American Academy of Pediatrics. In order to prevent rickets and vitamin D deficiency, the American Academy of Pediatrics recommends vitamin D supplementation for breastfed infants beginning within the first few days after birth (Wagner et al., 2008).

The hypothesis that racial differences in perinatal vitamin D status are contributing to the average IQ gap has important social implications, is biologically plausible, provides a parsimonious explanation for previously documented empirical regularities, yields testable predictions and suggests a simple and cheap method of reducing the average IQ gap. Although the hypothesis is consistent with the empirical

regularities documented here, the link between perinatal vitamin D status and later IQ remains tenuous. Considering the importance of the average IQ gap and the attractive features of this hypothesis, further research is warranted.

The potential contribution of genetic differences to the average IQ gap is a controversial topic; this may be in part due to an assumption that attributing any part of the average IQ gap to genetic differences is equivalent to claiming that the gap cannot be eliminated. Further study may fail to confirm a relationship between vitamin D status and later IQ; nevertheless, the very possibility illustrates the difference between attributing some portion of the gap to genetic differences and claiming that the gap must be accepted.

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## CHAPTER 2

### INTELLIGENCE AND EXPERIMENTATION WITH RECREATIONAL DRUGS

#### Introduction

Intelligence is positively related to health (Auld and Sidhu, 2005; Gottfredson and Deary, 2004). It has been argued that this relationship is driven in part by differences in the use of recreational drugs (Batty et al., 2006; Gottfredson, 2004). Several researchers have presented evidence that intelligence is negatively related to the probability of abusing alcohol or smoking (Batty et al., 2006; Kenkel et al., 2006; Heckman et al., 2006; Sander, 1999; Taylor et al., 2003; Wilmoth, 2010).

Despite this evidence, it will be argued here that more intelligent people are more likely to have experimented with recreational drugs. More intelligent people tend to value novelty more highly (Fagan, 1984; Raine et al., 2002; Zuckerman 1994). Those who value novel experiences more highly are more likely to experiment with recreational drugs as adolescents and young adults (Zuckerman 1994). Using data from a national survey, it will be shown that more intelligent people are more likely to have experimented with alcohol, marijuana, cocaine and other commonly used recreational drugs.

The remainder of this paper is organized as follows. The first section reviews the literature on intelligence and the use of recreational drugs. The second section describes the data and methods that will be used to explore the relationship between intelligence and experimentation with recreational drugs. The third section presents the results of the statistical analysis. The fourth section discusses those results and concludes.

## Intelligence and Recreational Drugs

Scores on tests of different types of reasoning or knowledge are often highly correlated with one another (Neisser et al., 1996). It is assumed here that these positive correlations arise because such scores reflect a single underlying personal characteristic that will be referred to as intelligence.

Intelligence defined in this way is positively related to health (Auld and Sidhu, 2005; Gottfredson and Deary, 2004). The use of recreational drugs contributes to about 25% of all deaths (Mokdad et al., 2004). It has been argued that the relationship between intelligence and health is driven in part by differences in the use of recreational drugs (Batty et al., 2006; Gottfredson, 2004).

Several researchers have presented evidence that more intelligent people are less likely to smoke (Kenkel et al., 2006; Heckman et al., 2006; Taylor et al., 2003). Evidence concerning the relationship between intelligence and alcohol abuse is mixed, with researchers reporting evidence of a positive (Batty et al., 2008; Hatch et al., 2007), a negative (Batty et al., 2006; Clark and Haughton, 1975; Sander, 1999) and a null (Kubicka et al., 2001; Mortensen et al., 2005; Wennberg et al., 2002) relationship. Wilmoth (2010) argued that these mixed results arose because the relationship between intelligence and alcohol abuse changes with age.

Although more intelligent people may be less likely to abuse alcohol or smoke cigarettes, it may nevertheless be the case that more intelligent people are more likely to have experimented with alcohol, cigarettes and other recreational drugs.

One important motivation for experimentation with alcohol and other recreational drugs may be the desire for novel experiences. The most widely studied instrument used to measure the desire for novel experiences is Zuckerman's Sensation Seeking Scale (SSS; Zuckerman et al., 1964; Zuckerman, 1994). Zuckerman (1994) defined sensation seeking as "a trait defined by the seeking of varied, novel, complex,

and intense sensations and experiences, and the willingness to take physical, social, legal and financial risks for the sake of such experience” (p. 27).

Zuckerman (1994) reviewed dozens of studies indicating that those with SSS scores that reflect a higher value for novel experiences are more likely to experiment with recreational drugs as adolescents and young adults. The SSS includes a small number of questions about experimentation with drugs, but excluding those questions from the SSS had little effect on the pattern observed.

The value placed on novelty is positively related to future intelligence in infants (Fagan, 1984) and young children (Raine et al., 2002). More intelligent people tend to have SSS scores that indicate they value novel experiences more highly (Zuckerman, 1994).

If more intelligent people tend to value novelty more highly and if those who value novel experiences more highly are more likely to experiment with recreational drugs, then intelligence may be positively related to the probability of having experimented with recreational drugs. The next section will describe the data and methods that will be used to test this hypothesis.

### Data and Methods

The hypothesis that intelligence is positively related to experimentation with recreational drugs will be explored using data from the National Longitudinal Survey of Youth 1979 (NLSY79). The NLSY79 is a survey of 12,686 men and women who were between the ages of 14 and 22 when first interviewed in 1979.

In 1980, nearly all NLSY79 participants were administered the Armed Services Vocational Aptitude Battery (ASVAB). Scores on four subtests from the ASVAB can be used to calculate an individual's Armed Forces Qualification Test (AFQT) score.

AFQT scores will be calculated here using the method described by Herrnstein and Murray (1994), who presented evidence that such AFQT scores serve as a good measure of intelligence. For ease of interpretation, AFQT scores will be normed by birth cohort to have a mean of 100 and a standard deviation of 15, the typical scale for IQ scores.

AFQT scores are affected by differences in education at the time of testing (Hansen et al., 2004; Neal and Johnson, 1996; Winship and Korenman, 1997) and researchers have sometimes adjusted AFQT scores to account for these differences (Auld and Sidhu, 2005). Given that intelligence has not been defined in terms of inherent ability, no adjustment for differences in education at the time of testing will be made in the analysis below. Using a method similar to that described by Auld and Sidhu (2005) to adjust AFQT scores for differences in education at the time of testing did not change the nature of the results that will be presented.

In 1982, 1983, 1984, 1985, 1988, 1989 and 1994, survey participants were asked if they had ever had a drink of an alcoholic beverage. Figure 2-1 shows how the proportion of observations in which the participant reported having drunk alcohol varied with IQ.

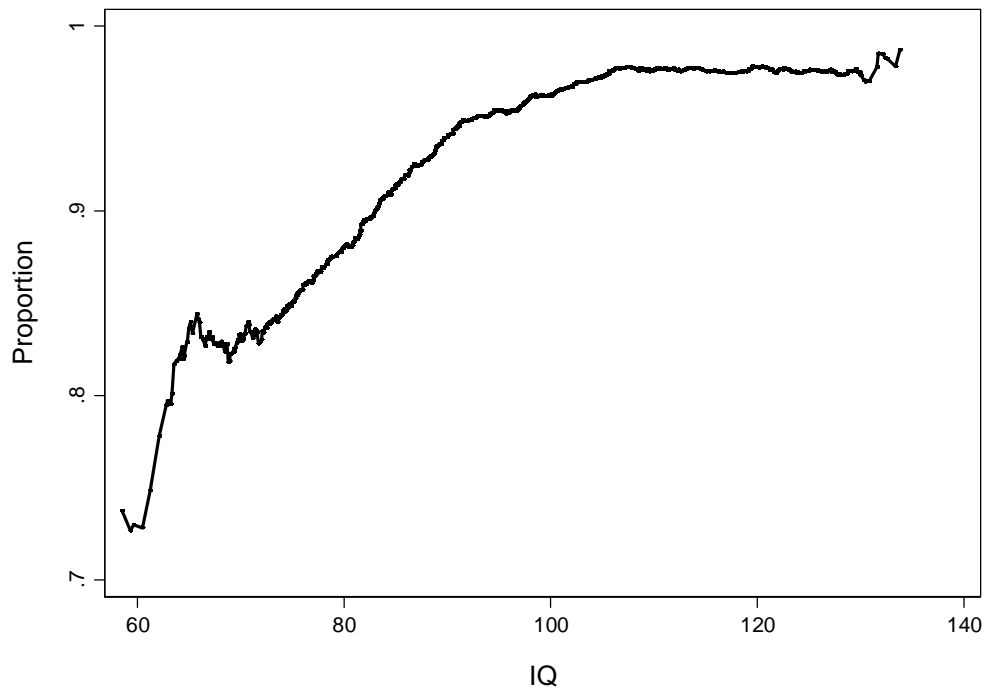


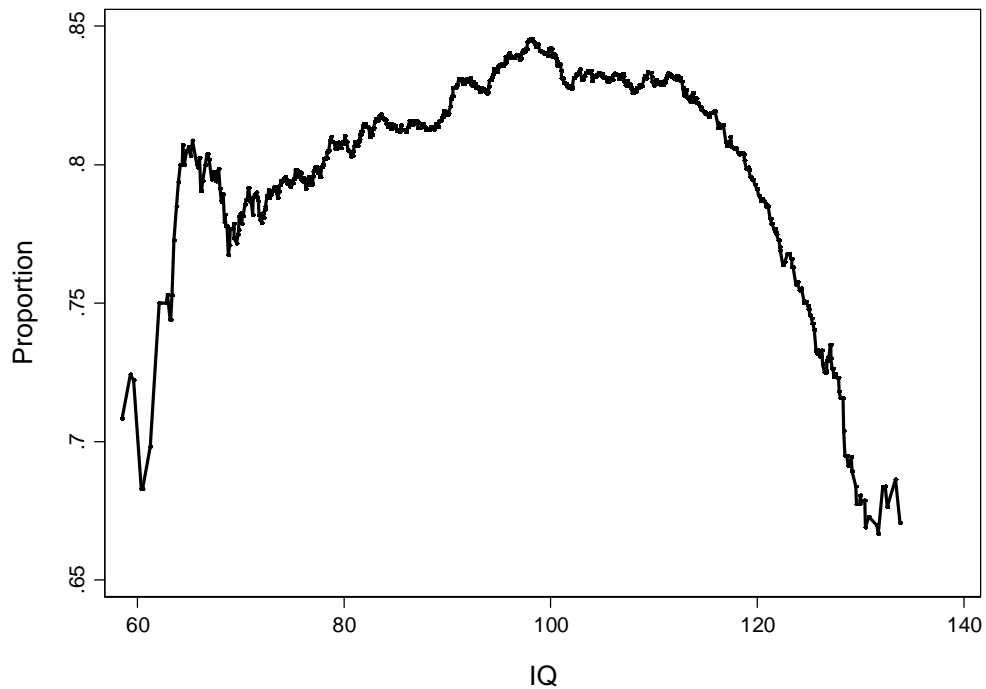
Figure 2-1

### IQ and Past Experimentation with Alcohol

Notes: Figure 2-1 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past alcohol consumption was a potential observation in the construction of this figure. This figure is based on 76,887 observations of 12,519 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having consumed alcohol.

In 1984, survey participants were asked if they had ever tried a cigarette.

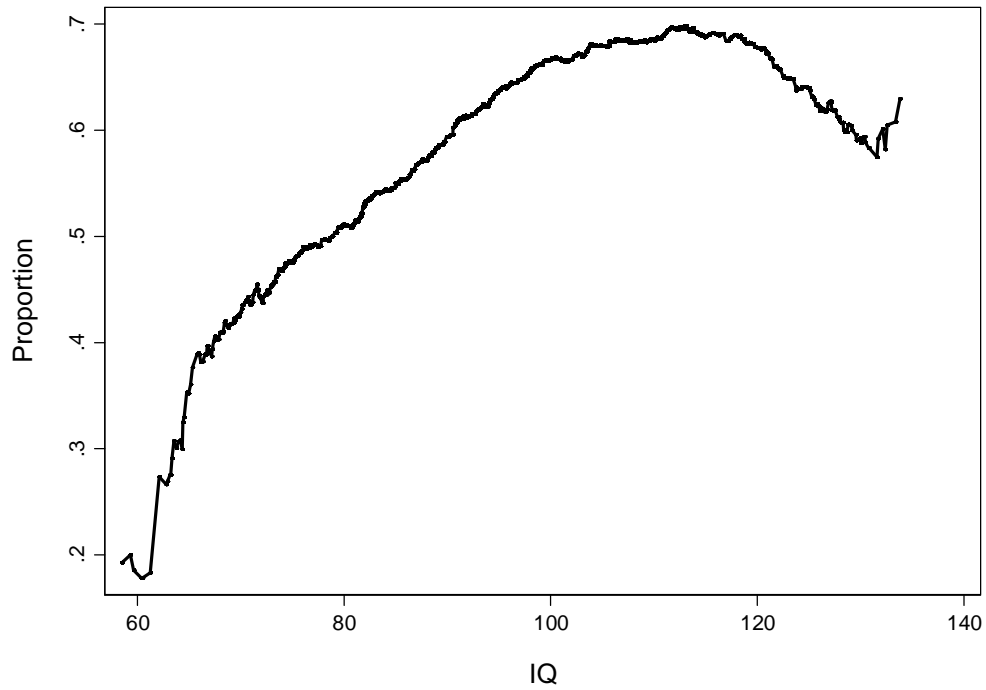
Figure 2-2 shows how the proportion of observations in which the participant reported having tried a cigarette varied with IQ.



**Figure 2-2**  
**IQ and Past Experimentation with Cigarettes**

Notes: Figure 2-2 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past cigarette consumption was a potential observation in the construction of this figure. This figure is based on 12,030 observations of 12,030 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having consumed cigarettes.

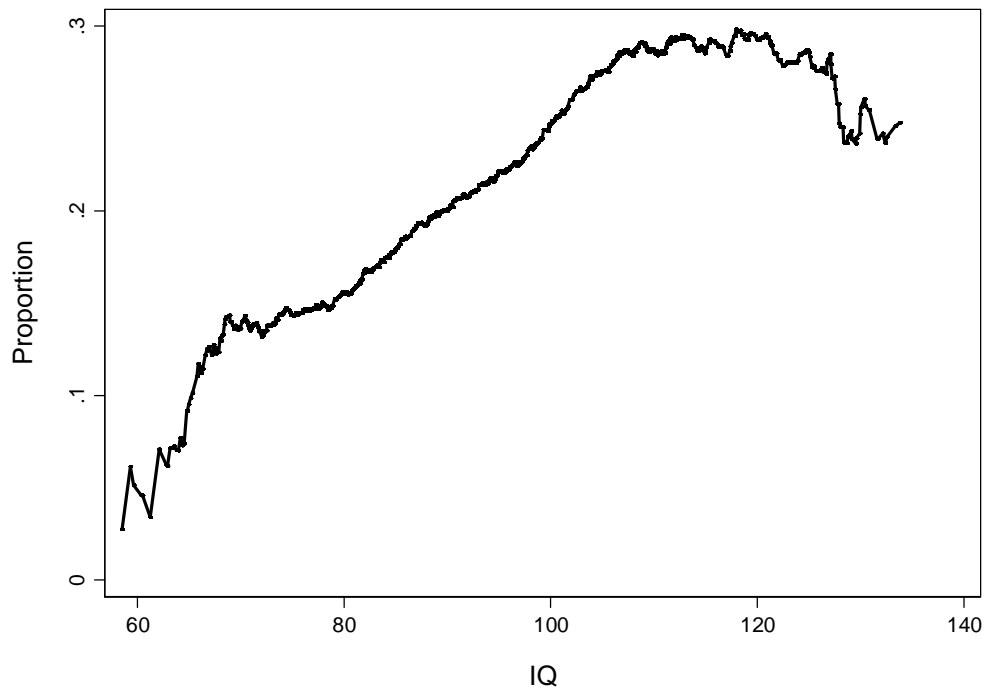
In 1984, 1988, 1992, 1994 and 1998, survey participants were asked if they had ever used marijuana or hashish. Figure 2-3 shows how the proportion of observations in which the participant reported having tried marijuana or hashish varied with IQ.



**Figure 2-3**  
**IQ and Past Experimentation with Marijuana**

Notes: Figure 2-3 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past marijuana consumption was a potential observation in the construction of this figure. This figure is based on 47,802 observations of 12,357 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having consumed marijuana or hashish.

In 1984, 1988, 1992, 1994 and 1998, survey participants were asked if they had ever used cocaine. Figure 2-4 shows how the proportion of observations in which the participant reported having tried cocaine varied with IQ.

