Intelligence and Age at First Intercourse: Cause or Confound?

Is the Link Between Intelligence and Age at First Intercourse Causal or Correlational? A Cross-Generational Sibling Comparison Design Using the NLSY

Intelligence and Age at First Intercourse: Maternal Siblings and Offspring Cousin Comparisons

Do Intelligent Adolescents Really Delay First Intercourse?

Do Intelligent Girls Delay Age at First Intercourse? Different Results Within-Families Versus Between-Families

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Abstract

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Intelligence and Age at First Intercourse: Cause or Confound?

Anecdotal evidence from the popular media, such as MTV’s reality television franchise, *16 and Pregnant* , suggests that teenage sexual involvement is on the rise. Academic evidence supports such evidence; age at ﬁrst intercourse (AFI) is indeed declining and has for some time (Bozon, 2003; Finer, 2007) [these cites are a bit problematic – the latest data in them is from 2003, which belies the “has for some time” suggestion – I think there are likely articles in the Alan Guttmacher journal Perspectives on Sexual and Reproductive Health that can help here – I’ll send several example articles that you can look through]. Early AFI is associated with downstream consequences, including lower education attainment (Harden, 2012; Spriggs & Halpern, 2008; Wellings et al., 2001), failure to meet education and career goals (Halpern, Joyner, Udry, & Suchindran, 2000), increased risk of teenage pregnancy (Leitenberg & Saltzman, 2000; Wellings et al., 2001), and increased rates of sexually transmitted infections (Kaestle, Halpern, Miller, & Ford,

2005). Moreover, beyond the obvious beneﬁt of avoiding those negative outcomes, delaying AFI is associated with greater relationship satisfaction, perception of increased attractiveness, and higher household income (Harden, 2012). Because many of the negative consequences above are severe and long-reaching, it is important to identify the causal mechanisms associated with early AFI. One potential causal influence on AFI that has received attention is intelligence.

Higher levels of intelligence are positively associated with delaying ﬁrst intercourse (Halpern et al., 2000; Mott, 1983; Paul, Fitzjohn, Herbison, & Dickson, 2000; Woodward, Fergusson, & Horwood, 2001), as well as less-intimate sexual involvement (Halpern et al.). Speciﬁcally, it has been suggested that intelligent individuals delay intercourse to “safeguard” their futures (Kirby, 2002b; Manlove, 1998; Raﬀaelli & Crockett, 2003). They perceive the risks associated with early intercourse, (e.g., pregnancy, STIs) to have life- and career–shattering outcomes (Halpern et al., 2000;

Harden & Mendle, 2011). Although the link between intelligence and AFI has face validity, and has been confidently asserted (or often implied) as a causal link, a fundamental confound exists in most past research that limits our ability to infer causality.

Virtually all of the AFI-intelligence literature has used between family designs. In all such analyses, genetic and environmental inﬂuences, such as education and maternal intelligence, are confounded (D’Onofrio et al, 2012 (AJPH article); Lahey & D’Onofrio, 2010; Harden, 2014; Rodgers et al, 2000). By ignoring such confounds, the source of variance is ambiguous, and researchers that attribute the source to specific between- or within-family sources risk misattributions of causality (Rowe & Rodgers, 1997;

Rutter, 2007). Indeed, both intelligence and AFI are heritable and have sizable

shared environmental variances (Harden & Mendle, 2011; Harden, 2014; Plomin & Spinath, 2004; Rodgers, Rowe, & Buster, 1999; Rodgers, Rowe, & May, 1994). Thus, we need to critically evaluate whether intelligence is a cause of AFI or merely a theoretically attractive confound. To resolve some of these methodological challenges, we use design innovations that emerge from the excellent cross-generational and longitudinal structure of the National Longitudinal Survey of Youth (NLSY; we use both the original NLSY79 survey and the NLSY-Children survey, described below).

**Cause or Confound?**

There are numerous theories that address the motivations for adolescents’ initiation of ﬁrst intercourse (see Rodgers, 1996 or Buhi & Goodson, 2007 for reviews), and even more speciﬁc precursors to first intercoruse (Buhi & Goodson, 2007; Kirby, 2002a; B. C. Miller et al.,

1997; Santelli & Beilenson, 1992; also cite D’Onofrio & Lahey’s JMF paper reviewing the pervious decade of research, 2010 or 2011). Many of these theories emphasize biology/genetics, where adolescent pubertal development (and associated hormone changes) drives onset of sexual behavior (W. B. Miller et al., 1999; Udry, 1979; Udry has several other more recent and quite famous papers on the link of hormones to adolescent sexual behavior that we should cite, including his PAA presidential address published in Demography) Other theoretical frameworks use social/environmental processes to explain developing sexual involvement in adolescence, such as Social Learning (DiBlasio & Benda, 1990; Hogben & Byrne, 1998), where social norms affect the likelihood of early sexual behavior; or Social Control theory (Hirschi, 2002), where societal and cultural influences reduce the likelihood that individuals will act on their natural tendency toward sexual involvement.

Under these environmental theories the underlying biology is either ignored or actively resisted (e.g.,f Social Control theory, while under many of the biololgical/genetictheories, the environmental components are often ignored.

However, numerous articles have also advocated integrative models (See Udry, 19?? – Demography paper, “What Biology do Sociologists Need to Know?”; Harden, Mendle, Hill, Turkheimer, & Emery, 2008; Harden, 2014). The integrative Biopsychosocial Model acknowledges both genetic and environmental contributions to human behavior (Engel, 1977; Petersen, 1987; Rodgers, Rowe, & Buster, 1999). Indeed, biology, psychology, and society jointly inﬂuence adolescents’ decisions to engage in sexual intercourse (Meschke, Zweig, Barber, & Eccles, 2000; Zimmer-Gembeck & Helfand, 2008).

**Intelligence as Cause**

The short-term risks of early AFI are primarily negative, whereas the rewards for delay are primarily positive. These consequences are suggested to extend into adulthood – early AFI has been related to adult delinquency (Harden et al., 2008), anti-social behavior, and substance abuse (Boislard & Poulin,

2011), whereas those with delayed AFI have higher household incomes in adulthood (Harden,

2012). It is intuitively appealing to believe that intelligent individuals are more likely to observe this potential risk-reward tradeoﬀ, and through volition act upon such observations by delaying first intercourse. Accordingly, intelligent individuals perceive the consequences of early AFI

to negatively influence their careers (Halpern et al., 2000; Harden & Mendle, 2011).

