Intelligence 42 (2014) 128–133

Contents lists available at ScienceDirect

Intelligence

Are birth order effects on intelligence really Flynn Effects? Reinterpreting Belmont and Marolla 40 years later

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ARTICLE INFO

Article history:
Received 17 April 2013
Received in revised form 11 July 2013
Accepted 6 August 2013
Available online 18 October 2013

Keywords:
Flynn Effect
Birth order
Intelligence
Cross-sectional data

ABSTRACT

I reinterpret a forty-year-old finding by Belmont and Marolla (1973), who believed their Dutch IQ patterns were caused by within-family processes related to birth order. However, their inferred relation was almost certainly caused by differences between families — in parental IQ, maternal education, and/or dozens of other processes. I show that the Flynn Effect (which emerges from and is likely caused by combinations of such between-family processes) can theoretically account for the Belmont and Marolla patterns. I then draw on past research and additional analysis to show that the Flynn Effect was actually occurring in The Netherlands at the correct time and magnitude to explain the Belmont and Marolla patterns.

1. Introduction

Forty years ago, a signal development in the scientific study of birth order was published by Belmont and Marolla (1973). After studying the relationship between birth order/family size and Ravens IQ scores in almost 400,000 Dutch military conscripts, they concluded: "This study serves to confirm the existence of independent relations of birth order and family size to intellectual performance" (p. 1100). Their result stimulated extensive birth order research and the development of several popular theories, including the confluence model (Zajonc, 1976) and the dilution model (Blake, 1981). But their conclusions implicated the incorrect explanatory source.

In this paper, I briefly review the birth order-intelligence literature, and I explain the artifact that has caused confusion and contention. The confluence and dilution theories place the explanatory power in the wrong theoretical source, within the family. But if birth order and related within-family processes are not the primary cause of cross-sectional IQ patterns, what did cause them? The Flynn Effect, which comes from outside the family and accounts for between-family differences, is the likely cause of the Belmont and Marolla (and many other) cross-sectional patterns.

2. The cross-sectional birth order artifact

Belmont and Marolla (1973) found a systematic decline in Ravens IQ scores across birth order and family size categories in a large (N = 386,114) cross-sectional population-based 1940's dataset of 19-year-old Dutch military conscripts (Fig. 1). The confluence model (Zajonc, 1976) posits that the average of the family's mental development affects developing children, and also posits a tutoring effect to account for the discontinuity of last-born Raven scores in Fig. 1. The dilution model (Blake, 1981) suggests that parental resources – attention, income, etc. – are diluted with more children within the family, affecting intelligence and other indicators of "child quality." These theories, which place the mechanisms to explain the Belmont and Marolla and other similar cross-sectional patterns within the family, predict negative relations between IQ and both birth order and family size for developing children; both theories

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http://dx.doi.org/10.1016/j.intell.2013.08.004

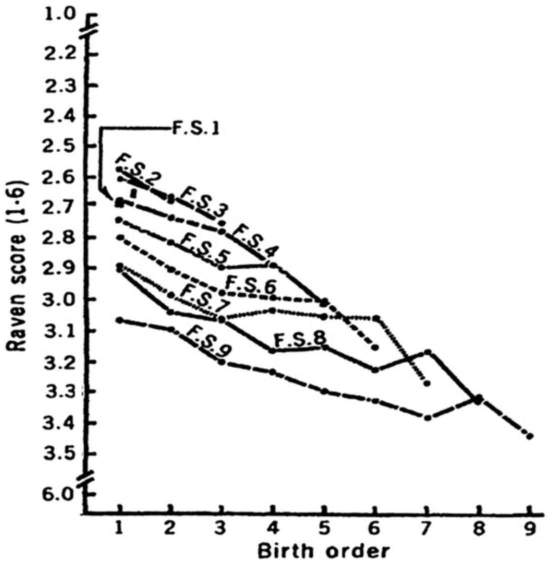

Fig. 1. The original Belmont and Marolla graph of birth order/family size by Ravens IQ. Ravens IQ of 2.8 equates to a standard IQ scale value of 100, and each Ravens .1 increment equates to 1 standard IQ point increment. The overall range of IQ means in the usual IQ metric is approximately [94,102.5].