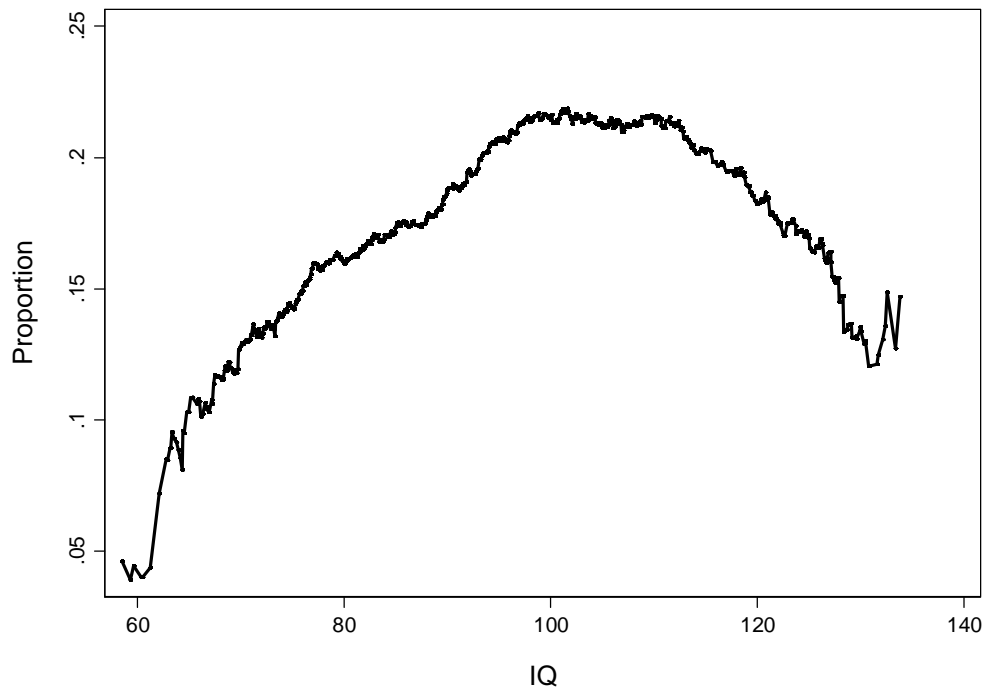


**Figure 2-4**  
**IQ and Past Experimentation with Cocaine**

Notes: Figure 2-4 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past cocaine consumption was a potential observation in the construction of this figure. This figure is based on 47,736 observations of 12,361 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having consumed cocaine.

In 1992, 1994 and 1998, survey participants were asked if they had ever used pain killers such as Darvon, Demerol, Percodan or Tylenol with codeine without a doctor's instructions. Figure 2-5 shows how the proportion of observations in which the participant reported having used pain killers without a doctor's instructions varied with IQ.

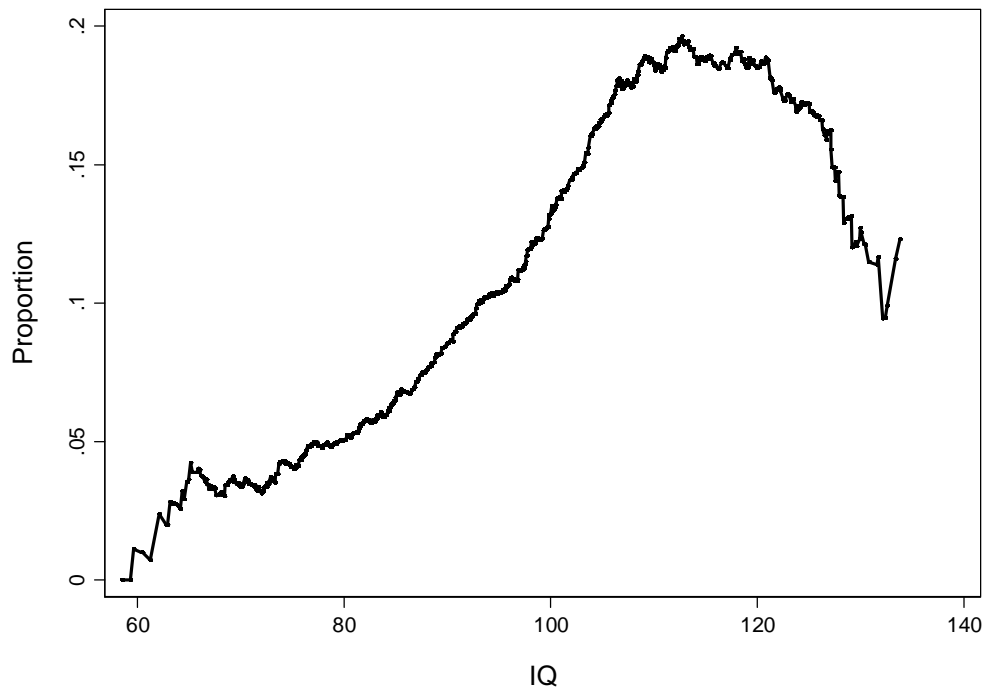




**Figure 2-5**  
**IQ and Past Experimentation with Pain Killers**

Notes: Figure 2-5 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past consumption of pain killers was a potential observation in the construction of this figure. This figure is based on 25,798 observations of 9,281 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having used pain killers without a doctor's instructions.

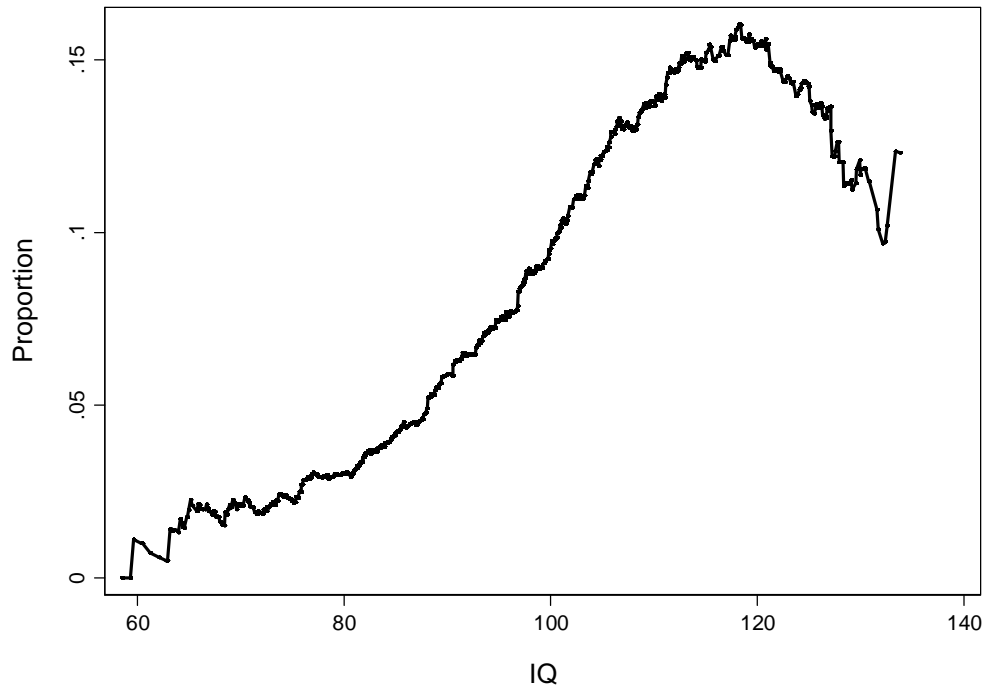
In 1992, 1994 and 1998, survey participants were asked if they had ever used stimulants such as amphetamines, Preludin, uppers and speed without a doctor's instructions. Figure 2-6 shows how the proportion of observations in which the participant reported having used stimulants without a doctor's instructions varied with IQ.



**Figure 2-6**  
**IQ and Past Experimentation with Stimulants**

Notes: Figure 2-6 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past consumption of stimulants was a potential observation in the construction of this figure. This figure is based on 25,780 observations of 9,282 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having used stimulants without a doctor's instructions.

In 1992, 1994 and 1998, survey participants were asked if they had every used hallucinogens such as LSD, PCP, peyote and mescaline without a doctor's instructions. Figure 2-7 shows how the proportion of observations in which the participant reported having used hallucinogens without a doctor's instructions varied with IQ.

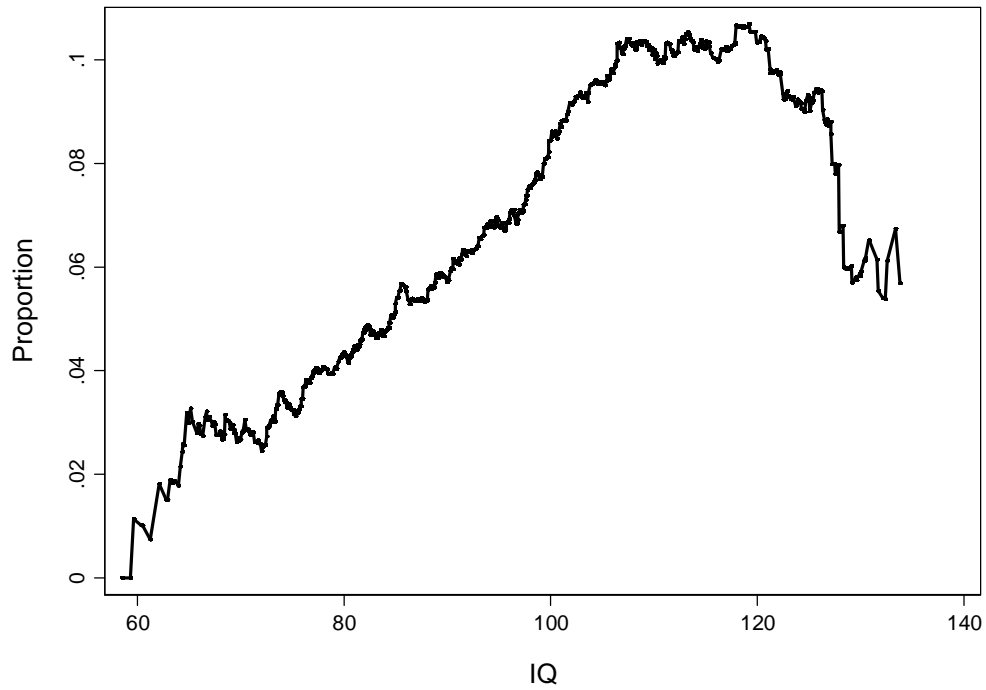


**Figure 2-7**  
**IQ and Past Experimentation with Hallucinogens**

Notes: Figure 2-7 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past consumption of hallucinogens was a potential observation in the construction of this figure. This figure is based on 25,786 observations of 9,281 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having used hallucinogens without a doctor's instructions.

In 1992, 1994 and 1998, survey participants were asked if they had ever used tranquilizers such as Librium, Valium and Xanax without a doctor's instructions.

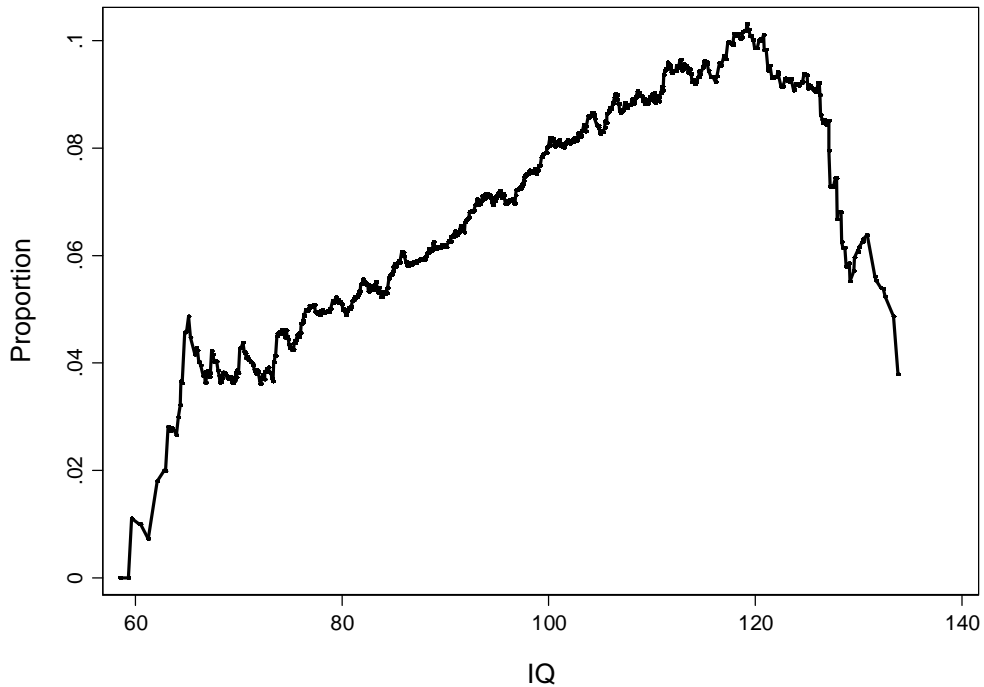
Figure 2-8 shows how the proportion of observations in which the participant reported having used tranquilizers without a doctor's instructions varied with IQ.



**Figure 2-8**  
**IQ and Past Experimentation with Tranquilizers**

Notes: Figure 2-8 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past consumption of tranquilizers was a potential observation in the construction of this figure. This figure is based on 25,790 observations of 9,283 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having used tranquilizers without a doctor's instructions.

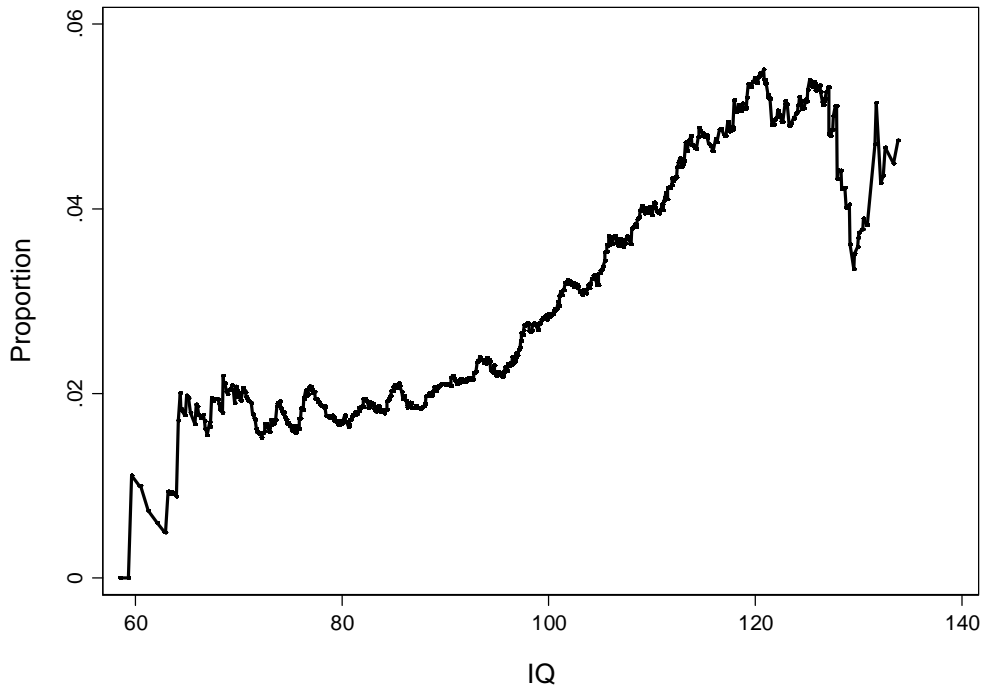
In 1992, 1994 and 1998, survey participants were asked if they had ever used sedatives such as barbiturates, sleeping pills and Seconal without a doctor's instructions. Figure 2-9 shows how the proportion of observations in which the participant reported having used sedatives without a doctor's instructions varied with IQ.



**Figure 2-9**  
**IQ and Past Experimentation with Sedatives**

Notes: Figure 2-9 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past consumption of sedatives was a potential observation in the construction of this figure. This figure is based on 25,784 observations of 9,282 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having used sedatives without a doctor's instructions.

In 1992, 1994 and 1998, survey participants were asked if they had ever used inhalants such as glue, amyl nitrite, poppers and aerosol sprays without a doctor's instructions. Figure 2-10 shows how the proportion of observations in which the participant reported having used inhalants without a doctor's instructions varied with IQ.