Indeed, most of the literature has contributed to this belief, that intelligence is causally connected to AFI. Those with higher educational goals delay their ﬁrst intercourse (Boislard & Poulin, 2011; Schvaneveldt, Miller, Berry,

& Lee, 2001), whereas those who engaged in early sexual intercourse reduced their educational goals compared to earlier higher goals (Schvaneveldt et al., 2001). Beyond academic goals, those with a greater aﬃnity for risk and those who perceive beneﬁts from teen-pregnancy are more likely to engage in risky sexual activities (Raﬀaelli &

Crockett, 2003). A greater understanding of the risks associated with sexual intercourse, such as HIV transmission, is also associated with delayed AFI (C. Mathews et al., 2009).

Smarter adolescents are more likely to report delayed intercourse (Halpern et al.,

2000; Mott, 1983; Paul et al., 2000; Woodward et al., 2001). Beyond intercourse, smarter individuals appear to postpone all sexual/romantic activity (Halpern et al.,

2000). Such blanket delays may be a proactive attempt to avoid ﬁrst intercourse precursors. Thus, many researchers have concluded that “[h]igher intelligence operates as a protective factor against early sexual activity during adolescence, and lower intelligence, to a point, is a risk factor” (Halpern et al., 2000 p. 213).

However, Halpern et al. (2000) and many of the other studies we have referenced above (e.g., C. Mathews et al., 2009; B. C. Miller et al., 1997; Paul et al., 2000) have used between family, typically cross-sectional, designs. Such designs cannot logically distinguish between processes that act to create diﬀerences between families and

processes that create diﬀerences among family members (Lahey & D’Onofrio, 2010; Rodgers et al, 2000).

Thus the previous studies do not provide conclusive evidence that intelligence is the causal inﬂuence behind the AFI-intelligence relationship. Logically, other alternatives are that AFI has a causal link to intelligence (which is unlikely, for the obvious theoretical reasons, including that a child’s intelligence precedes AFI in time) or that other confounds cause these two outcomes to correlate, but not causally. There are dozens, perhaps hundreds, of such confounds that can logically contend to explain the link between child intelligence and AFI.

**Intelligence as a Confound**

An equally valid set of explanations exist in which intelligence is not the causal factor behind the AFI-intelligence relationship, but rather one of dozens of potentially explanatory processes (though obviously a theoretically explanatory process). Instead, various confounds including family-level selection eﬀects, or third variables at the individual level could be causing the relationship. Indeed many such ﬁndings that link intelligence with various outcomes are quite possibly the product of misattributing between family confounds to individual-yahooyahoo level causes.

The relationship between birth order and intelligence is a classic example of this misattribution (See Rodgers, Cleveland, van den Oord, & Rowe, 2000; Rodgers, 2014; Damian & Roberts, 2015). Between-family studies that rely on cross-sectional data have consistently found that ﬁrst born children have higher IQs than later born children (Belmont & Marolla, 1973; Zajonc, 1976. Yet within family studies have often found zero relationship (Berbaum & Moreland, 1980; Retherford & Sewell, 1991; Rodgers, 1984; Rodgers et al., 2000). Moreover, when designs that can distinguish within- and between-family variancehave been conducted, the methodological source of the IQ-birth order eﬀects have emerged from the between-family variance (Black, Devereux, & Salvanes, 2011; Rodgers et al., 2000; Wichman, Rodgers, & Maccallum, 2006, 2007). Potential causes of this confound include maternal age at first birth, parental IQ, parental education, and SES1 (Page & Grandon, 1979; Rodgers, 2001, Rodgers et al, 2008). See Anastasi (1956) for an insightful overview, written prior to the IQ-birth order debate.2[In the paragraph above, we should probably give lip service to the couple of recent very large national studies that have found a significant birth order effect using within-familiy data. One of the Bjerkedajl et al studies, and Kiernan Barclay’s recent study]

There is support in the literature suggesting that between-family inﬂuences such as SES and maternal intelligence could drive the

1 Selection eﬀects based on SES should not to be confused with the conﬂuence/resource dilution model

(Blake, 1981; Zajonc & Bargh, 1980) [ this seems superfluous, I’d delete this footnote]

2 “Parenthetically, it may be added that studies on the relation of birth order to intellectual and other

psychological characteristics have frequently yielded ambiguous and inconsistent results because of the failure to take family size into account.”(Anastasi, 1956, pg 201) [I’d delete this as well, journals don’t like footnotes very much these days unless they’re really necessary.]

relationship. Socioeconomic status is associated with the onset of ﬁrst intercourse

(Lammers, Ireland, Resnick, & Blum, 2000) and correlated with intelligence (Murray,

1998; Neisser et al., 1996; Strenze, 2007). Parental intelligence and parental education are also linked with child intelligence (Bouchard, Jr., 2004; Devlin, Daniels, & Roeder,

1997; Mercy & Steelman, 1982), and pose viable alternative explanations in which parents could be influencing, or even actively dissuading, their children from engaging in early intercourse. For example, daughters whose mothers communicated frequently about the risk associated with sexual intercourse were less likely to have unprotected sex and engaged in sex less frequently (Hutchinson, Jemmott, Jemmott, Braverman, & Fong, 2003). Thus it could be that intelligent mothers, not intelligent children, are the ones recognizing the consequences of early intercourse and acting accordingly. In order to better understand the causal relation between intelligence and AFI, we need to be able to untangle between- and within-family processes, using both data and designs that have the ability to separate these sources of variance.