were designed explicitly to match the Belmont and Marolla patterns. A competing theory to both confluence and dilution attributed the cause of the intelligence patterns to differences between families, an admixture hypothesis (Valendia, Grandon, & Page, 1978). This theory also predicts a negative relation between IQ and family size, but no relation between IQ and birth order. A roundtable arguing these various positions was published in *American Psychologist* 25 years after publication of the confluence model (Downey, 2001; Rodgers, 2001; Zajonc, 2001).

There exists a large and coherent literature criticizing birth order and other within-family mechanisms as explanations of cross-sectional IQ patterns, on both empirical and theoretical grounds. Schooler (1972) referred to birth order patterns in general as "not here, not now!" Criticism of birth order and its purported link to intelligence escalated following publication of the confluence and the dilution model. By now it is widely accepted by many birth order researchers (though still argued by others) that most (perhaps all) of the causal explanation for the Belmont and Marolla (1973) patterns came from sources outside the family. Belmont and Marolla's misattribution resulted from their use of cross-sectional data. Whereas birth order is a concept defined across siblings within a particular family, their data came from different families: The mean IQ for first-borns came from one set of families, the mean IQ of second-borns from (virtually) entirely different families, etc. In research designs based on cross-sectional data patterns, within- and between-family variance is inherently confounded, and cannot be distinguished. Given the confound, it is a risk to propose that IQ patterns (or any other outcome) emerge from within-family processes, because there are dozens of between-family processes that are eligible explanatory candidates as well. Yet, that risk has been engaged (apparently without full cognizance) by a number of researchers over the past 40 years. Rodgers, Cleveland, van den Oord, and Rowe (2000) presented a pragmatic and simple example:

> "To illustrate, imagine comparing the first-born child in a large middle-class White family in Michigan to the second-born child in a medium-sized affluent Black family in Atlanta to a third-born child in a small low-income Hispanic family in California. If differences between these children's intelligence are observed, it is impossible to tell whether they are due to SES, race, region of the country, birth order, family size, or other variables related to these. Yet, that is exactly the type of comparison that arises from cross-sectional data" (p. 602).

It is notable that Blake (1981), even as she promoted dilution (which can have both between- and within-family influences, creating the confound discussed above) took exception to the need for Zajonc's tutoring effect within the confluence model, noting that the original research on the Dutch data (see Stein, Susser, Saenger, & Marolla, 1972) evaluated the effect of a famine in The Netherlands on IQ outcomes. Blake argued that this primarily between-family effect caused the last-born discontinuity, thus shifting the Zajonc explanation for the last-born discontinuity in the Belmont and Marolla data outside the family, an argument that anticipates the main point of the current paper. Regarding this particular between-family confound, she concluded (p. 432) that "only and last-born children in this cohort of young Dutch men appear to have been negatively selected — on average they were more likely to come from families that suffered the worst." Her argument also and at least partially accounts for a recent finding by Kristensen and Bjerkedal (2007) showing that IQ scores of second-born brothers who lose a sibling to death, and third-born siblings who lost two siblings to death, approximately match first-born scores; their argument is that birth order must be a social rather than biological variable as it influences intelligence. However, their basic birth order finding is based on a (primarily) cross-sectional dataset similar to Belmont and Marolla's (1973) data; further, the families in that dataset who experienced death of an older sibling were undoubtedly different from those who did not (just as Belmont and Marolla's data contained between-family variance caused by the effect of famine), in potentially many different ways, and so the comparison confounds birth order interpretations of the type that they offer with potentially dozens of between-family interpretations. When a within-family subset of these data were studied (Bjerkedal, Kristensen, Skjeret, & Brevik, 2007), a small birth order-intelligence effect remained, an unusual finding that runs counter to the corpus of other literature. However, they did not repeat the sibling-death analysis within this within-family dataset, and so we still don't know whether to interpret their original primarily cross-sectional result as emerging from within- or between-family variance (or, potentially, from both).