**Figure 2-10**  
**IQ and Past Experimentation with Inhalants**

Notes: Figure 2-10 is based on data from the National Longitudinal Survey of Youth 1979. Each unique combination of individual and year with questions about past consumption of inhalants was a potential observation in the construction of this figure. This figure is based on 25,772 observations of 9,282 individuals. Each point in the graph represents the proportion of those observations where IQ is within five points of the value depicted on the horizontal axis in which the participant reported having used inhalants without a doctor's instructions.

Survey participants were also asked about the use of heroin, ecstasy and steroids, but very few participants reported having used those substances. Because those substances were so rarely used, it was not possible to estimate the full empirical model that will be described below. When an abbreviated model was estimated, no statistically significant relationship was found between intelligence and the use of those substances. This may reflect the limited data available.

In each survey year, participants were asked about income, education, family size, urban residence and region of residence. In 1979, survey participants were asked about race and ethnicity. Race and ethnicity will be represented in the following analysis by white, black and Hispanic indicator variables. In 1979, 1982, and 2000,

participants were asked to name their religion, if any, and asked about the frequency with which they attended religious services. In survey years for which values for these control variables are missing, the most recent value from a preceding year will be used.

The Rotter Locus of Control Scale measures the beliefs people hold as to whether the courses of their lives are primarily determined by themselves or by external forces. Participants were given a version of the Rotter Locus of Control Scale in 1979. The responses elicited were given numerical values and summed so that lower scores indicate stronger beliefs that the courses of their lives are primarily determined by themselves.

The Rosenberg Self-Esteem Scale measures people's approval of themselves. Participants were given a version of the Rosenberg Self-Esteem Scale in 1980. Item responses were given numerical values and summed so that higher totals indicate higher levels of self-esteem.

The measures of personality described in the previous paragraphs were not included as control variables in many of the previous studies of the relationship between intelligence and recreational drug use. When the analysis described below was repeated without the inclusion of those control variables, similar results were obtained.

Table 2-1 summarizes these data. Each unique combination of individual and survey year with questions about the use of recreational drugs is a potential observation in the table below and the analysis that follows.

Table 2-1  
NLSY79 Selected Summary Statistics

<u>Variables</u>	<u>Obs</u>	<u>Means</u>	<u>Std. Devs.</u>
<i>alcohol</i> <sub>i,y</sub>	76887	0.9429	0.2320
<i>cigarettes</i> <sub>i,y</sub>	12030	0.8138	0.3893
<i>marijuana</i> <sub>i,y</sub>	47802	0.6153	0.4865
<i>cocaine</i> <sub>i,y</sub>	47736	0.2330	0.4228
<i>pain killers</i> <sub>i,y</sub>	25798	0.1872	0.3901
<i>stimulants</i> <sub>i,y</sub>	25780	0.1224	0.3277
<i>hallucinogens</i> <sub>i,y</sub>	25786	0.0924	0.2896
<i>tranquilizers</i> <sub>i,y</sub>	25790	0.0751	0.2636
<i>sedatives</i> <sub>i,y</sub>	25784	0.0735	0.2610
<i>inhalants</i> <sub>i,y</sub>	25772	0.0310	0.1733
<i>IQ</i> <sub>i</sub>	89946	99.7245	15.1737
<i>highest grade completed</i> <sub>i,y</sub>	94068	12.4007	2.3751
<i>age</i> <sub>i,y</sub>	94344	26.5260	5.5058
<i>married</i> <sub>i,y</sub>	94344	0.4244	0.4943
<i>white</i> <sub>i</sub>	94344	0.4943	0.5000
<i>black</i> <sub>i</sub>	94344	0.2605	0.4389
<i>Hispanic</i> <sub>i</sub>	94344	0.1551	0.3620
<i>male</i> <sub>i</sub>	94344	0.4960	0.5000
<i>Rotter Locus of Control Scale</i> <sub>i</sub>	93332	8.7087	2.4112
<i>Rosenberg Self-Esteem Scale</i> <sub>i</sub>	90284	32.2789	4.1055

Notes: Table 2-1 summarizes data from the NLSY79. Each unique combination of participant and survey year with questions about the use of recreational drugs is potentially an observation in this table. These observations represent 12,551 individuals. Subscripts denote the dimensions with which variables vary. The subscript *i* indicates individuals and the subscript *y* indicates survey year. The variables *alcohol*<sub>i,y</sub>, *cigarettes*<sub>i,y</sub>, *marijuana*<sub>i,y</sub>, *cocaine*<sub>i,y</sub>, *pain killers*<sub>i,y</sub>, *stimulants*<sub>i,y</sub>, *hallucinogens*<sub>i,y</sub>, *tranquilizers*<sub>i,y</sub>, *sedatives*<sub>i,y</sub>, and *inhalants*<sub>i,y</sub> are all indicator variables equal to one if the participant reported having used those substances and zero otherwise. The variables *married*<sub>i,y</sub>, *white*<sub>i</sub>, *black*<sub>i</sub>, *Hispanic*<sub>i</sub> and *male*<sub>i</sub> are all indicator variables equal to one if they describe the participant and zero otherwise. Additional variables that will be included in the analysis below are income and family size as well as indicator variables for urban residence, region of residence, religious affiliation and the frequency with which religious services were attended. Region of residence will be described using indicator variables for residence in the northeast, north central, southern and western regions of the United States. Religious affiliation will be described by a group of ten indicator variables corresponding to the categories of general protestant, Baptist, Episcopalian, Lutheran, Methodist, Presbyterian, Roman Catholic, Jewish, other religion and no religion. The frequency with which religious services were attended will be described by a group of six indicator variables corresponding to the categories of no attendance, infrequent attendance, attends about once per month, attends two to three times per month, attends about once per week and attends more than once per week.

In many cases, individuals were asked about experimentation with a given recreational drug in multiple survey years. In order to use all of the available data, each unique combination of individual and survey year with questions about experimentation with recreational drugs is a potential observation in this analysis. In many cases, this will result in multiple observations corresponding to a single individual.

Such observations are not independent of one another. For example, if a



participant has used a recreational drug by a given survey year, they must also have used that drug by each subsequent survey year. Researchers commonly use Cox hazard models in such circumstances, but that is not possible here because in most cases it is not known when drug use was initiated. Instead, all relevant observations will be used in estimating maximum likelihood probit models. The lack of independence will be accounted for through the use of robust standard errors, with clustering at the individual level.

The figures above suggest that the relationship between IQ and experimentation with recreational drugs is not monotonic. In order to allow for this, coefficients will be estimated for empirical equations of the following form:

$$\Pr(\text{experimented}_{i,y}) = \Phi(\beta_0 + \beta_{IQ}IQ_i + \beta_{IQ^2}IQ_i^2 + \vec{\beta}\vec{X}'_{i,y})$$

The expression  $\Pr(\text{experimented}_{i,y})$  denotes the probability that individual  $i$  has experimented with a given recreational drug by survey year  $y$ . The function  $\Phi(\cdot)$  denotes the cumulative standard normal distribution. The vector  $\vec{X}_{i,y}$  contains the variables other than  $IQ$  that are described in Table 2-1 and the note that accompanies it.

If the desire for novel experiences is an important motivation for experimentation with recreational drugs and if intelligence is positively related to the value placed on novelty then one might expect that, on average, intelligence will be positively related to the probability of experimentation with a given recreational drug. The average relationship between IQ and the probability of having experimented with a given recreational drug is the average value of  $\frac{\partial \Pr(\text{experimented}_{i,y})}{\partial IQ_i}$ . This is sometimes referred to as the “average marginal effect.”

All statistical analyses were conducted using Stata 11.

## Results

Table 2-2 reports coefficients from probit regressions predicting the probabilities of experimentation with alcohol, cigarettes, marijuana, cocaine, pain killers, stimulants, hallucinogens, tranquilizers, sedatives and inhalants.

The results presented in Table 2-2 can be used to explore the possibility that the relationship between intelligence and experimentation with recreational drugs is not monotonic. The negative coefficients on  $IQ_i^2$  indicate that as IQ increases the relationship between IQ and the probability of having experimented with a recreational drug becomes less positive for all the recreational drugs examined here except inhalants, where the hypothesis of linearity cannot be rejected. With the exception of inhalants, the predicted relationship between intelligence and the probability of having experimented with a given recreational drug is negative at the highest levels of IQ observed in the data.

In Figures 2-1 through 2-10, it appears that, on average, the probability of having experimented with recreational drugs is increasing with intelligence. Table 2-3 reports the average derivatives of the predicted probabilities of past experimentation with respect to IQ. The results presented in Table 2-3 demonstrate that the pattern observed in Figures 2-1 through 2-10 is preserved after accounting for a wide range of personal characteristics.

Table 2-2  
Selected Coefficients from Probit Models Predicting Past Experimentation with Recreational Drugs

Variables	Alcohol	Cigarettes	Marijuana	Cocaine	Pain Killers	Stimulants	Hallucinogens	Tranquilizers	Sedatives	Inhalants
$IQ_i$	0.1189*** (0.0129)	0.0836*** (0.0123)	0.1202*** (0.0093)	0.0796*** (0.0102)	0.0796*** (0.0104)	0.1053*** (0.0141)	0.1074*** (0.0169)	0.0758*** (0.0150)	0.0495*** (0.0137)	0.0092 (0.0179)
$IQ_i^2$	-0.0005*** (0.0001)	-0.0004*** (0.0001)	-0.0005*** (0.0000)	-0.0003*** (0.0001)	-0.0004*** (0.0001)	-0.0004*** (0.0001)	-0.0004*** (0.0001)	-0.0003*** (0.0001)	-0.0002*** (0.0001)	0.0000 (0.0001)
$highest\ grade\ completed_{i,y}$	-0.0161 (0.0100)	-0.1016*** (0.0102)	-0.0546*** (0.0059)	-0.0493*** (0.0063)	-0.0403*** (0.0063)	-0.0554*** (0.0080)	-0.0461*** (0.0092)	-0.0456*** (0.0088)	-0.0432*** (0.0085)	-0.0250** (0.0119)
$age_{i,y}$	0.0369*** (0.0033)	0.0634*** (0.0074)	0.0056*** (0.0013)	0.0267*** (0.0014)	0.0028 (0.0031)	0.0039 (0.0037)	0.0211*** (0.0042)	0.0071* (0.0041)	0.0191*** (0.0041)	0.0181*** (0.0054)
$married_{i,y}$	-0.0590* (0.0311)	-0.0714** (0.0339)	-0.1405*** (0.0189)	-0.2590*** (0.0205)	-0.1442*** (0.0261)	-0.1245*** (0.0330)	-0.1926*** (0.0380)	-0.2339*** (0.0362)	-0.2415*** (0.0358)	-0.2193*** (0.0478)
$male_i$	0.2871*** (0.0341)	0.1289*** (0.0296)	0.2852*** (0.0224)	0.2944*** (0.0235)	0.0897*** (0.0239)	0.1088*** (0.0305)	0.3070*** (0.0354)	0.0514 (0.0337)	0.0631* (0.0329)	0.2167*** (0.0441)
$Rotter\ Locus\ of\ Control\ Scale_i$	0.006 (0.0073)	0.0071 (0.0066)	0.002 (0.0049)	-0.0018 (0.0052)	0.0019 (0.0053)	0.0062 (0.0068)	0.0084 (0.0075)	-0.0001 (0.0074)	-0.0021 (0.0072)	-0.0068 (0.0097)
$Rosenberg\ Self-Esteem\ Scale_i$	0.0093** (0.0045)	-0.0113*** (0.0041)	-0.0046 (0.0030)	-0.0098*** (0.0031)	-0.0044 (0.0032)	-0.0135*** (0.0041)	-0.0064 (0.0046)	-0.0075* (0.0044)	-0.0117*** (0.0045)	-0.0103* (0.0061)
Observations	68915	10623	43415	43344	23638	23621	23627	23630	23625	23612
Individuals	11046	10623	10938	10942	8475	8476	8475	8476	8476	8476

Notes: Table 2-2 reports coefficients from a maximum likelihood probit model estimated using data from the National Longitudinal Survey of Youth 1979. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the individual level. Subscripts denote the dimensions with which variables vary. The subscript  $i$  indicates individuals and the subscript  $y$  indicates survey year. Additional variables that were included in the model were income and family size as well as indicator variables for white, black, Hispanic, urban residence, region of residence, religious affiliation and the frequency with which religious services were attended. Region of residence was described using indicator variables for residence in the northeastern, north central and southern regions of the United States, with the category of western region omitted. Religious affiliation was described by a group of nine indicator variables corresponding to the categories of general protestant, Baptist, Episcopalian, Lutheran, Methodist, Presbyterian, Roman Catholic, Jewish or other religion, with the category of no religion omitted. The frequency with which religious services were attended was described by a group of five indicator variables corresponding to the categories of infrequent attendance, attends about once per month, attends two to three times per month, attends about once per week and attends more than once per week, with the category of no attendance omitted.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

Table 2-3  
Average Marginal Effects of IQ on Probabilities of Past Experimentation

<u>Drugs</u>	<u>Average Marginal Effects</u>
Alcohol	0.0022*** (0.0002)
Cigarettes	0.0004 (0.0004)
Marijuana	0.0048*** (0.0004)
Cocaine	0.0035*** (0.0003)
Pain Killers	0.0015*** (0.0003)
Stimulants	0.0031*** (0.0003)
Hallucinogens	0.0027*** (0.0003)
Tranquilizers	0.0015*** (0.0002)
Sedatives	0.0013*** (0.0002)
Inhalants	0.0009*** (0.0002)

Notes: Table 2-3 reports average marginal effects calculated using maximum likelihood probit models and data from the National Longitudinal Survey of Youth 1979. Average marginal effects and standard errors were calculated using the results described in Table 2-2 and the accompanying notes. Delta method standard errors appear in parentheses; covariates were treated as fixed in calculating the standard errors.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

As can be seen from Table 2-3, the average relationship between intelligence and the probability of having experimented is positive for each of the ten types of recreational drugs that NLSY79 participants most commonly reported having used. The relationship is statistically significant at the one percent level for every recreational drug except cigarettes.

Differences in intelligence are associated with large differences in the probabilities of having used recreational drugs. Table 2-4 is presented to provide a sense of the size of these differences. In the first column of Table 2-4, the marginal effects reported in Table 2-3 are multiplied by a one standard deviation change in IQ.

In the second column of Table 2-4, the percentages of observations in which participants reported having used the recreational drugs are reported. In the third column of Table 2-4, the approximate percentage changes in the probabilities of having used the recreational drugs are reported.

The change in the probability of having experimented with a given recreational drug associated with a one standard deviation increase in IQ ranges from a low of an increase of less one percent relative to the mean for cigarettes to a high of an increase of about 44% relative to the mean for hallucinogens.

One potential concern with these results is that past college attendance may be related to both intelligence and the probability of having experimented with recreational drugs. Although years of education completed is controlled for in the analysis presented here, the inclusion of this variable may be inadequate to isolate the relationship between intelligence and the probability of having experimented with recreational drugs. In order to address this concern, the statistical analysis described above was performed separately for those individuals who had completed fewer than twelve years of education by 2006, the most recent year for which data were available. Similar results were obtained. The similarity of the results suggests that differences in college attendance are not driving the observed patterns of behavior.

Table 2-4  
 Approximate Changes in the Probabilities of Past Experimentation with Recreational  
 Drugs Associated with a One Standard Deviation Increase in IQ

<u>Drugs</u>	<u>Percentage Point Change in Probability</u>	<u>Percent Having Experimented</u>	<u>Percentage Change in Probability</u>
Alcohol	3.30	94.29	3.50
Cigarettes	0.60	81.38	0.74
Marijuana	7.20	61.53	11.70
Cocaine	5.25	23.30	22.53
Pain Killers	2.25	18.72	12.02
Stimulants	4.65	12.24	37.99
Hallucinogens	4.05	9.24	43.83
Tranquilizers	2.25	7.51	29.96
Sedatives	1.95	7.35	26.53
Inhalants	1.35	3.10	43.55

Notes: Values listed in the column headed "Percentage Point Change in Probability" were calculated by multiplying the average marginal effects presented in Table 2-3 by one standard deviation of IQ, which is equal to 15 IQ points. Values listed in the column headed "Percent Having Experimented" were taken from Table 2-1. Values listed in the column headed "Percentage Change in Probability" were calculated by dividing the values in the column headed "Percentage Point Change in Probability" by the values in column headed "Percent Having Experimented."

Note that the term "average marginal effect" is used here as a term of art. No claim is being made regarding causality. Because intelligence has not been defined in terms of any particular ability, any outcome or ability could in principal reflect differences in intelligence. As a result, it is not clear how one would define the appropriate counterfactual to use in measuring the effects of differences in intelligence on experimentation with recreational drugs.