**Prior Within Family Analyses**

Two past studies have explicitly separated between- and within-family inﬂuences on the AFI-intelligence relationship (Harden & Mendle, 2011; Nedelec et al, 2012).3 Harden & Mendle used 536 same-sex twin pairs from the Add Health Study to “test[] whether relations between intelligence, academic achievement and age at ﬁrst sex were due to unmeasured genetic and environmental diﬀerences between families.” Twins who diﬀered in their intelligence or their academic

achievement did not diﬀer in their age at ﬁrst intercourse. They concluded that ”the association between intelligence and age at ﬁrst sex could be attributed entirely to unmeasured environmental diﬀerences between families.” Nedelec, Schwartz, Connolly, and Beaver (2012) conducted an exploratory analysis of MZ twin pairs from the same sample used by Harden and Mendle, using intelligence difference scores to predict various social outcomes. They found consistent null results, though there samples were small and their statistical analyses were substantially underpowered.

3

**Current Study, Summary [some of this material more naturally goes in the Methods section]**

To summarize, the current study examines the relationship between intelligence and age at ﬁrst intercourse, using siblings and their children from a multi-generational nationally representative sample, the NLSY. This examination extends the intelligence literature in several key ways. First, we tested whether the relationship between intelligence and AFIexisted in either or both between- and within-family analyses.Second, we evaluated the alternative explanation that maternal intelligence inﬂuences child AFI, using the cross-generational structure of the NLSY. Third,we replicated our findings using two different age periods.

[I don’t think these predictions make very much sense until the design and dataset are described. Let’s delete the following up to the Methods section, and let this section end with the sentence starting “Third, … We may want to move all of this to the Methods section, I’m not sure yet

We made the following predictions, based primarily upon Harden & Mendle (2011)

and Meredith (2013):

Between Families,

1. Does Gen2 intelligence predict Gen2 AFI?: We expect intelligence to be associated with age of ﬁrst intercourse because there is a sizable body of literature reporting that result (Kirby, 2002b; Manlove, 1998; Raﬀaelli & Crockett, 2003).

2. Does Gen1 intelligence predict Gen2 AFI?: We also expect maternal intelligence to be associated with age of ﬁrst intercourse because the heritability of intelligence is quite high (Bouchard, Jr., 2004; Devlin et al., 1997). If intelligence does causally inﬂuence AFI we would expect that the cross-generational association between AFI and intelligence would be considerably weaker, but existent. However, if the intelligence-AFI relationship is the product of between family confounds, then we would expect that the cross-generational association between AFI and intelligence would be stronger than the within generation association because maternal intelligence would be more closely linked with household SES and various parental causes. Comparably sized eﬀects would also be consistent with a between family confound. Given that Harden & Mendle (2011) and Meredith (2013) found no within family eﬀect for intelligence, we expect that maternal intelligence will have a comparable or larger eﬀect on between family AFI than child intelligence.

Within Families,

3. Does Gen2 intelligence predict Gen2 AFI?: No, we do not expect to ﬁnd all

within family diﬀerences in intelligence and AFI, given that neither Harden & Mendle

(2011) nor Meredith (2013) reported an eﬀect.

4. Does Gen1 intelligence predict Gen2 AFI?: Unknown: it is possible that maternal intelligence will have an eﬀect, as such a link would explain the between family eﬀects as well as many of the alternative household-level inﬂuences.

5. Is the relationship consistent across methods?: Doubtful, we do not expect the results to be consistent across methods because both Harden & Mendle (2011) and Meredith (2013) found no within-familiy eﬀect, while the traditional ﬁndings from between family studies ﬁnd an eﬀect (Kirby, 2002b; Manlove, 1998; Raﬀaelli &

Crockett, 2003).

**Method**

**Research Design**

We adapted Kenny and colleagues’ (2001; 2006) reciprocal standard dyad model to facilitate sibling comparisons. Sibling-based quasi-experimental models are particularly eﬀective for incorporating genetic and environmental design elements (Lahey & D’Onofrio, 2010; Rutter, 2007). Our model uses differences between both pairs of mothers and pairs of adolescents, which provides the measures that explicitly account for within-family variance. Further, within-family differences create a powerful control for virtually all background heterogeneity (variance) associated with both genetic and environmental differences (Lahey & D’Onofrio). We compare individuals from within the family in the context of the following models. First, we predict the difference in AFI, YiΔ , for a given pair of NLSY-Children, indexed as i, in the following model:

YiΔ = *β*0 + *β*1 Y¯i + *β*2 X¯i + *β*3 XiΔ (1)

where,

*Yi*Δ = *Yi*1 *− Yi*2 ; *Xi*Δ = *Xi*1 *− Xi*2, and

*Yi*1 = max(*Yij* ); *Yi*2 = min(*Yij* ); (2)

In this model, the relative diﬀerence in NLSY-Children AFI outcomes (YΔ ) is predicted from the

mean level of AFI (Ymean)[needs to be Y-bar, as in the equation], the mean level of intelligence, the predictor (Xmean ),[same] and the between-kin intelligence diﬀerence (XiΔ ). The mean levels support causal inference through at least partial control for genes and shared environment in previous generations. Within this model, there is explicit separation of within-family variance (within YΔ and XΔ, and betwee-family variance, within the X-bar and Y-var means.

Thus, this model allows us to explicitly untangle between- and within-family inﬂuences. If there is a true causal link between intelligence and AFI

, then we expect kin

diﬀerences in intelligence to be signiﬁcantly associated with kin diﬀerences in AFI outcome. If the eﬀect is spurious – only the function of between family confounds – then we would expect to ﬁnd no signiﬁcant relationship between the diﬀerences in the outcome with the diﬀerences in the predictor.

**Sample**

The National Longitudinal Survey of Youth 1979 dataset (NLSY79) is based on a nationally representative household probability sample, jointly sponsored by the US Bureau of Labor and US Department of Defense. On December 31, 1978, 12,686 adolescents were sampled within a household probability sample from

8,770 households on a battery of measures. The initial sample consisted of three subsamples:

• a cross–sectional household probability sample of 6,111 non-institutionalized adolescents residing in the United States on December 31*st* of 1978;

• a separate over–sampled civilian subsample of 5,295 racial minorities and disadvantaged whites;

• a representative sample of 1,280 youth serving in the US Military on September

30*th* , 1978.

In the two civilian samples, subjects’ birthdates ranged from January 1, 1957 to December

31, 1964, and were between the ages of 14 and 21 on December 31, 1978; military subject’s birthdates ranged from January 1, 1957 to December 31, 1961, and were between 17 and 21 years old. Participants were surveyed annually until 1994, and then surveyed biennially to the present. Two waves of planned attrition occurred. After the 1984 interview, all but 201 randomly selected members of the military sample were dropped. After the 1990 interview, all 1,643 disadvantaged whites from the oversample were dropped. More information about the sampling process and the data can be found on the Bureau of Labor Statistics (BLS) website: [http://www.bls.gov/nls/nlsy79.htm.](http://www.bls.gov/nls/nlsy79.htm)

In 1986, the biological children of the female NLSY79 participants were surveyed,

resulting in the NLSY79 Children and Young Adults (NLSY-Children) survey. The

11,512 respondents in the NLSY-Children data are also surveyed on a biennial basis. In the current study, participants in the NLSY79 will typically be referred to as the Generation 1 (Gen1) sample, whereas the NLSY–Children will be referred to as the Generation 2 (Gen2) sample.

**Tetrads**

To conduct our study using the necessary within-family information, we require sister pairs in General 1 who both had children. The children of these sisters are cousin-pairs. In the original NLSY79 and NLSY-Children surveys, identification of level of sibling relatedness in the NLSY was primarily inferential. NLSY79 twins, full siblings, half siblings, and adoptive siblings were distinguishable indirectly from respondent and maternal information about the biological father. NLSY-Children respondents within a given family were all full- or half-siblings, because they were (by design) the biological children of the NLSY79 females. In 2006, the NLSY surveys both included explicit indicators of the level of sibling relatedness. Our research teacm has recently completed a final multi-year project to reliably and validly identify the kinship pairs within these two datasets. These kinship pairs are used in the current study.

Specifically, Mother-Child-Aunt-Nibling (MCAN) tetrads were created using the NLSY Kinship Links (Rodgers et al., 2015) and supporting R package (Beasley et al., 2015). The oldest two female kin (Mother, Aunt) were selected from each NLSY79 household (note thatadditional female Generation 1 sister pairs – a relatively small number -- were excluded). Three tetrad designs were employed, in which the genders of Generation 2 were the deﬁning feature:

• Mother-Daughter-Aunt-Niece (MDAN) tetrads included the oldest Generation 2 female child from each of the two Generation 1 sisters,

• Mother-Son-Aunt-Nephew (MSAN) tetrads included the oldest Generation 2 male child from each of the Generation 1 sisters, and

• The first two types of tetrads were combined together into Mother-Child-Aunt-Nibling (MCAN) included the ﬁrst born child from each of the sisters. (Note: “Nibling” refers to an u niece or nephew with unspecified gender; compare to “Sibling.”)

All outcomes were standardized by gender prior to tetrad creation. [more detail here is required – standardized within gender pair? By subtracting the gender pair mean from each score? Or standardized within all females, and all males, by subtracting the male mean and the female mean? Rationale?] Table 3 on page 27 reports descriptive statistics for all relevant variables used throughout this paper by whether the respondent has a sibling in the sample. [This paragraph is problematic – first, tables are always referred to consecutively, Table 1 first, Table 2 second, etc; second, tables need to make sense when referred to, and the measures, e.g., AFQT, haven’t been defined yet so the reader doesn’t know yet what these measure mean – this paragraph information needs to move to the section where the measures are defined – and the information here isn’t relevant to the construction of the tetrads anyway]

**Measures**

**Generation 1 AFI.** NLSY-79 subjects indicated their AFI a maximum of three times, inresponse to questions in 1983, 1984, and 1985). The 1984 and 1985 questions were included to asses those with non-response in 1983, but in fact many female respondents were surveyed multiple times. Further, females were asked for additional related information (Year of First Intercourse, Month of First Intercourse) in 1984 and

1985.

We used the repeated questions to estimate

test-retest reliability of self-reported AFI and the AFI diﬀerence scores. [this should be Table 1?] In Table 6 on page 30,[delete all page references, they aren’t required or standard, and leaving them out allows the table pages to “float” as revisions occur] the lower triangle reports the correlations of self-reported AFI across 1983-1985; the diagonal indicates the number of respondents reporting AFI for that year, and upper triangle indicate the number of respondents that reported AFI for both respect years. Reliabilities aren’t typically evaluated for significance, take these stars out – also indicate either in the table or in the text, or both, what NANA means. The test-retest reliabilities are moderate to high ( r *>* .75) across all viable pairings, suggesting that our subjects are consistently reporting their AFIs.

**Generation 2 AFI.** Over the life-time of the NLSY-Children survey, participants were asked approximately the same questions to asses AFI that their mothers were asked. However, Generation 2 respondents were only asked for AFI information once they had reached age 15 or later. The exact nature of the question varied by administration. Between

1988 and 2000, subjects were asked for age, year, and month of ﬁrst intercourse. After

2000, subjects were only asked their age.

[Mason – I find this paragraph really confusing, both the motivation and the procedure – I helped you do this, and I still don’t know what most of this means. Did we create a SAS variable for age when we could? And otherwise created the most precise variable we could with what we had? More discussion about this before we’re ready for this paragraph to go public.] We calculated AFI as follows.. First, we transformed year of ﬁrst intercourse into age. If subjects reported both age and year within the same survey, if they were different we averaged the age scores. We also averaged the minimum and maximum AFI scores if scores were different across years. Across all survey years, we identiﬁed the minimum AFI and maximum AFI for each subject. When we only had information on year available, we adjusted Then we took the average of those two scores. Given that the expected AFI of a subject

= the reported AFI, we added 1 to the Maximum AFI. Therefore, if the subject only reported one instance of AFI, their AFI would now reﬂect their expected AFI. For example, a subject who reports AFI at 16 could be 16 years and 1 day old OR 16 years and 364 days old. Thus the expected value for 16 is in fact 16.5. We calculated AFI in this manner because we wished to include the maximum amount of information without ignoring the expected value problem with self-reported age. Using this method, the average Gen2 AFI was 16.01 years (sd = 2*.*30; n = 6288).4

4 Taking the average of all AFIs (without addressing expected value), results in 15.49 (sd = 2.30; n =

6288). Adding in expected value of .5 changes this value to 15.99.