### Discussion

It was hypothesized that more intelligent people would be more likely to experiment with recreational drugs because more intelligent people tend to value novel experiences more highly. The results presented above indicate that the relationship between intelligence and the probability of having experimented with recreational drugs is positive, as predicted. It need not be the case that the positive relationship documented here is driven entirely by differences in the desire for novel experiences,

however. Other differences could be contributing to the relationship as well.

For example, many of the drugs studied here cannot be purchased legally for recreational use. It may simply be that more intelligent people tend to be more successful at overcoming obstacles to attaining these drugs.

Another possibility is that more intelligent people are more likely to experiment with recreational drugs because they are less concerned about the difficulties associated with addiction. More intelligent people tend to be more successful at self-control (Dempster, 1991; Evdokimidis et al., 2002; Heitz et al., 2005; Salthouse et al., 2003; Schmeichel et al., 2003; Shoda et al., 1990; Friedman et al. (2006) reported mixed results) and so they may be more successful at restricting their consumption of addictive goods (Wilmoth, 2010). If more intelligent people anticipate that they will be more successful at restricting their consumption of addictive goods, it could cause them to be more likely to experiment with recreational drugs.

A third possibility is that the positive relationship between intelligence and experimentation with recreational drugs arises because more intelligent people have better information about the health risks association with recreational drug use. Viscusi (1990) reported evidence that people commonly overestimate the health risks associated with smoking. If that is the case, those with better information will tend to have lower estimates of the health risks and may therefore be more likely to experiment with cigarettes. Note, however, that cigarettes are the recreational drug for which the relationship between intelligence and experimentation was the least positive.

The apparent absence of a monotonic relationship between intelligence experimentation with recreational drugs was unexpected. The patterns observed in the figures and the statistical analysis suggest that the relationship between IQ and

experimentation with recreational drugs is negative at the highest levels of IQ.

One possible reason for the lack of a monotonic relationship is that the relationship between intelligence and the value placed on novelty is not monotonic. Studies of the relationship between intelligence and the value placed on novelty have not generally provided enough information to evaluate this possibility.

A second possible reason for the negative relationship at the highest levels of IQ is homophily. People tend to associate with others who are similar to themselves in dimensions such as race, age, and education; this pattern holds for intelligence as well (McPherson et al., 2001). There may be some social component to the consumption of recreational drugs; indeed, many drugs may be available only through social networks. High levels of intelligence are unusual and may therefore be socially isolating (Plucker and Levy, 2001; Winner, 2000). This may limit access to recreational drugs among those with high levels of intelligence.

A third possibility is that intelligence is positively related to traits that decrease the probability of experimentation with recreational drugs. For example, more intelligent people tend to discount the future less (Benjamin et al., 2006; Dohmen et al., 2007; Shamosh and Gray (2008) performed a meta-analysis of 24 studies). It may be that over some ranges of IQ scores differences in the value of novelty are dominant while over other ranges differences in these other traits are more important.

Although some researchers have found evidence of a negative relationship between intelligence and alcohol abuse, it was observed in these data that more intelligent people are more likely to have consumed alcohol. Similarly, although several researchers have found evidence of a strong negative relationship between intelligence and the probability of smoking, no negative relationship between intelligence and the probability of having used cigarettes was found here. These results suggest that, conditional on having tried alcohol, more intelligence people are



less likely to abuse alcohol later in life. Similarly, it appears that, conditional on having tried cigarettes, more intelligent people are less likely to be smokers. It may be that once the novelty of using these recreational drugs has worn away differences other than differences in the value placed on novelty begin to drive the patterns of behavior observed. Such differences could include differences in information, differences in success at self-control or differences in discounting of the future.

The positive association between intelligence and experimentation with recreational drugs may have some policy implications. Each year the federal government spends over a billion dollars on preventing the initiation of recreational drug use (Office of National Drug Control Policy, 2009). For policymakers interested in discouraging experimentation with recreational drugs, information about which individuals are more likely to engage in such experimentation may be useful.

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## CHAPTER 3

### INTELLIGENCE AND THE CHOICE TO CONSUME A LARGE AMOUNT OF ALCOHOL

#### Introduction

Scores on tests of different types of reasoning or knowledge are often highly correlated with one another (Neisser et al., 1996). It is assumed here that these positive correlations arise because such scores reflect a single personal characteristic that will be referred to as intelligence. This is sometimes called the “psychometric” definition of intelligence.

Note that intelligence has not been defined in terms of inherent ability (cf. Auld and Sidhu, 2005). A variety of evidence indicates that genes interact with the environment to determine outcomes in such a way that the ordering of outcomes may not be preserved across different environments (Bakermans-Kranenburg et al., 2008; Bakermans-Kranenburg et al., 2008; Belsky et al., 2007; Ellis and Boyce, 2008; Caspi et al., 2007; Heckman, 2008). As a result, it may not be possible to rank people by inherent ability.

Intelligence as defined here is correlated with many important life outcomes, including health, education, poverty, crime and marriage (Auld and Sidhu, 2005; Gottfredson, 1997, 2004; Herrnstein and Murray, 1994). Gottfredson (2004) and Batty et al. (2006) argued that the positive relationship between intelligence and health is due in part to a negative relationship between intelligence and alcohol abuse.

Studies of the relationship between intelligence and heavy alcohol consumption have generated apparently conflicting results, however, with reports of a positive, a negative and a null relationship (Batty et al., 2006; Batty et al., 2008; Clark

and Haughton, 1975; Hatch et al., 2007; Kubicka et al., 2001; Mortensen et al., 2005; Sander, 1999; Wennberg et al., 2002). The scholarly literature provides some clues as to how these apparently conflicting results arose.

More intelligent people value novelty more highly (Fagan, 1984; Raine et al., 2002; Zuckerman, 1994). Those who place a higher value on novel sensations are more likely to experiment with recreational drugs and alcohol (Zuckerman, 1994). This could lead to a positive relationship between intelligence and heavy alcohol consumption when people are young.

More intelligent people tend to be more successful at self-control (Dempster, 1991; Evdokimidis et al., 2002; Heitz et al., 2005; Salthouse et al., 2003). Alcohol is an addictive substance (Goldstein, 2001; Robinson and Berridge, 1993) and restricting alcohol consumption may therefore require self-control (Bechara, 2005; Robinson and Berridge, 1993). As people become older, they tend to restrict their alcohol consumption (Karlman et al., 2006). If more intelligent people are more successful at restricting their alcohol consumption, then the relationship between intelligence and heavy alcohol consumption may become more negative with age.

An analysis of data from the National Longitudinal Survey of Youth 1979 (NLSY79) shows that the sign of the relationship between intelligence and the probability of heavy alcohol consumption changes from positive to negative with age. Evidence from the National Health Interview Survey is presented that suggests that this change is not a result of changes in information about the health risks associated with heavy alcohol consumption.

The NLSY79 is used to further explore the nature of the relationship between intelligence and heavy alcohol consumption. It is shown that more intelligent people are less likely to have never consumed an alcoholic beverage, which is consistent with the hypothesis that the relationship is positive when people are young because of



differences in experimentation with alcohol. It is also shown that more intelligent people are less likely to report having failed in an attempt to restrict alcohol consumption, which is consistent with the hypothesis that the relationship becomes negative when people are older because more intelligent people are more successful at self-control.

This analysis has implications for economic theory. Over the last several decades, a number of economists have argued that the standard theoretical framework is incomplete because it fails to account for the difficulties associated with self-control (Benhabib and Bisin, 2005; Bernheim and Rangel, 2004; Fudenberg and Levine, 2006; Gul and Pesendorfer, 2001, 2007; Lowenstein and O'Donoghue, 2007; Ozdenoren et al, 2008; Thaler and Shefrin, 1981). This study builds on that work and demonstrates empirically that alternative models can provide new insights into important behaviors.

Health and the other life outcomes mentioned above are of obvious interest to policymakers. In order to design policies that will improve welfare, it is helpful to understand the decision processes that influence those life outcomes. The results presented here provide some insight into those decision processes and therefore have important policy implications.

The remainder of this paper is organized as follows. The first section reviews the literature on intelligence and heavy alcohol consumption. The second section presents a simple model of impulse control and uses that model as a basis for exploring how the relationship between intelligence and heavy alcohol consumption may change with age. The third section describes the data that will be analyzed in this paper. The fourth section presents an empirical analysis of the relationship between intelligence and heavy alcohol consumption. The fifth section discusses some limitations of the theoretical and empirical analyses. The sixth section discusses the implications of the results presented here.

## Intelligence and Heavy Alcohol Consumption

This section is divided into four subsections. The first subsection reviews the literature on alcohol abuse and intelligence. The second subsection discusses a kind of task studied by psychologists that may be a useful model for efforts to resist cravings. The third subsection discusses why intelligence may be related to success at self-control. The fourth subsection discusses why failures of self-control may occur.

### *Intelligence and Heavy Alcohol Consumption*

Alcohol abuse is the third leading cause of premature deaths in the United States. Mokdad et al. (2004) calculated that each year about 85,000 people die as a result of alcohol abuse; this is about 3.5% of total annual deaths in the United States. Average annual expenditures on health care attributable to alcohol abuse total about \$19 billion (Harwood, 2000). About \$1.4 billion are spent on alcohol abuse prevention each year, with the majority of that spent by the federal government (Harwood et al., 1998; Harwood, 2000).

Government spending on alcohol abuse prevention suggests that the health and financial costs described above are of interest to policymakers. A sound understanding of the decision processes related to alcohol abuse is helpful for designing effective policies. It will be argued here that an analysis of the relationship between intelligence and heavy alcohol consumption can provide some insight into those decision processes.

Estimates of the relationship between intelligence and heavy alcohol consumption vary widely. Researchers have reported a positive (Batty et al., 2008; Hatch et al., 2007), a negative (Batty et al., 2006; Clark and Haughton, 1975; Sander, 1999) and a null (Kubicka et al., 2001; Mortensen et al., 2005; Wennberg et al., 2002) relationship. One possible explanation for these disparate findings is that the

relationship between intelligence and heavy alcohol consumption varies with age. Previous studies have tended to find a positive relationship among younger people and a negative relationship among older people (Batty et al., 2006; Batty et al., 2008; Clark and Haughton, 1975; Sander, 1999).

Some results from the scholarly literature may provide clues as to why the relationship is positive when people are young. Those who place a higher value on novel sensations are more likely to experiment with recreational drugs and alcohol as adolescents and young adults (Zuckerman, 1994). More intelligent people tend to value novelty more highly (Fagan, 1984; Raine et al., 2002; Zuckerman, 1994). Therefore the positive initial relationship between intelligence and heavy alcohol consumption may be driven by differences in experimentation with alcohol (Wilmoth, 2010).

As people become older, they tend to restrict their alcohol consumption (Karlman et al., 2006). If more intelligent people are more successful at restricting their alcohol consumption, this could cause the relationship between intelligence and heavy alcohol consumption to become negative. The next two subsections summarize several studies that suggest a possible relationship between intelligence and success at restricting alcohol consumption.

### *Addiction and Impulse Control*

One key aspect of addiction is that environmental cues can trigger cravings in addicts (Gardner and David, 1999; Goldstein, 2001; Robinson and Berridge, 1993). Such cravings can lead to relapse in those addicts who are trying to quit (Niaura et al., 1988).

Cravings may not simply be changes in the utility of consumption (cf. Laibson, 2001). Rather, Robinson and Berridge (1993) and Berridge and Robinson (2003)

argued that addictive substances change the brain in a way that decouples the motivation to consume that substance from the pleasure of consumption. They wrote, “The neural system responsible for ‘wanting’ incentives is proposed to be separable from those responsible for ‘liking’ incentives (i.e., for mediating pleasure) and repeated drug use only sensitizes the neural system responsible for ‘wanting.’ Because of this, addictive behavior is fundamentally a problem of sensitization-induced excessive ‘wanting’ alone” (Robinson and Berridge, 1993, p. 249).

A kind of task widely studied by psychologists may serve as a useful model for efforts to resist cravings. In this kind of task, study participants are exposed to a stimulus to which there is a natural, automatic or “prepotent” response and they are asked to deviate from that response. Such tasks will be referred to here as impulse control tasks. The next subsection reviews several studies that would lead one to expect more intelligent people to be more successful at impulse control tasks.

### *Mental Resources*

Higher mental functions, including those related to reasoning and impulse control, seem to call on a common set of limited mental resources (Baddeley, 2007; Baumeister and Vohs, 2003; Halford et al., 2007; Heitz et al., 2005; Norman and Shallice, 1986). Results in the scholarly literature indicate that more intelligent people tend to have higher levels of those resources available to them.

It will be assumed here that there are two limited mental resources, attention and willpower. This two-resource framework resembles that used by Lowenstein and O’Donoghue (2007).

The first resource, attention, is assumed to be limited in scope (Baddeley, 2007; Cowan, 2001; Norman and Shallice, 1986). This limitation results in a decrement in performance when multiple tasks requiring attention are performed

simultaneously. Cowan (2001) reviewed evidence concerning a biological basis for limited scope of attention.

The second resource, willpower, is assumed to be limited and depletable in the short run (Baumeister et al., 2007). A number of studies have demonstrated that performing one task that requires resisting impulses affects performance on a subsequent task that also requires resisting impulses (Baumeister and Vohs, 2003; Muraven and Baumeister, 2000). Gailliot et al. (2007) presented evidence concerning a biological basis for depletable willpower.

Muraven and Slessareva (2003) showed that a high enough monetary compensation for performing a task requiring the expenditure of willpower can eliminate differences in performance between those who have previously expended willpower and those who have not. This indicates that the disutility associated with expending willpower is higher when willpower is depleted and that decision makers weigh the utility from consuming goods against the disutility from expending willpower.

If resisting cravings requires the expenditure of the same limited mental resources that are involved in performing impulse control tasks, one would expect abstaining to cause addicts to do worse on a concurrent task that involves resisting impulses. Pettiford et al. (2007) reported that abstaining from smoking caused smokers to do worse on such a task. This suggests that impulse control tasks can serve as a good model for efforts to resist cravings.

Intelligence scores are positively related to performance on a variety of tasks involving higher mental functions (Conway et al., 2003; Cowan et al., 2006; Duncan et al., 1996; Heitz et al., 2005; Stankov, 1983), suggesting that more intelligent people tend to have higher levels of mental resources available to them. Cowan et al. (2006) measured intelligence, scope of attention and performance on a task requiring

willpower. A multiple regression analysis indicated that more intelligent people tend to have higher levels of both attention and willpower. If more intelligent people have higher levels of those mental resources available to them, they may be more successful at impulse control tasks. The next subsection discusses why people fail at impulse control tasks and the implications of such failures for economic models of choice.

### *Why People Fail*

Heitz et al. (2005) argued that errors in an impulse control task can arise when participants fail to continuously attend the goal of the task. Continuous control of attention requires the expenditure of willpower (Muraven and Baumeister, 2000). In vigilance tasks, participants must continuously control their attention in order to detect a brief signal. As performance of a vigilance task is prolonged and willpower is depleted, the probability of detecting a signal typically falls (See et al., 1995). It was argued above that expending willpower is more costly when willpower has been previously depleted. The decrease in accuracy as performance of a vigilance task is prolonged therefore suggests that there is a tradeoff between the disutility incurred through the expenditure of mental resources and the consistency with which attention is controlled.

Sporadic lapses in attention to goals are inconsistent with most economic models of choice because they imply that no single preference ordering or objective function can completely describe behavior. Even in models in which self-control is costly, it is typically assumed that decision makers continuously attend their goals (Fudenberg and Levine, 2006; Gul and Pesendorfer, 2001, 2007; Lowenstein and O'Donoghue, 2007; Ozdenoren et al., 2008; Thaler and Shefrin, 1981).

In contrast, Benhabib and Bisin (2005) recognized the costliness of continuous attention to goals. They wrote “[c]ognitive control might fail, as controlled processes

fail to inhibit automatic reactions, because actively maintaining the representation of a goal is costly, due to the severe biological limitations of the activation capacity of the supervisory attention system of the cortex” (p. 464). They presented a savings model in which consumers can, at a fixed cost, attend their savings goal. Whenever the expected loss in utility from acting impulsively would be larger than the fixed cost of attending their goal, consumers attend their goal and exercise complete control over their behavior.

A different model that is also consistent with lapses in attention to goals was proposed by Bernheim and Rangel (2004). In their model, addicts may sometimes use the substance to which they are addicted regardless of the goals they hold. In contrast with the model proposed by Benhabib and Bisin, however, Bernheim and Rangel did not explicitly incorporate internal resources for self-control.