After transforming all AFI scores, we recoded impossible AFIs as missing.

A score was impossible if the reported AFI exceeded participant’s age at time of survey (AFI= 15*.*99, sd = 2*.*30, n = 6235). Next, we excluded all AFIs below age 12 (16.14, sd = 2*.*10, n = 6087). Finally we excluded subjects who reported AFI prior to menarche (16.16, sd = 2*.*09, n = 6047). We excluded those below age 12 because those responses likely are the result of misunderstanding or non-consensual sexual activity. AFI varied by gender and race. Most notably, women reported AFIs that were 6 months later than men, and black men reported the lowest AFI (15 yrs) of any race-gender categories. For a complete portrayal of summary statistics, see [should be Table 2] Table 3 on page 27

and see Figure 1 on page 38.

**Generation 1 Intelligence**

The Armed Services Vocational Aptitude Battery (ASVAB; Form 8A; Palmer, Hartke, Ree, Welsh, & Valentine, Jr., 1988) was administered to Gen1 participants in 1980. The Armed Forces Qualiﬁcation Test (AFQT) is contained within the ASVAB, and used as a measure of general trainability (Maier & Sims, 1986). It is a composite of four subscales: Arithmetic Reasoning (AR; 30 items), Math Knowledge (MK; 25 items), Paragraph Comprehension (PC; 15 items), and Word Knowledge (WK;

35 items). Other administrations of the pencil

and paper ASVAB reveal that all the AFQT subscales have high coefficient *α* internal consistency (

*αAR* = *.*91; *αWK* = *.*92; *αPC* = *.*81; *αMK* = *.*87; Kass, Mitchell, Grafton, & Wing, 1982). Reported reliability of the overall AFQT (version 8A) ranges from .87 to .93 (Palmer et al., 1988).

Methods of calculating the AFQT have varied throughout the ASVAB’s administrative lifetime (Mayberry & Hiatt, 1992). For pencil and paper

administrations, standard scores were created for each of the subscale scores (*x*¯ = 50, sd

= 10), and then combined into a standard score. Then, the AFQT standard score is derived from the following formula:

AFQT = AR + MK + 2VE*,* (3)

where VE = PC + WK. (4) Many researchers have used the AFQT standard score as a proxy for general intelligence (*g*) (Herrnstein & Murray, 1994; Der, Batty, & Deary, 2009). Indeed, the military has

found that the AFQT correlated 0.8 with the Wechsler Adult Intelligence Scale (WAIS; McGrevy, Knouse, & Thompson, 1974). Moreover, the AFQT consistently predicts outcomes traditionally associated with intelligence(Welsh, Kucinkas, & Curran, 1990), including grades (Wilbourn, Valentine, Jr., & Ree, 1984; J. J. Mathews, 1977).

**Generation 2 Intelligence**

NLSY-Children respondents, as a part of the survey, complete the following test batteries:

• Peabody Individual Achievement Test (PIAT; Dunn & Markwardt, 1970):

**–** Math Subtest (84 items),

**–** Reading Recognition Subtest (84 items),

**–** Reading Comprehension Subtest (84 items),

• The Peabody Picture Vocabulary Test-Revised (PPVT-R; Form L; Dunn & Dunn,

1981; 175 items), and

• Digit Span Subscale of the Wechsler Intelligence Scales for Children Revised (WISC-R; Wechsler, 1974; 28 items).

The standard scores of the PVVT-R, PIATs, and Digit Span considered valid and reliable assessments of cognitive ability (Mott & Baker, 1995). However, subjects were surveyed on a biennial basis. Thus we could not use cognitive tests at a fixed exact age. Instead, we aggregated scores across a 4 year window, and targeted the midpoint between ages 9 and 10. We targeted 9.5 because all cognitive tests were administered within the 8–11 age window, we wanted to maximize the number of subjects with viable ability scores, and we wanted to ensure temporal precedence aby measuring intelligence prior to the occurrence of AFI. In the case of missing subtests, we allowed age 11 standard scores to replace age 9 standard scores, and age 8 standard scores to

replace age 10 standard scores. Our replacement strategy ensured that the average age of testing matched the average of our targeted ages.

To obtain intellectual ability measures for each NLSY-children respondent, we fit a confirmatory factor analysis model (using Mlus; Muthen & Muthen, 2014) and their robust maximum likelihood estimator option. A single-factor model fit fairly well (RMSEA = .101; CFI = .973; TLI = .946), supporting the use of this model to construct a unidimensional scale score for each respondent. We used factor scores obtained from this model as our measures of NLSY-Children intelligence.

**Replicability & Reliability.** We repeated our aggregates of Gen2 intelligence, centered at ages 10.5 and 11.5, and replicated all of our analyses. These replications can be found in the Appendices A and B, respectively. The test-retest reliabilities of Gen2 intelligence across our three aggregations is reported in the lower triangle of [Table 3?]Table 8 on page 30. The diagonal indicates the number of respondents with intelligence aggregations for that year, and upper triangle reveal the number of respondents with viable scores for both respective ages. [stars go away]The test-retest correlations are very high ( r > .90) across all pairings, suggesting that our method captures consistent measures of intelligence across ages.

**Reliability of Diﬀerence Scores**

Our design assumes that the diﬀerence scores of our measures are reliable. INSERT MORE ON THIS. We’ve reported the test-retest reliability of Gen2 intelligence and Gen1 AFI in earlier sections. Here, we report the test-retest reliability of the pairwise diﬀerences of those measures.

**Estimated Reliabilities. [There’s a lot lot too much detail in this section. The reader just needs to know how we did it (e.g., test-retest, coefficient alpha, or Lord’s formula), and what the value is. There’s almost 3 pages here – it should be around 6-8 lines – and probably should be merged into the section above on reliability of the separate scores. I also doubt that we need any tables for this.]** Sibling diﬀerences in AFI as reported in 1983, 1984,

and 1985 were strongly correlated with each other (See Table **??** on page ??).

Comparing sibling diﬀerences in AFI as reported in 1983 and 1984 (n = 783 pairs) we

found a strong correlation (r = .76). The sample of sibling pairs with complete information in 1985 was too small (n = 12) to compare to the other two years. Regardless, sibling diﬀerences in self-reported AFI appear reliable. Although we could not calculate test-retest reliabilities for Gen2, we have no reason to believe that those diﬀerences would fundamentally diﬀer from Gen1’s reports.

Cousin diﬀerences in intelligence as assessed at ages 9.5, 10.5, and 11.5 were correlated using three diﬀerent linking methods (Mixed, Daughers, Sons). Table 9 on page 31 reports the correlated diﬀerences of the ﬁrst borns of each sister, Table 10 on page 31 reports the correlated diﬀerences of the ﬁrst born girls, and Table 11 on page 31 reports the correlated diﬀerences of the ﬁrst born sons. Reliabilities across linking methods was consistent and high (min r = .86; max r = .95). However, again, we were unable to calculate the test-retest diﬀerence score reliabilities for Gen1

**Calculated Reliabilities.** Nonetheless, we were able to conﬁrm that diﬀerence

scores for both generations were reliable for the measures we could estimate. For the remainder, we have calculated the reliability of the diﬀerence scores using the following

equation (Lord, 1963):

*σ*2 2

*x ρxx* + *σy ρyy −* 2*ρxy σx σy*

*ρdd* =

*σ*2 2

(5)

where,

*x* + *σy −* 2*ρxy σx σy*

• *ρdd* is the reliability of the diﬀerence score,

• *σ*2 is the variance of kin1 ’s score,

*x*

• *ρxx* is the reliability of kin1 ’s score,

• *σ*2 is the variance of kin2 ’s score,

*y*

• *ρyy* is the reliability of kin2 ’s score,

• *ρxy* is the correlation between kin1 ’s and kin2 ’s scores.

Accordingly, we can substitute the following values into equation 5 to calculate the diﬀerence score reliability for Generation 1 intelligence. where,

• *σ*2 and *σ*2 are 1.1881 (from Table 1 on page 26)

*x y*

• *ρxx* and *ρyy* are .87 (the low end of AFQT reliability reported in Palmer et al.,

1988),

• *ρxy* is the correlation between sisters is .67.

sigmax = sqrt (1.1881)

sigmay = s igmax rxx = .87

ryy = rxx rxy =.67

( s igmax \* s igmax \* r x x + s igmay \* s igmay \* r y y -2\* r x y \* s igmax \* s igmay ) / ( s igmax \* s igmax + s igmay \* s igmay -2\* r x y \* s igmax \* s igmay )

# # [1] 0 . 6 0 6

The calculated reliability of Generation 1’s diﬀerences in AFQT was 0.606, acceptable, but lower than the empirical correlation we derived for cousin diﬀerences.

We can also calculate the diﬀerence score reliability for Generation 2 AFI, by substituting the following values into equation 5, where,

• *σ*2 and *σ*2 are 4.41 (from Table 2 on page 26)

*x y*

• *ρxx* and *ρyy* are .76 (from Table 6 on page 30),

• *ρxy* is the AFI correlation between ﬁrst born cousins is .099.(from Figure 3 on page 40)

sigmax = sqrt (4.41)

sigmay = s igmax rxx = .76

ryy = rxx rxy = . 0 9 9

( s igmax \* s igmax \* r x x + s igmay \* s igmay \* r y y -2\* r x y \* s igmax \* s igmay ) / ( s igmax \* s igmax + s igmay \* s igmay -2\* r x y \* s igmax \* s igmay )

# # [1] 0 . 7 3 4

Gen2 Mean AFI diﬀerence scores were also reliable (r = 0.734) and comparable to

Generation 1 sibling diﬀerences.

**Results**

We examined the relationship between AFI and intelligence using two designs: a between-family design, and a within-family design (which also includes between-family variance in the differences between the family means). The results are organized into those two designs. The between-family analyses report the relationships between the within-family average AFI and various measures of ability. The within-family analyses replicate the between family ﬁndings using within-family difference scores by testing whether diﬀerences in AFI can be explained by diﬀerences in various measures of ability.

**Between-Family Analyses**

First, we examined the between-family results. We tested whether the family average of Gen2 AFI could be predicted by the family averages of Gen1 intellectual ability and of Gen2 intellectual ability. We evaluated the inﬂuences both independently and simultaneously. All intelligence scores have been standardized by generation (*g* = 0, sd = 1), prior to averaging by household. AFI scores have been standardized by gender (AFI = 0, sd = 1), prior to averaging by household.

**Gen1 Mean Intelligence** *→* **Gen2 Mean AFI.** Gen1 sister averages (NLSY79 mothers) of standardized AFQT scores were used to predict Gen2 averages of gender standardized AFI. [Table 4?] Table 12 on page 32 displays the results by Gen2 linking. The Mixed model reports the averages of the ﬁrst borns child (both males and females) of each sister (n = 342), the Daughters model reports the averages of the ﬁrst born girls (n = 264), and the Sons model reports the averages of the ﬁrst born sons (n = 282). All three models reveal similar results. A one

unit increase in the average standardized intelligence of the children’s mothers predicted [a statistically significant?]

*≈ .*013 increase in average Gen2 AFI [what are the AFI units? Months? Years? Should probably indicate that]. The adjusted R2 varied slightly by Gen2 linking

(Mixed = *.*087, Daughters = *.*097, Sons = *.*103).

**Gen2 Mean Intelligence** *→* **Gen2 Mean AFI.** Gen2 cousin averages of standardized intellectual ability scores were used to predict Gen2 averages of gender-standardized AFI. Table 5?Table 13 on page 33 displays the results by Gen2 linking. The Mixed model reports the averages of the ﬁrst-borns of each of the NLSY79 mothers (sisters) (n = 344), the Daughters model reports the averages of the ﬁrst born girls (n = 267), and the Sons model reports the averages of the ﬁrst born sons (n = 283). All three models reveal similar results. A one unit increase in the average standardized intelligence of the children predicted [a statistically significant?] *≈ .*075 year? Month? increase in average Gen2 AFI. The adjusted R2 varied slightly by Gen2 linking (Mixed

= *.*014, Daughters = *.*016, Sons = *.*009). [Much smaller R-squares, by a whole order of magnitude – are we sure these are correct?]