The following section presents a model of impulse control that builds on the frameworks developed by Benhabib and Bisin and by Bernheim and Rangel by allowing a tradeoff between the disutility incurred through generating self-control and the consistency with which goals are attended. This model, together with the literature reviewed above, suggests that intelligence is positively related to success at resisting impulses.

### A Theoretical Model of Impulse Control and Addiction

This section presents a theoretical model of how the relationship between intelligence and heavy alcohol consumption changes with age. In developing a model of that relationship, it is helpful to first develop a formal model of impulse control and to use that model of impulse control as a basis for analyzing attempts by addicts to break their addictions.

This section is divided into three subsections. The first subsection contains a

simple formalization of the conceptual framework developed above and uses that model to analyze the relationship between intelligence and impulse control. The second subsection analyzes a simple model of attempts by addicts to break their addictions. The third subsection presents a model of how the relationship between intelligence and heavy alcohol consumption changes with age.

### *Impulse Control*

Suppose that a decision maker selects from a set of consumption options  $X$ . If the decision maker acts impulsively, they will select option  $x_m \in X$ . If the decision maker acts deliberately, they will choose option  $x_d \in X$ . Assume  $x_d \neq x_m$ . The probability of selecting the impulsive option is determined by the level of self-control generated by the decision maker,  $s \in \mathbb{R}_+$ .

Let  $P(s)$  denote the probability of selecting the impulsive option. Assume that  $P(s)$  is twice differentiable, with  $\frac{dP(s)}{ds} \leq 0$  and  $\frac{d^2P(s)}{ds^2} \geq 0$ . In other words, higher levels of self-control decrease the probability of selecting the impulsive option and the marginal effect of additional self-control is decreasing. The probability  $P(s)$  reflects any behavioral and cognitive strategies employed; such strategies may require self-control to implement (Eigsti et al., 2006).

The decision maker is an expected utility maximizer with preferences over  $X$  and the amount of self-control generated. Let the variable  $i \in \mathbb{R}$  index the mental resources available. Assume preferences can be represented by a utility function that is additively separable in consumption and self-control generated,  $u(x, s; i) = u_x(x) - u_s(s; i)$ . Assume the deliberately chosen option yields higher utility from consumption,  $u_x(x_d) > u_x(x_m)$ . Let  $u_s(s; i)$  be twice differentiable, with  $\frac{\partial u_s(s; i)}{\partial s} > 0$  and  $\frac{\partial^2 u_s(s; i)}{\partial s^2} > 0$ . This is consistent with the literature reviewed above.



Generating self-control requires the use of resources that are valuable and limited, and the disutility from using these resources to generate self-control becomes higher as the resources are exhausted. Let  $\bar{s}(i)$  denote the maximum amount of self-control that can be generated given the level of resources available.

The decision maker solves the maximization problem

$$\max_{s \in [0, \bar{s}]} P(s)u_x(x_m) + (1 - P(s))u_x(x_d) - u_s(s; i)$$

This problem has a unique solution,  $s^*$ . An interior solution is characterized by the first order condition

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$$\frac{dP(s^*)}{ds}(u_x(x_m) - u_x(x_d)) = \frac{\partial u_s(s^*; i)}{\partial s}$$

The decision maker will choose a level of self-control such that the marginal expected benefit from reducing the probability of acting impulsively is equal to the marginal cost of generating additional self-control.

For those with fewer mental resources available, the disutility associated with using those resources to generate self-control is assumed to be higher. This implies that  $\frac{\partial u_s(s; i)}{\partial i} \leq 0$  and  $\frac{\partial^2 u_s(s; i)}{\partial i \partial s} < 0$ . These assumptions are consistent with the literature reviewed above and analogous to the assumption that  $\frac{\partial^2 u_s(s; i)}{\partial s^2} > 0$ .

Laboratory experiments have demonstrated that decreasing the attention or willpower available to an individual results in worse performance on tasks requiring self-control. It is assumed here that a similar relationship holds for differences between individuals.

It follows from the first order condition and the assumptions on  $u_s(s; i)$  and  $P(s)$  that, for an interior solution,  $P(s^*)$  is strictly decreasing in  $i$ . For those with

more mental resources available, the equilibrium probability of acting impulsively is lower.

If intelligence is positively related to both attention and willpower, one would therefore expect more intelligent people to be more successful at impulse control tasks. A variety of evidence indicates that this is the case (Dempster, 1991; Evdokimidis et al., 2002; Heitz et al., 2005; Salthouse et al., 2003; Schmeichel et al., 2003; Shoda et al., 1990; Friedman et al. (2006) report mixed results). In fact, the relationship is strong enough that, in an early review of a relevant literature, Dempster (1991) wrote, “[the evidence] is sufficiently provocative to suggest that inhibitory processes are a neglected, but critically important, dimension of intelligence” (p. 167).

As with most economic models of choice, this model is intended primarily to take on an “as if” interpretation (Friedman, 1953). The actual decision-making process may be much more complicated than what has been described here and may not be entirely conscious. The choice described above is proposed as a model of this process in the sense that the behavior this model predicts approximates the behavior generated by the actual decision-making process, so that decision makers act as if they were making the choice described here.

The next subsection uses this model of impulse control as a basis for a model of attempts by addicts to quit using the substance to which they are addicted.

### *Intelligence, Addiction and Quitting*

Successfully resisting impulses to use an addictive good may desensitize addicts to the cues that trigger those impulses (Goldstein, 2001; Niaura et al., 1988). Those who have desensitized themselves will be said to have broken their addictions.

Given that resisting impulses is less costly for those with more mental resources, one might expect those with more mental resources to be more likely to

succeed in breaking their addictions. The assumptions that have been made so far are not sufficient to imply this, however, because differences in mental resources will affect both the marginal cost and the marginal benefit of generating self-control. This subsection describes a model that illustrates why the assumptions made so far are insufficient to imply that those with more mental resources will be more likely to succeed in breaking their addictions.

Suppose that an addict would prefer not to use the good to which they are addicted and they must generate self-control in order to abstain. Suppose that if the addict uses the good to which they are addicted in a given period they will continue to be an addict in the subsequent period. If they abstain, however, then they will break their addiction and will no longer need to generate self-control to avoid using the good to which they were addicted.

Assume an addict lives for an infinite number of periods. Let the function  $u(x, s; i) = u_x(x) - u_s(s; i)$  described in the previous subsection represent single-period utility and let  $P(s)$  represent the probability that an addict fails to abstain. Assume the decision maker has a discount factor  $\beta$ . Let  $V(a, i)$  be the expected utility of a decision maker with addiction level  $a \in \{0, 1\}$ , where  $a = 1$  indicates that the decision maker is addicted. For clarity, the impulsive option will be denoted by  $x = use$  and the deliberate option by  $x = abstain$ . Consider the recursive formulation of the decision maker's problem.  $V(1, i)$  is equal to

$$\max_{s \in [0, \bar{s}]} [P(s)u_x(use) + (1 - P(s))u_x(abstain) - u_s(s; i) + \beta(P(s)V(1, i) + (1 - P(s))V(0, i))]$$

and  $V(0, i)$  is equal to

$$u_x(abstain) + \beta V(0, i) = \frac{u_x(abstain)}{1 - \beta}.$$

The addict's problem has a unique solution,  $s^*$ . Using the first order condition and the implicit function theorem, it can be shown that at an interior solution  $s^*$  will be increasing in  $i$  if and only if  $-\frac{\partial^2 u_s(s^*; i)}{\partial i \partial s} > \frac{dP(s^*)}{ds} \frac{\beta}{1 - \beta P(s^*)} \left( \frac{\partial u_s(s^*; i)}{\partial i} \right)$ .

By the first order condition, at an interior solution

$$\frac{dP(s^*)}{ds} (u_x(\text{use}) - u_x(\text{abstain})) - \frac{\partial u_s(s^*; \bar{v})}{\partial s} + \beta \frac{dP(s^*)}{ds} (V(1, \bar{v}) - \frac{u_x(\text{abstain})}{1 - \beta}) = 0$$

By the implicit function theorem,  $\frac{\partial s^*(i)}{\partial i}$  is equal to

$$\frac{-\frac{\partial^2 u_s(s^*, \bar{v})}{\partial i \partial s} + \beta \frac{dP(s^*)}{ds} \frac{dV(1, \bar{v})}{di}}{\frac{d^2 P(s^*)}{ds^2} (u_x(\text{use}) - u_x(\text{abstain})) - \frac{\partial^2 u_s(s^*, \bar{v})}{\partial s^2} + \beta \frac{d^2 P(s^*)}{ds^2} (V(1, \bar{v}) - \frac{u_x(\text{abstain})}{1 - \beta})}$$

The denominator is negative, so the sign of  $\frac{\partial s^*(i)}{\partial i}$  is the sign of

$-\frac{\partial^2 u_s(s^*, \bar{v})}{\partial i \partial s} + \beta \frac{dP(s^*)}{ds} \frac{dV(1, \bar{v})}{di}$ . By the envelope theorem and the definition of  $V(1, \bar{v})$ ,  $\frac{dV(1, \bar{v})}{di} = \frac{\partial V(1, \bar{v})}{\partial i}$  and  $\frac{\partial V(1, \bar{v})}{\partial i} = -\frac{\partial u_s(s^*; \bar{v})}{\partial i} + \beta P(s^*) \frac{\partial V(1, \bar{v})}{\partial i}$ . The numerator is therefore equal to  $-\frac{\partial^2 u_s(s^*, \bar{v})}{\partial i \partial s} + \frac{dP(s^*)}{ds} \frac{\beta}{1 - \beta P(s^*)} \left( -\frac{\partial u_s(s^*; \bar{v})}{\partial i} \right)$ . Thus  $s^*$  is increasing in  $i$  if and only if  $-\frac{\partial^2 u_s(s^*, \bar{v})}{\partial i \partial s} > \frac{dP(s^*)}{ds} \frac{\beta}{1 - \beta P(s^*)} \left( \frac{\partial u_s(s^*; \bar{v})}{\partial i} \right)$ .

The term  $-\frac{\partial^2 u_s(s^*, \bar{v})}{\partial i \partial s}$  is the decrease in the marginal cost of generating self-control when  $i$  increases. The term  $\frac{dP(s^*)}{ds} \frac{\beta}{1 - \beta P(s^*)} \left( \frac{\partial u_s(s^*; \bar{v})}{\partial i} \right)$  is the decrease in the marginal benefit. In each period, if the addict succeeds in abstaining they will avoid the disutility associated with generating self-control in future periods. The

expected marginal benefit of generating self-control will therefore include the term  $\frac{dP(s^*)}{ds} \beta \sum_{t=0}^{\infty} \beta^t P(s^*)^t (-u_s(s^*; i)) = \frac{dP(s^*)}{ds} \frac{\beta}{1 - \beta P(s^*)} (-u_s(s^*; i))$ . When  $i$  increases, the decrease in the expected marginal benefit of generating self-control will therefore be  $\frac{dP(s^*)}{ds} \frac{\beta}{1 - \beta P(s^*)} \left( \frac{\partial u_s(s^*; i)}{\partial i} \right)$ .

While the assumptions made so far do not imply that those who are more successful at resisting impulses will be more successful at breaking their addictions, some evidence from the scholarly literature suggests that this is the case. Bechara (2005) reviewed a variety of evidence indicating that those who use addictive goods are generally less successful at resisting impulses and argued that this is at least in part because those who are more successful at resisting impulses are more successful at restricting their consumption of addictive goods.

More intelligent people are more successful at resisting impulses. Therefore one would expect more intelligent people to be more successful at breaking their addictions. The next subsection explores the implications this could have for how the relationship between intelligence and heavy alcohol consumption changes with age.

#### *Age, Intelligence and Heavy Alcohol Consumption*

If more intelligent people are both more likely to experiment with alcohol and more likely to succeed at breaking their addictions, then the sign of the relationship between intelligence and heavy alcohol consumption may change with age.

Assume that in each period the decision maker chooses between consuming a large amount of alcohol, denoted by  $x = heavy$ , and a more moderate amount of alcohol, denoted by  $x = restricted$ . If the decision maker is an addict, they will need to generate self-control in order to restrict their alcohol consumption. Suppose that if the decision maker consumes a large amount of alcohol in a given period they will be

an addict in the next period. If they restrict their consumption, however, then they will not be addicted in the next period and will no longer need to generate self-control in order to restrict their alcohol consumption.

Assume that the utility of consumption depends on the decision maker's type and consumption history. Denote utility from consumption by  $u_x(x; type, h)$ . Let the variable  $h \in \{0, 1\}$  take on a value of one if the decision maker has consumed a large amount of alcohol in the past and a value of zero otherwise. Assume there are three types of decision makers.

The first type of decision maker will be called a "chooser." Denote choosers by  $type = c$ . If the decision maker is a chooser, then  $u_x(heavy; c, h) > u_x(restricted; c, h)$  regardless of consumption history  $h$ . Such a decision maker will deliberately choose to consume a large amount of alcohol in every period.

The second type of decision maker will be called an "avoider." Denote avoiders by  $type = a$ . If the decision maker is an avoider, then  $u_x(restricted; a, h) > u_x(heavy; a, h)$  regardless of the consumption history  $h$ . Such a decision maker will never consume a large amount of alcohol.

The third type of decision maker will be called an "experimenter." Denote experimenters by  $type = e$ . If the decision maker is an experimenter, then the utility of consumption will depend on the decision maker's consumption history. Assume  $u_x(restricted; e, 1) > u_x(heavy; e, 1)$  so that if the decision maker has consumed a large amount of alcohol in the past they will prefer to restrict consumption.

Let the function  $V(1, i, e)$  denote the expected utility of an experimenter who has consumed a large amount of alcohol in the past and is addicted to alcohol.

Assume  $u_x(heavy; e, 0) + \beta V(1, i, e) > \frac{u_x(restricted; e, 0)}{1 - \beta}$ . Then the experimenter will

choose to consume a large amount of alcohol in the first period, when doing so

provides a novel experience, but will afterward attempt to restrict consumption.

Let  $P(c)$ ,  $P(a)$  and  $P(e)$  be the probabilities that a consumer is of each type and assume these probabilities are differentiable with respect to  $i$ . Consistent with the literature reviewed above, assume that the probability of being an experimenter is increasing in intelligence, so that  $\frac{\partial P(e)}{\partial i} > 0$ . Let  $P(s^*)$  be the probability that an experimenter who is addicted to alcohol succeeds in restricting their consumption in a given period. Assume  $s^*$  is an interior solution, which, together with the first order condition, implies  $0 < P(s^*) < 1$ . Consistent with the analysis above, assume that more intelligent people generate more self-control, so that  $\frac{\partial s^*(i)}{\partial i} > 0$ .

The probability that a decision maker consumes heavily in period  $t$  is given by  $P_{heavy}(t, i) = P(c) + P(e)P(s^*(i))^{t-1}$ . Differentiating  $P_{heavy}(t, i)$  with respect to  $i$  and rearranging yields the following equation.

$$\frac{\partial P_{heavy}(t, i)}{\partial i} = \frac{\partial P(c)}{\partial i} + P(s^*(i))^{t-2} \left( \frac{\partial P(e)}{\partial i} P(s^*(i)) + (t-1)P(e) \frac{\partial P(s^*(i))}{\partial s} \frac{\partial s^*(i)}{\partial i} \right)$$

In the initial period,  $\frac{\partial P_{heavy}(t, i)}{\partial i} = \frac{\partial P(c)}{\partial i} + \frac{\partial P(e)}{\partial i} > \frac{\partial P(c)}{\partial i}$ . Note that  $\frac{\partial P(e)}{\partial i} P(s^*(i))$  is positive and does not vary with  $t$  while  $(t-1)P(e) \frac{\partial P(s^*(i))}{\partial s} \frac{\partial s^*(i)}{\partial i}$  is negative and linear in  $t$ . Therefore  $\frac{\partial P_{heavy}(t, i)}{\partial i}$  will be initially decreasing in  $t$  and, for sufficiently large  $t$ ,  $\frac{\partial P_{heavy}(t, i)}{\partial i} < \frac{\partial P(c)}{\partial i}$ . Finally, note that  $\frac{\partial P_{heavy}(t, i)}{\partial i}$  converges to  $\frac{\partial P(c)}{\partial i}$ , so that while  $\frac{\partial P_{heavy}(t, i)}{\partial i}$  is initially decreasing in  $t$  it must also eventually increase in  $t$ . In this model, those with lower levels of mental resources available eventually succeed at breaking their addictions, but they typically succeed later.

The following figure shows how  $\frac{\partial P_{heavy}(t,i)}{\partial i}$  varies with  $t$  for some arbitrary values of  $P(e)$ ,  $\frac{\partial P(c)}{\partial i}$ ,  $\frac{\partial P(e)}{\partial i}$ ,  $P(s^*(i))$  and  $\frac{\partial P(s^*(i))}{\partial s} \frac{\partial s^*(i)}{\partial i}$ . Although time is discrete in the model,  $\frac{\partial P_{heavy}(t,i)}{\partial i}$  is drawn as a continuous function of  $t$  in Figure 3-1.

These theoretical results provide some insight into how the relationship between intelligence and heavy alcohol consumption may change with age. If  $\frac{\partial P(c)}{\partial i}$  is near zero, then one would expect a positive relationship between intelligence and heavy alcohol consumption at young ages. As people became older, one would expect the relationship between intelligence and heavy alcohol consumption to become negative. Finally, in the long run, one would expect to see only a weak relationship between intelligence and heavy alcohol consumption.

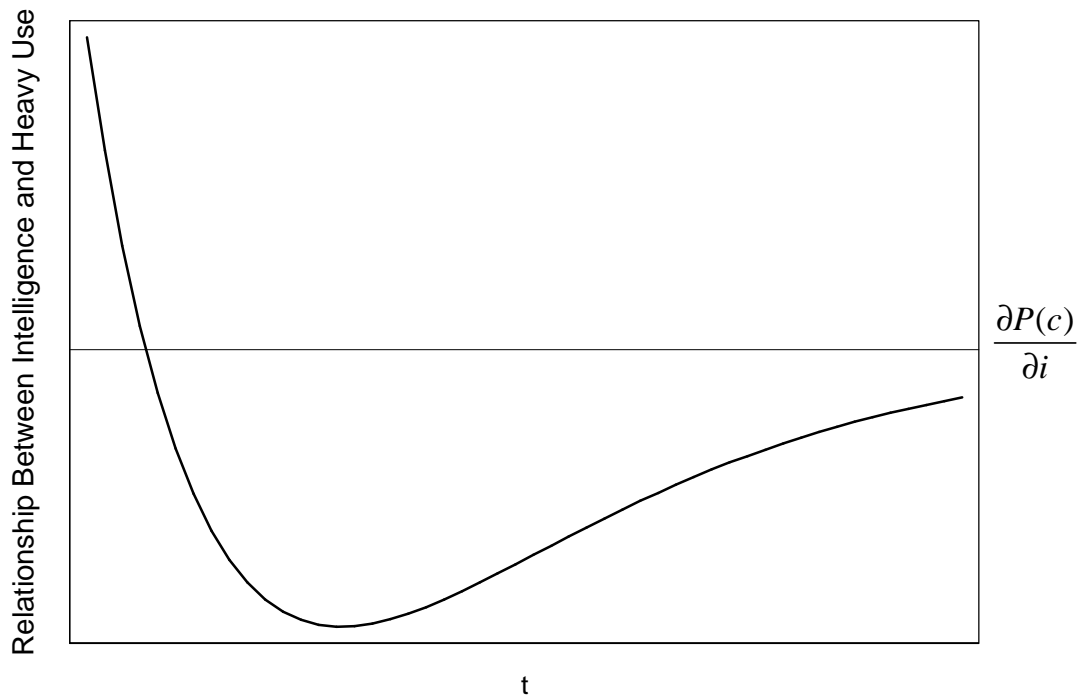


Figure 3-1

Predicted Changes in  $\frac{\partial P_{heavy}(t,i)}{\partial i}$  Over Time



These changes with age in the relationship between intelligence and heavy alcohol consumption could give rise to the mixed results previously reported. The next section describes the data that will be used to examine the relationship between age, intelligence and heavy alcohol consumption.

### Data and Methods

Two sources of data will be used here. The first is the National Longitudinal Survey of Youth 1979 (NLSY79), which provides measures of intelligence and alcohol consumption. The second is the National Health Interview Survey (NHIS), which provides measures of health knowledge.

The NLSY79 collected and continues to collect a wide range of data on a sample of 12,686 men and women who were between the ages of 14 and 22 when first interviewed in 1979. In 1980 the Armed Services Vocational Aptitude Battery (ASVAB) was administered to nearly all survey participants. Scores on four subtests can be used to calculate an Armed Forces Qualification Test (AFQT) score, which Hernnstein and Murray (1994) argued is an excellent measure of intelligence. Participants were asked about alcohol consumption in 1982, 1983, 1984, 1985, 1988, 1989, 1994, 2002 and 2006, although the questions asked varied widely across years.

In the analysis that follows, AFQT scores are calculated using the 1989 scoring scheme as described by Hernnstein and Murray (1994). For ease of interpretation, scores are then adjusted by birth cohort to have a mean of 100 and a standard deviation of 15, the typical scale for IQ scores.

AFQT scores are affected by differences in education at the time of testing (Hansen et al., 2004; Neal and Johnson, 1996; Winship and Korenman, 1997) and economists have sometimes adjusted AFQT scores to account for these differences (Auld and Sidhu, 2005). Given that intelligence has not been defined in terms of

inherent ability, there seems to be little justification for assuming that it is unaffected by differences in background, including differences in education. In none of the previous studies of the relationship between intelligence and heavy alcohol consumption that were described above was IQ adjusted for differences in background. The results reported here will be based on analyses in which IQ scores are not adjusted for differences in background. When adjustments were made using a method similar to that described by Auld and Sidhu (2005), qualitatively similar results were obtained.

In each survey year a wide variety of data were gathered, including information on income, education, family size, marital status, urban residence and region of residence. In years for which values for these control variables are missing, the most recent preceding value of that variable for that participant will be used. Based on answers to a series of questions about racial and ethnic origin, the race and ethnicity of study participants are described in the following analysis by white, black and Hispanic indicator variables. Indicator variables also record whether participants reported being currently enrolled as college students at the time of each interview.

The Rotter Locus of Control Scale used here is calculated using responses to four items presented to participants in 1979. The responses elicited are meant to measure the beliefs participants hold as to whether the course of their lives is primarily determined by themselves or by external forces. Item responses were given numerical values and summed so that lower scores indicate stronger beliefs that the course of their lives is primarily determined by themselves.

In 1980, the Rosenberg Self-Esteem Scale was administered to survey participants. This scale consists of ten items intended to measure participants' approval of themselves. Item responses were given numerical values and summed so that higher totals indicate higher levels of self-esteem.

The measures of personality described in the two preceding paragraphs were not included as control variables in many previous studies of the relationship between intelligence and heavy alcohol consumption. Heckman et al. (2006) included these variables in an analysis of the importance of cognitive ability and abilities like self-control in determining life outcomes and these variables are included here in order to facilitate comparison with that study. Qualitatively similar results to those that will be reported here were obtained when these personality variables were omitted.

In every year with alcohol questions, participants who reported consuming alcohol were asked how often they had consumed six or more drinks on a single occasion in the past month. These answers are used to generate an indicator variable equal to one if the participant reported consuming six or more drinks on a single occasion in the past month. This variable is set to zero for participants who did not drink.

This indicator variable will be the measure of heavy alcohol consumption analyzed here. One strength of this variable as a measure of heavy alcohol consumption is that it is unaffected by differences in moderate alcohol consumption. Furthermore, it is only for this measure that data are available from all of the survey years with alcohol questions. Because these panel data describe only a narrow age range in each year, it is crucial that the measure of heavy alcohol consumption be available for a wide range of survey years if it is to be used to investigate how the relationship between intelligence and heavy alcohol consumption changes with age.

This measure of heavy consumption is closely related to the concept of binge drinking. Binge drinking is defined by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) as drinking that results in a blood alcohol concentration above 0.08 gram percent. For men, this typically requires about five drinks in two hours (NIAAA, 2004). For women, this typically requires about four drinks in two hours

(NIAAA, 2004). About 92% of those who drink excessively engage in binge drinking (Town et al., 2006).

In the NLSY79, those drinkers who had consumed six or more drinks on a single occasion in the previous month drank approximately twice as often as those drinkers who had not. Those drinkers who had consumed six or more drinks on a single occasion during the previous month drank, on average, about ten days per month. Those drinkers who had not consumed six or more drinks on a single occasion in the previous month drank, on average, only about five days per month.

The blood alcohol concentration associated with six drinks varies by body weight (Posey and Mozayani, 2007). In several interview years, participants were asked to report their body weight. Body weight will be included as a control variable in the following analysis. In years for which body weight was not reported, the most recent preceding value for that participant will be used.

In 1982, 1983, 1984, 1985, 1988, 1989 and 1994, survey participants were asked if they had ever drunk an alcoholic beverage. Answers to this question were used to generate an indicator variable equal to one if the participant had never drunk an alcoholic beverage.

In 1989, survey participants who drank were asked if they had ever needed a drink so bad that they could not think of anything else. Answers to this question were used to generate an indicator variable equal to one if the condition had ever arisen. This variable is not defined for participants who did not drink in 1989.

In 1984, 1985, 1988, 1989 and 1994, participants who drank were asked if during the past year they had tried to restrict their alcohol consumption and failed. These answers are used to generate an indicator variable equal to one if this condition occurred. This variable is not defined for participants who did not drink in the relevant year.

In the data that will be analyzed here, answers to the question about failed attempts to restrict consumption are predictive of heavy alcohol consumption as defined above. Among those who reported having tried to restrict their consumption and failed, 78% reported heavy consumption. Among those who reported that they had not tried to restrict their consumption and failed, only 44% reported heavy consumption. Note that both proportions are higher than the overall proportion that will be reported in Table 3-1 because the variable reflecting failed attempts to restrict consumption is defined only for those who consumed alcohol while the proportion that will be reported in Table 3-1 also includes those who did not consume alcohol.

As noted above, some key questions were asked only to those who consumed alcohol. As discussed in the section on limitations, this could introduce a selection problem. It will be argued there that selection is unlikely to be driving the results that will be presented here.

Evidence concerning alcohol consumption is available for participants between the ages of 17 and 50. Observations of individuals at age 17 will be omitted from this analysis because as minors they may have had limited control over their alcohol consumption. Few observations in these data represent individuals above age 48. Therefore this analysis will be restricted to those between the ages of 18 and 48.

The NLSY79 experienced a substantial amount of attrition between 1982 and 2006, with over twelve thousand observations in 1982 and less than eight thousand observations in 2006. Changes in the composition of the group participating in the survey could result in changes in the observed relationship between intelligence and heavy alcohol consumption. Most of the variation in age in these data is a result of the fact that alcohol questions were asked in multiple survey years, so this attrition could in principle affect estimates of how the relationship between intelligence and heavy alcohol consumption changes with age. In order to eliminate any such effects, only

those individuals who were still participating in the survey in 2006 will be included in the following analysis. Similar results to those that will be reported here were obtained when survey year was included as an independent variable.

Table 3-1 summarizes selected variables from the NLSY79 data. Each unique combination of individual and interview year with alcohol questions is potentially an observation in this table and in the analysis that follows.

Table 3-1  
NLSY79 Selected Summary Statistics

<u>Variables</u>	<u>Obs.</u>	<u>Means</u>	<u>Std. Devs.</u>
<i>six or more drinks on a single occasion in last month</i>	65804	0.294	0.456
<i>never drunk an alcoholic beverage</i>	51244	0.058	0.234
<i>needed so bad could not think</i>	4704	0.029	0.169
<i>tried to cut back or quit and failed in past year</i>	19279	0.062	0.242
<i>IQ</i>	63262	99.388	15.427
<i>age</i>	65804	29.050	8.401
<i>highest grade completed</i>	65595	12.524	2.392
<i>currently enrolled as a college student</i>	65803	0.100	0.300
<i>Rotter Locus of Control Scale</i>	65166	8.763	2.404
<i>Rosenberg Self-Esteem Scale</i>	63331	32.236	4.072
<i>married</i>	65804	0.431	0.495
<i>income (\$1,000s)</i>	65508	35.605	60.986
<i>white</i>	65804	0.455	0.498
<i>black</i>	65804	0.300	0.458
<i>Hispanic</i>	65804	0.174	0.379
<i>male</i>	65804	0.485	0.500

Notes: Table 3-1 summarizes data from the National Longitudinal Survey of Youth, 1979. Each unique combination of individual and survey year with questions about alcohol consumption is a potential observation in this table. These observations represent the 7,653 individuals still participating in the NLSY79 in 2006. The variables *six or more drinks on a single occasion in last month*, *never drunk an alcoholic beverage*, *needed so bad could not think* and *tried to cut back or quit and failed in past year* are indicator variables that take on a value of one if they describe the observation and zero otherwise. The variables *currently enrolled as a college student*, *married*, *white*, *black*, *Hispanic* and *male* are indicator variables that take on a value of one if they describe the observation and zero otherwise. Additional variables that will be included in the analysis below are variables measuring family size and weight as well as indicator variables for urban residence and region of residence. Region of residence will be described using indicator variables for residence in the northeastern, north central, southern and western regions of the United States.

The other source of data that will be analyzed here is the National Health Interview Survey (NHIS). The NHIS is a continuing survey that collects information on the health of the US population. It is administered by the National Center for Health Statistics, which is a part of the Centers for Disease Control and Prevention. Between 1982 and 1996 the survey consisted of two parts, a basic set of health and demographic questions that was consistent across years and a group of supplemental questions that varied across years. In 1985, the Health Promotion and Disease Prevention Supplement tested the health knowledge of participants. One of the questions asked was about the relationship between alcohol abuse and cirrhosis of the liver. Answers are used to generate an indicator variable equal to one if the respondent reported that alcohol abuse definitely increases the likelihood of cirrhosis of the liver.

Information on age, education, race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence was also gathered. Because the analysis of the NLSY79 data will be limited those between the ages of 18 and 48, the analysis of the NHIS will also be limited to individuals in that age range. Table 3-2 summarizes the NHIS data.

The next section uses these data to analyze the relationship between intelligence, self-control and heavy alcohol consumption. All of the outcomes that will be examined here are dichotomous. Linear probability models will be used throughout. In most of the regressions described below, it is the interactions between independent variables that are of interest. The use of nonlinear probability models to investigate such relationships presents technical issues (Ai and Norton, 2003). All statistical analyses were performed using Stata 11.

Table 3-2  
NHIS Selected Summary Statistics

<u>Variables</u>	<u>Obs.</u>	<u>Means</u>	<u>Std. Devs.</u>
<i>heavy drinking definitely increases risk of cirrhosis of the liver</i>	20557	0.809	0.393
<i>highest grade completed</i>	20557	12.986	2.585
<i>age</i>	20557	31.772	8.151
<i>income less than \$5000</i>	20557	0.090	0.287
<i>income between \$5,000 and \$7,000</i>	20557	0.036	0.186
<i>income between \$7,000 and \$10,000</i>	20557	0.055	0.228
<i>income between \$10,000 and \$15,000</i>	20557	0.102	0.303
<i>income between \$15,000 and \$20,000</i>	20557	0.115	0.319
<i>income between \$20,000 and \$25,000</i>	20557	0.103	0.305
<i>income between \$25,000 and \$35,000</i>	20557	0.188	0.390
<i>income between \$35,000 and \$50,000</i>	20557	0.139	0.346
<i>income greater than \$50,000</i>	20557	0.084	0.277
<i>income missing</i>	20557	0.087	0.282
<i>married</i>	20522	0.557	0.497
<i>white</i>	20557	0.818	0.386
<i>black</i>	20557	0.154	0.361
<i>hispanic</i>	20557	0.070	0.255
<i>male</i>	20557	0.560	0.496

Notes: Table 3-2 summarizes data from the National Health Interview Survey, 1985. The variable *heavy drinking definitely increases risk of cirrhosis of the liver* is an indicator variable equal to one if the participant said that heavy drinking definitely increases the risk of cirrhosis of the liver and zero if the participant indicated otherwise. Income is described by a group of ten indicator variables equal to one if the participant's income category corresponds to the variable name and zero otherwise. The variables *married*, *white*, *black*, *Hispanic* and *male* are indicator variables that take on a value of one if they describe the participant and zero otherwise. Additional variables that will be included in the analysis below are variables measuring family size and weight as well as indicator variables for urban residence and region of residence. Region of residence will be described using indicator variables for residence in the northeast, north central, southern and western regions of the United States.

## Results

Karlamangla et al. (2006) reported that heavy alcohol consumption falls with age. Figure 3-2 demonstrates this pattern using data from the NLSY79.