**Joint Mean Intelligence** *→* **Gen2 Mean AFI.** Results from the Gen1 sister averages of standardized AFQT scores and Gen2 cousin averages of standardized intellectual ability scores predictions of Gen2 averages of gender standardized AFI are displayed in

Table 14 on page 34. Again, three models based on Gen2 linking are displayed: Mixed

(n = 337), Daughters(n = 260), and the Sons(n = 278). All three models reveal similar

results. Gen1 (maternal) intelligence was signiﬁcantly associated with Gen2 AFI (p *< .*01), while Gen2 (child) intelligence was not signiﬁcantly associated with Gen2 AFI. A one unit increase in the average standardized intelligence of the children’s mothers predicted *≈ .*014 month? Year? increase in average Gen2 AFI. The adjusted R2 varied slightly by Gen2 linking (Mixed = *.*086, Daughters = *.*097, Sons = *.*100); each was practically identical to the Mean Gen1

Intelligence models.

**Within-Family Analyses**

We replicated the between-family analyses reported in the previous subsection, using within family difference scores and means. Using the discordant sibling model, we predicted the diﬀerences in Generation 2 AFI as a function of diﬀerences in intelligence, controlling for means of the outcomes and predictors. We ran three series of models, where we examined the individual and then joint inﬂuence of Gen1 intelligence and

Gen2 intelligence. Moreover, within each series we included three Generation 2 linking method variants, just as we did in the between family analyses: Mixed model reports the diﬀerences of the ﬁrst borns of each sister, the Daughters model reports the diﬀerences

of the ﬁrst born girls, and the Sons model reports the diﬀerences of the ﬁrst born sons.

**G1 Intelligence Difference** *→* **Gen2 AFI Differences.** Generation 1 sister diﬀerences in standardized AFQT scores were used to predict Gen2 diﬀerences of gender standardized AFI, controlling for Generation 1 sister averages of standardized AFQT scores and

Gen2 averages of gender standardized AFI (to account for between-family variance). Table 6? Table 15 on page 35 displays the results by Generation 2 linking method. The Mixed model reports the averages and diﬀerences of the ﬁrst borns of each sister (n = 336), the Daughters model reports the averages and diﬀerences of the ﬁrst born girls (n = 258), and the Sons model reports the averages and diﬀerences of the ﬁrst born sons (n = 278). All three models reveal similar results. Generation 2 averages of gender standardized AFI (between-family measures) were signiﬁcant predictors of Gen2 diﬀerences in gender standardized AFI (p *< .*01), across all three linking methods. A one unit increase in the average gender standardized AFI predicted *≈* 0*.*34 increase in

average Gen2 AFI diﬀerence, controlling for all over variables in the model.

In the Sons model, the Generation 1 sister average of standardized AFQT scores was a signiﬁcant predictor of diﬀerences in Gen2 AFI (p *< .*01). A one unit increase in the average standardized intelligence of the children’s mothers predicted *≈ .*0083 decrease in the AFI diﬀerence between siblings. All other variables were not signiﬁcant, including all kin diﬀerence variables (the within-family measures). The adjusted R2 varied slightly by Generation 2 linking method (Mixed = *.*066, Daughters = *.*072, Sons = *.*106).

**Gen2 Dif Intelligence** *→* **Gen2 Dif AFI.** Gen2 cousin diﬀerences in standardized intellectual ability scores were used to predict Gen2 diﬀerences of gender standardized AFI, controlling for Gen2 cousin averages of standardized ability scores and gender standardized AFI. Table **??** on page ?? displays the results by Generation 2 linking method. The Mixed model reports the averages and diﬀerences of the ﬁrst borns of each sister (n = 291), the Daughters model reports the averages and diﬀerences of the ﬁrst born girls (n = 223), and the Sons model reports the averages and diﬀerences of the

ﬁrst born sons (n = 238). All three models reveal similar results. Gen2 averages of gender standardized AFI were signiﬁcant predictors of Generation 2 diﬀerences in gender standardized AFI (p *< .*01), across all three linking methods. A one unit increase in the average gender standardized AFI predicted *≈* 0*.*38 months? Years? increase in average Gen2 AFI diﬀerence, controlling for all over variables in the model.

In the Sons model, the Generation 2 cousin average of standardized ability scores was a signiﬁcant predictor of diﬀerences in Generation 2 AFI (p *< .*05). A one unit increase in the average standardized intelligence of the children predicted *≈ .*107 decrease in the AFI diﬀerence between siblings. All other variables were not signiﬁcant, including all kin diﬀerence variables. The adjusted R2 varied slightly by Generation 2 linking method (Mixed = *.*103, Daughters = *.*121, Sons = *.*132).

**Joint Dif Intelligence** *→* **Gen2 Dif AFI.** Generation 1 sister diﬀerences in standardized AFQT scores and Gen2 cousin diﬀerences in standardized intellectual ability scores were used to predict Generation 2 diﬀerences of gender standardized AFI, controlling for Generation 1 sister averages of standardized AFQT scores, Gen2 cousin averages of

standardized ability scores, and Gen2 cousin averages of gender standardized AFI.

Table 17 on page 37 displays the results by Generation 2 linking method. The Mixed model reports the averages and diﬀerences of the ﬁrst borns of each sister (n = 285), the Daughters model reports the averages and diﬀerences of the ﬁrst born girls (n = 217), and the Sons model reports the averages and diﬀerences of the ﬁrst born sons (n

= 235). All three models reveal similar results. Gen2 averages of gender standardized AFI were signiﬁcant predictors of Generation 2 diﬀerences in gender standardized AFI (p *< .*01), across all three linking methods. A one unit increase in the average gender standardized AFI predicted *≈* 0*.*38 units? increase in Generation 2 AFI diﬀerence, controlling for all over variables in the model. All other variables were not signiﬁcant, including all kin diﬀerence variables. The adjusted R2 varied slightly by Generation 2 linking method (Mixed = *.*090, Daughters

= *.*105, Sons = *.*131).