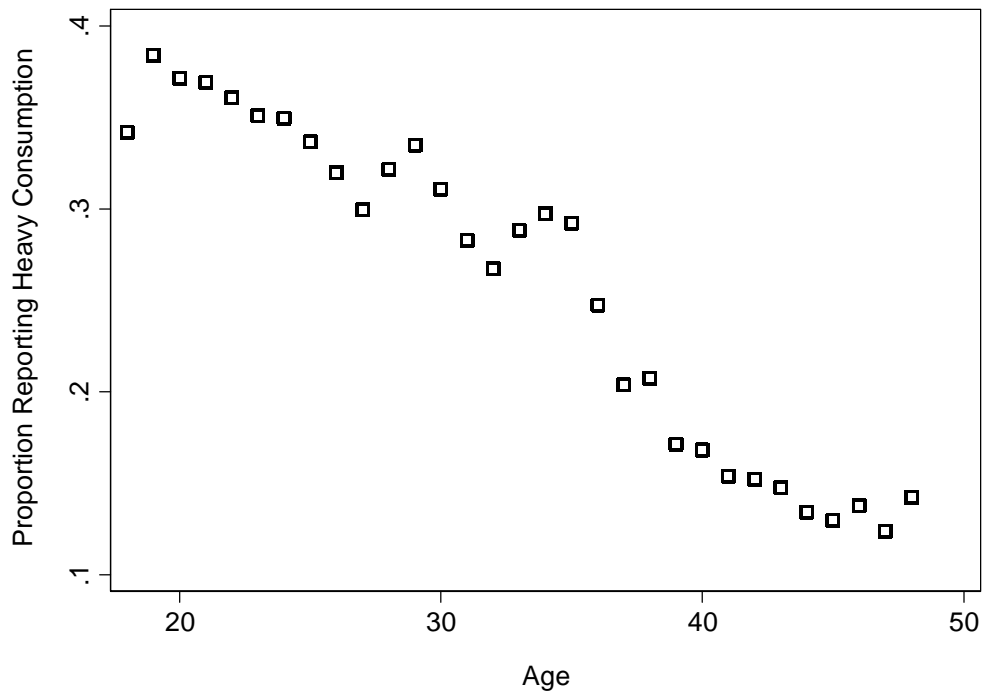


Figure 3-2

Age and Heavy Alcohol Consumption

Notes: Figure 3-2 is based on data from the National Longitudinal Survey of Youth, 1979. “Heavy consumption” indicates consumption of six or more drinks on a single occasion in the month preceding the interview.

Note that the National Minimum Drinking Age Act of 1984, which made standard a minimum legal drinking age of 21, wasn’t fully implemented until 1988 (New York Times, 1988) while the earliest alcohol consumption questions analyzed here were asked in 1982. In these data, the proportion of participants reporting heavy alcohol consumption peaks at age 19, when it is about 38%.

Previous studies of the relationship between intelligence and heavy alcohol consumption have produced conflicting results. It was argued above that these conflicting results may have arisen because the relationship between intelligence and heavy alcohol consumption becomes more negative with age. Figure 3-3 graphs heavy alcohol consumption against age separately for those whose IQ scores are above average and those whose IQ scores are below average.

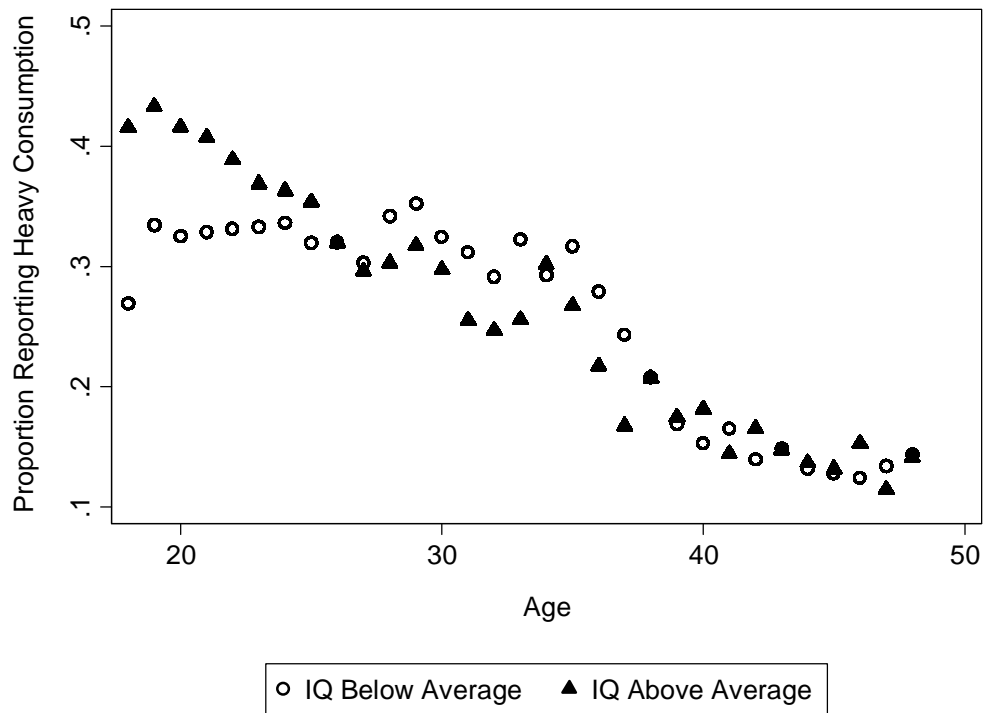


Figure 3-3

Age and Heavy Alcohol Consumption by IQ

Notes: Figure 3-3 is based on data from the National Longitudinal Survey of Youth, 1979. “Heavy consumption” indicates consumption of six or more drinks on a single occasion in the month preceding the interview.

In Figure 3-3, it appears that the relationship between intelligence and heavy alcohol consumption is initially positive but becomes negative with age.

Multiple regression analysis provides additional evidence that this is the case. As a point of reference, Table 3-3 shows the relationship between IQ and heavy alcohol consumption in these data when the coefficient on IQ is not allowed to vary with age.

Although Figure 3-3 appears to demonstrate a strong relationship between IQ and heavy alcohol consumption, in a regression in which the coefficient on IQ is not allowed to vary with age that coefficient is near zero and not statistically significant.

Table 3-3  
 Selected Coefficients from a Simple Model Predicting the Probability of Having Consumed Six or More Drinks on a Single Occasion in the Previous Month

<u>Variables</u>	<u>Coefficients</u>
<i>IQ</i>	0.000220 (0.000316)
<i>age</i>	-0.008207*** (0.000284)
<i>highest grade completed</i>	-0.013578*** (0.001599)
<i>current college enrollment</i>	-0.034548*** (0.007296)
<i>Rotter Locus of Control Scale</i>	0.001604 (0.001390)
<i>Rosenberg Self-Esteem Scale</i>	-0.000962 (0.000846)
Observations	60589
R <sup>2</sup>	0.129

Notes: Table 3-3 presents coefficients from a linear probability model estimated using data from the National Longitudinal Survey of Youth, 1979. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the individual level. Each unique combination of individual and survey year with questions about alcohol consumption was a potential observation in this analysis. These observations represent 7,062 individuals who were still participating in the NLSY79 in 2006. The regression equation also included variables measuring race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

Table 3-4 shows the relationship between intelligence and heavy alcohol consumption when the coefficient on IQ is allowed to vary with age. The relationship between IQ and the predicted probability of heavy alcohol consumption is graphed against age in Figure 3-4.

The IQ terms are jointly statistically significant at the 0.0001 level and the three terms in which IQ is interacted with age are also jointly significant at the 0.0001 level. IQ is strongly related to heavy alcohol consumption and the hypothesis that the relationship does not vary with age can be rejected.

Table 3-4  
 Selected Coefficients from a More Sophisticated Model Predicting the Probability of  
 Having Consumed Six or More Drinks on a Single Occasion in the Previous Month

<u>Variables</u>	<u>Coefficients</u>
<i>IQ</i>	0.041979*** (0.007555)
<i>IQ*age</i>	-0.003507*** (0.000733)
<i>IQ*age<sup>2</sup></i>	0.000092*** (0.000023)
<i>IQ*age<sup>3</sup></i>	-0.000001*** (0.000000)
<i>highest grade completed</i>	-0.013298*** (0.001660)
<i>current college enrollment</i>	-0.040079*** (0.007574)
<i>Rotter Locus of Control Scale</i>	0.001989 (0.001390)
<i>Rosenberg Self-Esteem Scale</i>	-0.001120 (0.000846)
Observations	60589
R <sup>2</sup>	0.133

Notes: Table 3-4 presents coefficients from a linear probability model estimated using data from the National Longitudinal Survey of Youth, 1979. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the individual level. Each unique combination of individual and survey year with questions about alcohol consumption was a potential observation in this analysis. These observations represent 7,062 individuals who were still participating in the NLSY79 in 2006. The regression equation also included variables measuring race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

Figure 3-4 shows how the predicted relationship between IQ and heavy alcohol consumption varies with age for those between the ages of 18 and 48. Similar patterns are observed when additional terms raising age to higher powers and interacting IQ with age raised to higher powers are included in the regression.

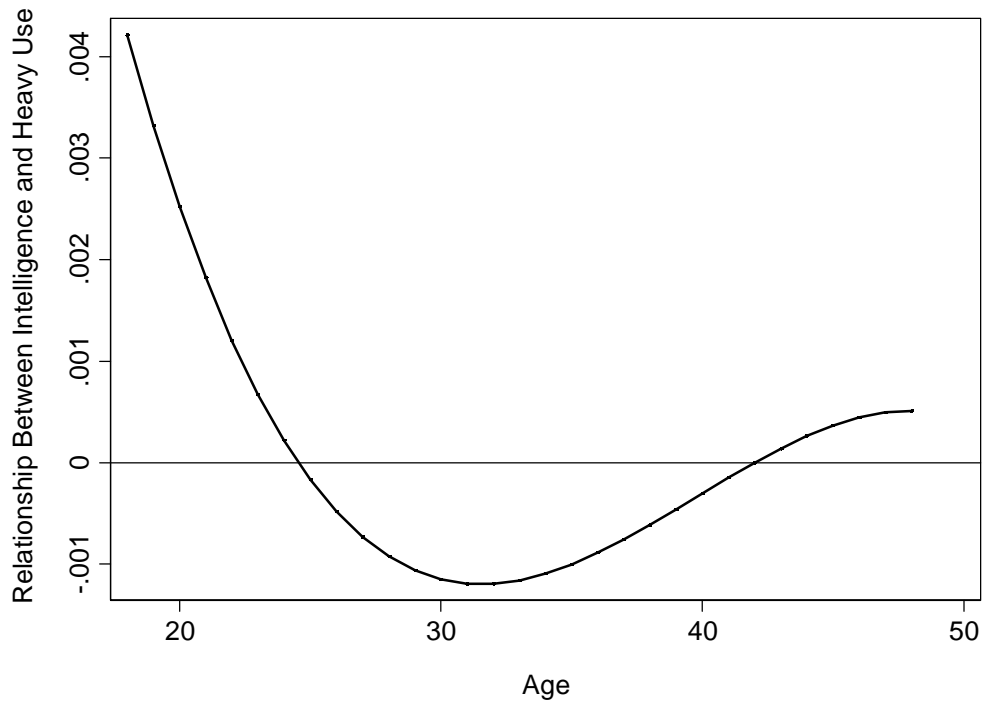


Figure 3-4  
IQ and Heavy Alcohol Consumption

Notes: Figure 3-4 is based on the regression coefficients reported in Table 3-4. “Heavy consumption” indicates consumption of six or more drinks on a single occasion in the month preceding the interview.

The pattern shown in Figure 3-4 closely resembles the predicted pattern shown in Figure 3-1 and is consistent with differences by intelligence in success at self-control. These regression results indicate that in the United States the relationship between intelligence and the probability of heavy alcohol consumption is initially positive, but becomes negative around age 25. This change in the relationship between intelligence and heavy alcohol consumption could lead to the mixed results reported in previous studies.

In about 29 percent of observations, participants reported having six or more drinks on a single occasion in the previous month. At age 18, the average marginal effect is about 0.004 and a one standard deviation increase in IQ is associated with about a 6.3 percentage point increase in the probability of heavy consumption. The

average marginal effect of IQ reaches its nadir at about age 32, when it is about negative 0.0012. At age 32, a one standard deviation increase in IQ is associated with about a 1.8 percentage point decrease in the probability of heavy consumption. Therefore the relationship between a one standard deviation increase in IQ and the probability of heavy alcohol consumption ranges from an increase of about 21% relative to the mean to a decrease of about six percent.

In the regression results above, the relationship between current college enrollment and heavy alcohol consumption is negative and statistically significant. One potential concern about the results presented here may be that college environments could vary widely and the type of institution attended may be related to intelligence, with more intelligent students attending colleges where heavy alcohol consumption is more prevalent. A second potential concern is that college enrollment may affect not only the level of consumption while enrolled but also the evolution of consumption over time. In either case, simply including an indicator variable for college enrollment could be inadequate to isolate the relationship between intelligence and heavy alcohol consumption.

To address these concerns, the analysis above was performed separately for those who had completed fewer than twelve years of school by 2006, the most recent year for which data were available. Qualitatively similar results were obtained, suggesting that the effect of experiencing a college environment is not driving the relationship between intelligence and heavy alcohol consumption described here.

As can be seen in Figure 3-4, the relationship between IQ and the probability of heavy alcohol consumption becomes negative with age. Past discussions of the relationship between intelligence and life outcomes have focused on the relationship between intelligence and information. One possible explanation for the pattern depicted in Figure 3-4 may be that people tend to restrict their alcohol consumption as

they age because they learn about the health risks associated with heavy alcohol consumption and the pattern observed in Figure 3-4 arises because more intelligent people learn more about those health risks.

No direct measures of knowledge of health risks are available in the NLSY79, so the NHIS will be used to examine the hypothesis that the information gap between the more intelligent and the less intelligent widens with age. While no direct measure of intelligence is available in the NHIS, education is reported. Education is highly correlated with intelligence (Neisser et al., 1996) and those with higher levels of education have been shown to be better-informed about health risks (Kenkel, 1991). Table 3-5 shows how the relationship between education and information changes with age.

Table 3-5  
Selected Coefficients from a Model Relating Education and Age to Knowledge that Heavy Drinking Increases the Likelihood of Cirrhosis of the Liver

<u>Variables</u>	<u>Coefficients</u>
<i>highest grade completed</i>	0.036878*** (0.004772)
<i>age</i>	0.007919*** (0.001757)
<i>age*highest grade completed</i>	-0.000516*** (0.000137)
Observations	20522
R <sup>2</sup>	0.048

Notes: Table 3-5 reports coefficients from a linear probability model estimated using data from the National Health Interview Survey, 1985. Robust standard errors are in parentheses. Only individuals between the ages of 18 and 48 were included in this analysis. The regression equation also included variables measuring race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

If decision makers are learning as they age, one would expect beliefs to eventually converge as they became more accurate. The results in Table 3-5 show this pattern, with a positive coefficient on education, a positive coefficient on age and negative coefficient on the interaction term. It therefore seems unlikely that the relationship between intelligence and heavy alcohol consumption becomes more negative with age because of a widening of the information gap between the more intelligent and the less intelligent.

The literature review and theoretical analysis presented above suggest an alternative explanation for the pattern depicted in Figure 3-4. The NLSY79 will be used to explore the possibility that differences in experimentation with alcohol contribute to the positive relationship when people are young. The NLSY79 will also be used to explore the possibility that differences in success at self-control contribute to the negative relationship when people are older.

If intelligence is positively related to experimentation with alcohol, one would expect a negative relationship between intelligence and the probability of never having drunk an alcoholic beverage.

As can be seen in Table 3-6, the relationship between IQ and the probability that a survey participant had never drunk an alcoholic beverage is negative and statistically significant. The coefficient on IQ is about negative 0.002, so a one standard deviation increase in IQ is associated with about at 2.8 percentage point decrease in the probably of never having drunk an alcoholic beverage. In these data, the mean probability of never having drunk an alcoholic beverage is about 0.058, so a one standard deviation increase in IQ is associated with about a 48% percent decrease relative to the mean in the probability of never having drunk an alcoholic beverage.



Table 3-6  
Selected Coefficients from a Model Predicting the Probability of Having Never Drunk Alcohol

<u>Variables</u>	<u>Coefficients</u>
<i>IQ</i>	-0.001856*** (0.000215)
<i>age</i>	-0.003429*** (0.000342)
<i>highest grade completed</i>	0.003275*** (0.001229)
<i>current college enrollment</i>	0.002448 (0.004092)
<i>Rotter Locus of Control Scale</i>	-0.000499 (0.000863)
<i>Rosenberg Self-Esteem Scale</i>	-0.001517*** (0.000527)
Observations	47168
R <sup>2</sup>	0.049

Notes: Table 3-6 reports coefficients from a linear probability model estimated using data from the National Longitudinal Survey of Youth, 1979. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the individual level. Each unique combination of individual and survey year with questions about having ever consumed an alcoholic beverage was a potential observation in this analysis. These observations represent 7,039 individuals who were still participating in the NLSY79 in 2006. The regression equation also included variables measuring race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

Results qualitatively similar to those presented in Table 3-6 were obtained when the analysis was restricted to those who had not completed a year of college by 2006, the most recent year for which data are available.

It was argued above that intelligence is related to success at self-control because more intelligent people have higher levels of the mental resources necessary for attending their goals. In 1989, NLSY79 participants were asked if they had ever needed a drink so bad that they could not think of anything else. Interpreted literally in terms of the model described above, an affirmative answer would correspond to a situation in which  $P(\bar{s}(i)) = 0$ . In other words, the participant simply did not have sufficient mental resources to control what they attended. If intelligence is positively

related to the mental resources available, one would expect it to be negatively related to the probability of an affirmative answer to this question.

As can be seen in Table 3-7, IQ has a negative relationship with the probability that a participant ever needed a drink so bad that they could not think of anything else. In these data, only about 2.9% of drinkers reported that they had ever needed a drink so bad that they could not think of anything else. The coefficient on IQ is about negative 0.0008 and a one standard deviation increase in IQ is associated with about a 1.1 percentage point decrease in the probability of an affirmative answer. Therefore a one standard deviation increase in IQ is associated with about a 39% decrease relative to the mean in the probability of an affirmative answer.

Table 3-7  
Selected Coefficients from a Model Predicting the Probability of Having Needed a Drink So Bad that One Could Not Think of Anything Else

<u>Variables</u>	<u>Coefficients</u>
<i>IQ</i>	-0.000753*** (0.000286)
<i>age</i>	0.000229 (0.001178)
<i>highest grade completed</i>	-0.001419 (0.001396)
<i>current college enrollment</i>	0.005835 (0.010986)
<i>Rotter Locus of Control Scale</i>	-0.001966* (0.001181)
<i>Rosenberg Self-Esteem Scale</i>	-0.002808*** (0.000755)
Observations	4384
R <sup>2</sup>	0.022

Notes: Table 3-7 reports coefficients from a linear probability model estimated using data from the National Longitudinal Survey of Youth, 1979. Robust standard errors are in parentheses. The regression equation also included variables measuring race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

It was argued above that if more intelligent people are more successful at impulse control they may be less likely to fail in attempts to restrict their alcohol consumption. Table 3-8 demonstrates that this is the case.

Table 3-8  
Selected Coefficients from a Model Predicting the Probability of Having Tried to Restrict Consumption of Alcohol but Failed

<u>Variables</u>	<u>Coefficients</u>
<i>IQ</i>	-0.002015*** (0.000213)
<i>age</i>	-0.001487*** (0.000462)
<i>highest grade completed</i>	-0.004655*** (0.001143)
<i>current college enrollment</i>	-0.008184 (0.005226)
<i>Rotter Locus of Control Scale</i>	-0.000012 (0.000905)
<i>Rosenberg Self-Esteem Scale</i>	-0.002615*** (0.000568)
<b>Observations</b>	<b>17863</b>
<b>R<sup>2</sup></b>	<b>0.052</b>

Notes: Table 3-8 reports coefficients from a linear probability model estimated using data from the National Longitudinal Survey of Youth, 1979. Robust standard errors are in parentheses. Standard errors are adjusted for clustering at the individual level. Each unique combination of individual and survey year with questions about having tried in the previous year to restrict alcohol consumption and failed was a potential observation in this analysis. These observations represent 6,088 individuals who were still participating in the NLSY79 in 2006. The regression equation also included variables measuring race, ethnicity, gender, income, family size, marital status, weight, urban residence and region of residence.

\*\*\* Statistically different from zero with  $p < 0.01$

\*\* Statistically different from zero with  $p < 0.05$

\* Statistically different from zero with  $p < 0.1$

IQ is strongly related to the probability of reporting having failed during the previous year in an attempt to restrict alcohol consumption. In these data, in about 6.2% of observations of drinkers the respondent reported having failed during the previous year in an attempt to restrict their alcohol consumption. The coefficient on IQ is about negative 0.002 and a one standard deviation increase in IQ was associated with about a three percentage point decrease in the probability of reporting having failed in an attempt to restrict alcohol consumption. Therefore one standard deviation increase in IQ is associated with about a 49% decrease relative to the mean in the probability of reporting having failed in an attempt to restrict alcohol consumption.

The empirical results presented in this section indicate that the relationship between intelligence and heavy alcohol consumption becomes more negative with age and suggest that the relationship is driven at least in part by differences in experimentation with alcohol and differences in success at self-control. This study has several limitations, however, as will be discussed in the next section.

### Limitations

This study has two primary limitations. First, as with any theoretical analysis, a number of simplifying assumptions have been made. Second, as with any empirical analysis, the data available are not ideal.

The theoretical analysis was simplified by assuming that addiction is dichotomous and that those who succeed in abstaining in one period will no longer need to exercise self-control in order to abstain in the future. While desensitization to environmental cues will probably decrease the self-control needed to abstain, even those who have abstained for long periods of time are still at risk of relapse (Goldstein, 2001). Some other economic models of addiction have treated the weakening of addiction in a more nuanced manner (Becker and Murphy, 1988;

Bernheim and Rangel, 2004; Gruber and Köszegi, 2001; Orphanides and Zervos, 1995).

These data are not sufficient to estimate the importance of differences in the value placed on novelty. It is not clear to what extent the initial positive relationship between intelligence and heavy alcohol consumption is driven by differences in the value placed on novelty or how quickly the novelty associated with heavy alcohol consumption decreases. There are, of course, other possible explanations for the positive initial relationship between intelligence and heavy alcohol consumption. For example, it could be that individuals are aware of differences in the difficulties associated with self-control before making their initial decisions regarding alcohol. Those for whom self-control is less onerous might be less concerned about addiction and might therefore be more likely to engage in heavy alcohol consumption when they are young.

Neither are these data sufficient to estimate the importance of differences in the difficulties associated with self-control. This is true for at least three reasons.

First, differences in the cost of generating self-control could affect the option deliberately chosen. In the theoretical analysis presented above, the deliberately chosen option and the impulsive option were treated as fixed and differences in the probability of self-control failures were analyzed. It may be the case that the difficulties associated with self-control vary with the option deliberately chosen (Gul and Pesendorfer, 2001; Lowenstein and O'Donoghue, 2007). If so, then differences in the cost of generating self-control could affect which option was deliberately chosen. Such an effect of differences in the cost of generating self-control on observed behavior would not be captured by the questions about failed attempts to restrict consumption.

Second, not all self-control failures will be captured by the questions about

failed attempts to restrict consumption. Recall that the theoretical model described above is intended primarily to take on an “as if” interpretation. One reason for this interpretation is that the actual decision-making process may not always be an entirely conscious one. If the decision-making process is not entirely conscious, the role of self-control failures in determining consumption levels may not be clear to decision makers and as a result may not be reflected in their answers to survey questions.

Third, some decision makers may choose  $s^* = 0$ . In other words, for some decision makers it may be optimal to make no attempt to restrict consumption even if the utility from consumption would be higher if they succeeded in restricting their consumption. If the cost of generating self-control is lower for more intelligent people, then it may be the case that more intelligent people are less likely to choose  $s^* = 0$ .

The question about attempts to restrict alcohol consumption was only asked to drinkers and those who drank were only asked about attempts in which they failed. Because those who chose  $s^* = 0$  did not attempt to restrict their consumption, they would have answered that they had not failed in an attempt to restrict their consumption. The behavior of these decision makers would be affected in the expected way by differences in the cost of generating self-control but the presence of such decision makers in these data would make the relationship between intelligence and the probability of reporting a failed attempt to restrict consumption less negative rather than more negative.

In principle, this possibility could reverse the interpretation of the results presented above. Suppose that, contrary to the argument presented here, generating self-control were more costly for more intelligent people. Suppose that, as a result, more intelligent people were more likely to choose  $s^* = 0$ . Then it is possible that more intelligent people would be less likely to report failing to restrict consumption

because they were less likely to attempt to restrict consumption.

More generally, the fact that questions about attempts to restrict consumption and success or failure in those attempts were not asked separately could lead to a negative relationship between intelligence and reported failures under any scenario in which less intelligent people were more likely to attempt to restrict consumption. Such a scenario is not likely to be driving the results presented here, however. If less intelligent people were more likely to attempt to restrict their consumption, the negative relationship between intelligence and the probability of reporting a failed attempt to restrict consumption would be accompanied by a negative relationship between intelligence and the probability of successfully restricting consumption. Given that the relationship between intelligence and heavy alcohol consumption becomes more negative with age, however, it seems unlikely that less intelligent people are experiencing more successes in attempts to restrict consumption.

The results presented here are not intended to be interpreted as evidence of a causal relationship between intelligence and heavy alcohol consumption. Intelligence has not been defined in terms of any particular ability, so, in principle, any ability or achievement could reflect differences in intelligence. As a result, the appropriate counterfactual is difficult to identify and it is not clear how the effect of differences in intelligence on heavy alcohol consumption could be measured.

In the theoretical model described above, differences in success at self-control are caused by differences in the levels of mental resources available. Intelligence is correlated with the levels of these mental resources available and it seems reasonable to assume that, with a standard set of control variables, intelligence serves as a measure of the levels of mental resources available. The data do not allow for a direct test of this assumption, however. In the data analyzed here, direct measures of willpower and attention were not available. While the results presented here are

consistent with the hypothesis that intelligence is related to heavy alcohol consumption through differences in the levels of mental resources available, it is easy to imagine different data that would allow more direct and convincing tests of that hypothesis.

Previous studies of the relationship between intelligence and behavior have often focused on differences in information. Ideally, measures of information about the health risks associated with heavy alcohol consumption would have been included as control variables in all of the regressions relating intelligence to alcohol consumption. No measures of such knowledge were available in the NLSY79, however, and no direct measure of intelligence was available in the NHIS. While the results presented here suggest that changes with age in the relationship between intelligence and heavy alcohol consumption are not driven by changes in information, better data would allow a more precise and thorough analysis of the role differences in information play in determining the relationship between intelligence and heavy alcohol consumption.

Finally, survey data are accompanied by the risk of systematic measurement error. Survey participants may misremember or intentionally misrepresent their experiences and survey questions may allow for a range of interpretations. Given that the relationship between intelligence and the value of novelty and the relationship between intelligence and self-control have been repeatedly observed in other settings, however, it seems unlikely that such issues are driving the results presented here.

In spite of the limitations described in this section, this study makes several contributions to the literature. These contributions are discussed in the following section.



## Discussion

The analysis presented here makes several contributions to the literature. First, it clarifies the empirical relationship between intelligence and heavy alcohol consumption. Second, it provides new evidence concerning the relationship between AFQT scores and self-control. Third, it clarifies the relationship between intelligence and cognitive ability in a multiple regression framework. Fourth, it provides a new model for analyzing impulse control problems. Fifth, it provides some insight into the relationship between intelligence and life outcomes. Sixth, it provides some insight into the relationship between socioeconomic status and life outcomes. Seventh, it provides new evidence concerning the decision processes influencing behaviors such as heavy alcohol consumption.

The analysis presented here demonstrates that the relationship between intelligence and heavy alcohol consumption is positive when people are young but becomes more negative with age. This may explain the mixed results regarding the relationship between intelligence and heavy alcohol consumption that have been previously reported.

Heckman et al. (2006) analyzed the importance of cognitive ability and abilities like self-control in determining life outcomes. They assumed a single cognitive ability measured primarily by the AFQT and a single non-cognitive ability measured primarily by the Rotter Locus of Control Scale and the Rosenberg Self-Esteem Scale. The results presented in Table 3-8 suggest that AFQT may rival or surpass the Rotter Locus of Control Scale and the Rosenberg Self-Esteem Scale as a measure of success at self-control.

Economists often use the terms intelligence and cognitive ability interchangeably (Auld and Sidhu, 2005; Cawley et al., 1997; Heckman, 2008). This analysis makes clear the danger of such an approach to intelligence. Even when

intelligence is measured by measuring cognitive ability, as was the case here, intelligence scores indicate more than cognitive ability. As a result, the regression coefficient on a measure of intelligence may not represent the relationship between cognitive ability and the outcome of interest.

A new model of impulse control is presented here that builds on previous work by Benhabib and Bisin (2005), Bernheim and Rangel (2004) and Lowenstein and O'Donoghue (2007) to predict which decision makers will be more likely to fail in attempts to resist impulses. In this model decision makers control the probability of impulsive behavior through expending limited and valuable mental resources. Those with higher levels of these resources available are predicted to be less likely to act impulsively. More intelligent people have higher levels of these mental resources available and so the model predicts that they will be more likely to be successful at resisting impulses.

The analysis presented here provides some insight into the relationship between intelligence and life outcomes. Baumeister et al. (1994) and Baumeister et al. (2007) argued that the mental resources necessary for self-control play a crucial role in regulating many kinds of behavior. Intelligence is correlated with a number of life outcomes that are influenced by failures in this kind of self-regulation, including health, education, poverty, crime and marriage (Auld and Sidhu, 2005; Gottfredson, 1997, 2004; Herrnstein and Murray, 1994). Past discussions of the relationship between intelligence and life outcomes, including alcohol consumption, have often focused on differences by intelligence in information (Auld and Sidhu, 2005; Batty et al., 2006; Gottfredson, 1997, 2004; Herrnstein and Murray, 1994). The analysis presented here suggests that the relationship between intelligence and life outcomes is also, at least in part, a result of differences by intelligence in the mental resources necessary for self-control.

Differences by socioeconomic status in life outcomes are closely related to differences in intelligence (Cutler and Lleras-Muney, 2010; Gottfredson, 2004; Herrnstein and Murray, 1994). The results presented here suggest that differences by socioeconomic status in life outcomes may be driven in part by differences in success at self-control.

In designing policies that will improve welfare, it is helpful to have a sound understanding of the decision processes that influence the outcomes of interest. Differences in the behaviors deliberately chosen as a result of differences in information are consistent with standard economic models of choice. In contrast, differences in behavior as a result of differences in success at self-control indicate that such models are incomplete.

This analysis provides evidence that differences in alcohol consumption are driven in part by differences in success at self-control. The evidence is based primarily on answers to two questions. The first question investigated whether participants had ever needed a drink so bad that they had been unable to think of anything else. The second question investigated whether participants had tried to restrict their alcohol consumption and failed. Affirmative answers to these questions are difficult to reconcile with traditional economic theory, including the rational addiction framework (Becker and Murphy, 1988), but have a natural interpretation in the framework presented here. Furthermore, it was demonstrated that differences in the probability of affirmative answers were consistent with those predicted by the model presented here. In providing evidence of the importance of self-control in determining the relationship between intelligence and heavy alcohol consumption, this study provides support for the use of alternative models of choice that account for the difficulties associated with self-control.

If the relationship between intelligence and life outcomes were driven entirely

by the influence of differences in information on the behaviors deliberately chosen, the strong relationship between intelligence and life outcomes would suggest that efforts to provide the public with additional information could result in significant welfare improvements. While the potential benefits from providing information may be more limited if the relationship between intelligence and life outcomes is driven in part by differences in success at self-control, other kinds of policy interventions would also have the potential to improve welfare under that scenario. For example, Bernheim and Rangel (2004) argued that regulating environmental cues such as advertising may improve welfare by reducing the probability that those cues trigger impulses to use addictive goods. Such impulses can lead to relapse in addicts attempting to quit (Niaura et al., 1988).

The primary policy implications of this analysis stem from the fact that success at self-control may be improved. Success at self-control depends in part on the cognitive and behavioral strategies employed, and these strategies can be taught (Mischel et al., 1989). Furthermore, the mental resources available to decision makers do not appear to be fixed. In particular, a variety of evidence suggests that the amount of willpower available can be altered (Baumeister et al., 2006). The simile Baumeister et al used to describe willpower is that the will is like a muscle. In the short run exercising a muscle will tire it and decrease the amount of strength available, but in the long run exercise can strengthen the muscle. In the same way, willpower may be depletable in the short run but the amount of willpower available may grow in the long run as a result of exercising self-control.

For both of these reasons, one would expect practice at tasks involving self-control to result in improvements. Diamond et al. (2007) showed that incorporating self-control tasks into school curricula can cause students to perform better on measures of impulse control. Such programs have the potential to substantially improve welfare through affecting any number of important life outcomes.

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