**Discussion**

This article presents the relationship between AFI and intelligence using two diﬀerence designs: a between-family design, and a within-family design (that also includes between-family variance within it as well). The between-family design allowed us to replicate previous researchers who used a cross-sectional sample. The within-family design allowed us to separate within- and between-family variance, to determine the source of the explanatory processes. The logic of this separate allows us to get much close to the evaluating intelligence diﬀerences within the family to address issues of causality. The results revealed a stark contrast between the two methods, and cast doubt on the validity of past causal assertions.

**Between- vs. Within-Family Variance**

**Between-Family Results.** Notably, the between-family analyses showed a relationship between intelligence and AFI. Thus, we were able to replicate the ﬁndings of various researchers (Halpern et al., 2000; Mott, 1983; Paul et al., 2000; Woodward et al., 2001), and

conﬁrm hypotheses 1 and 2. However the relationship between AFI and intelligence was substantially stronger between maternal intelligence and child AFI than between the child’s own intelligence and child AFI, which suggests that family-level variables rather than individual-level intelligence is tahe likely source of the relationship. If the child’s own intelligence had been the primary causal inﬂuence on AFI we would have expected a considerably weaker cross-generational association

between AFI and intelligence. Instead we ﬁnd that the within generation association is

the weaker eﬀect, suggesting that the child’s own AFI is likely derivative of the child’s mother’s interlligence, which is the more likely causal causal inﬂuence.

Thus, the “new” and alternative interpretation of this ﬁnding would be that maternal intelligence is driving the eﬀect, and that past between-family analyses finding a link between child’s intelligence and AFI are likely because child’s intelligence is indirectly measuring maternal intelligence. Smarter mothers might be more eﬀective at encouraging their children to delay intercourse – perhaps by eﬀectively conveying the riskiness of sexual intercourse (Hutchinson et al., 2003; C. Mathews et al., 2009). Considering that intelligence is highly heritable (Bouchard, Jr., 2004) and thus highly correlated across generations,

this alternative explaination would still be consistent with the traditional between family ﬁndings, which do not control for maternal intelligence (Halpern et al., 2000; Mott, 1983; Paul et al., 2000; Woodward et al., 2001). However, we note that the Hardin and Mendle (2012?) findings, using biometrically-informed data, implicated the shared environment in this causal process. Our results are entirely consistent with theirs, using a different dataset and a different methodological approach to identify important sources of variance.

**Within-Family Results.** In the within-family analyses, the eﬀect vanishes for both maternal intelligence and child intelligence. The child of the smarter Generation 1 mother was not more likely to delay intercourse compared to the child of the less-smart Generation 1 mother. Moreover, in spite of our ﬁnding that the Generation 1 intelligence was a relatively stronger predictor of Generation 2 AFI, we did not ﬁnd that diﬀerences in Generation 1 maternal intelligence to be associated with diﬀerences in Generation 2

AFI.

This results casts doubts on the alternative explanation for the between-family results we posed in the previous paragraph. For, if Generation 1 intelligence was driving the eﬀect, we would have expected to find a signiﬁcant within-family link from maternal intelligence to child AFI, which we did not. Thus, it is likely that the maternal intelligence score is itself standing-in for other between-family processes. We know that maternal intelligence is highly correlated with maternal/parental education, with family SES, with maternal age at first birth, and a number of other between-family processes.

We interpret these results in relation to two previous findings. First, Rodgers et al (2008) used Danish twin data, and found that the link from education/cognitive ability to maternal age at first birth was entirely accounted for by between-family variance: “variance in AFB emerges from differences between families, not

differences between sisters within the same family” (Rodgers et al, p. S202) Second, Harden & Mendle’s (2011) results, obtained using the Add Health data, use intelligence as a predictor and AFI as an outcome, just as we did. Their biometrical finding of meaningful shared environmental is the equivalent biometrical result to our finding of only between-family variance. But our design allows us to cast further doubt on the direct and causal influence of maternal intelligence, and leaves the general family environment and other factors correlated with maternal intelligence as the likely causal influences on AFI.

**Concluding Remarks**

Rodgers et al. (2008) looked at the relationship between IQ and education as they inﬂuenced age at ﬁrst birth in Danish twin data. Their conclusion:

[V]ariance in AFB emerges from [IQ and education] diﬀerences between families, not diﬀerences between sisters within the same family.

We have exactly the same result in the current study. Notably, the IQ diﬀerences between siblings are relatively small; is this important? Under a purely genetic model, Rodgers & Rowe (1987), estimated the average absolute deviation in IQ among random pairs to be 17.1 IQ points, compared to 12.1 for full siblings. But cousins, who also are in our study, deviate on average by 16.1 IQ points, nearly as much as random pairs.

We believe that diﬀerences within the family simply are not important for deﬁning

AFI outcome diﬀerences. This ﬁnding matches the Harden & Mendle (2011) biometrical analysis of Add Health, where they found that only shared environmental inﬂuences mattered those would manifest in between-family diﬀerences, but not in within-family diﬀerences.

Further, we’re not convinced that in these between-family analyses, intelligence is the actual cause of AFI diﬀerences if so, we think they would perhaps diﬀuse a bit, but would still show up in within-family analyses Rather, we think maternal and child IQ

are indirect measures of many other household features, any one of which may be more proximal as the causal explanation income, parental education, family interaction. Or, the whole package of these features may stand in for a general environmental factor, a “little e,” which indexes the quality of home environment a composite of parental income, intelligence, education, family interaction. [interesting, similar concluding remarks to the ones I wrote above. I like yours as well as mine, or feel free to blend them.]

Should add as cites

Geronimus & Korenman, one of more papers from 1990’s using the NLSY to do sibling studies of the outcomes of adolescent pregnancy

Udry’s paper in Demography, “What Biology Do Sociologists Need to Know?”

One or more of Udry’s papers on relation of hormones to adolescent sexual behavior – some co-authored with John Billy – at least one paper on male hormones, and one on females

A couple of Patricia East’s papers comparing teenage sisters, one who gets pregnant and one who doesn’t

Rodgers, 1984, Developmental Psych, Confluence Effects: Not Here, Not Now