The obvious resolution is to use research designs based on within-family data to evaluate birth order and other within-family processes as they influence intelligence. Using within-family data from multiple families, within- and between-family variance can be analyzed into separate components, and properly attributed. This methodology has been used and elaborated in a number of previous papers (Guo & VanWey, 1999; Kanazawa, 2012; Retherford & Sewell, 1991; Rodgers et al., 2000; Steelman & Mercy, 1980; Valendia et al., 1978; Wichman, Rodgers, & MacCallum, 2006, 2007). Of critical importance, empirical investigation of within-family patterns has consistently found little or no birth order effect related to intelligence after between-family differences are accounted for. Within-family data sources that have shown statistically null effects include Outhit's (1933) small family dataset analyzed by Rodgers et al. (2000), a small sibling pair dataset analyzed by Pfouts (1980), Galbraith's (1982) within-family Utah data, several hundred families of sibling data from Fels analyzed by Rodgers (1984), Retherford and Sewell's (1991) large and representative family sample from the state of Wisconsin, and the National Longitudinal Survey of Youth data analyzed by Guo & VanWey (1999), Rodgers et al. (2000), and Wichman et al. (2006). In the very few within-family studies in which significant birth order (or related within-family) effects remained, they were relatively small (e.g., Bjerkedal et al., 2007). (It is noteworthy, furthermore, that virtually all of the within-family studies have used U.S. data, whereas the Bjerkedal et al. (2007) study used data from Scandinavia; differences between countries/cultures in birth order patterns is certainly plausible.) To summarize, belief in a theoretically meaningful relationship between birth order and intelligence emerged exclusively from cross-sectional data (with especially strong influence emerging from Belmont and Marolla's data patterns, then following from many other cross-sectional datasets); but these data sources cannot logically isolate birth order patterns from other explanatory sources. When data are used that reflect both within- and between-family processes, most or all of the meaningful IQ variance comes from differences between families.

If the original Belmont and Marolla (1973) patterns (Fig. 1) were not caused by birth order or other related within-family processes, then what did cause these systematic and fascinating patterns? There are many potential contenders that vary across families (and groups of families), including household SES, parental IQ/education, maternal age at first birth, parenting style, and various neighborhood, school, and community effects (Rodgers, 2001). A new explanatory process will be investigated here, one with broader theoretical scope than those listed above (because it subsumes many of those as special cases).

3. The Flynn Effect

The Flynn Effect (FE) is the name given to the systematic increase in IQ scores across time. Lynn (1982) and Flynn (1984, 1987) re-discovered the effect, which was originally identified many years before; see Lynn (in press) for an early history. The FE has been documented in dozens of countries around the world and for at least the past century. The size of the effect is usually around 3 IQ points per decade in well-developed counties, and occurs primarily in fluid intelligence associated with problem solving and analytical reasoning (Flynn, 1984; Rodgers & Wanstrom, 2007). Crystallized intelligence – verbal reasoning and memory – is usually found to be approximately flat (though a few recent studies have found small crystallized FE patterns).

No single FE cause has been widely accepted, although many explanatory hypotheses exist (see Ang, Rodgers, & Wanstrom, 2010, and especially Flynn, 2009, 2012, for summaries, evaluation, and critique of these various theories). These include hypotheses related to nutrition (Lynn, 1989), test taking skills (Brand, 1996), educational improvements (Blair, Gamson, Thorne, & Baker, 2005), outbreeding (Mingroni, 2007), gene-environment correlations that involve niche-picking related to intellectual level (Dickens & Flynn, 2001), a related theory involving "social multipliers" (Flynn, 2009), medical improvements (Steen, 2009), changing fertility patterns (Sundet, Borren, & Tambs, 2008), collective memory (Mahlberg, 1997) and a multiplicity hypothesis (Jensen, 1998). The FE is apparently a period effect, occurring outside the family (Rodgers, 1998). No within-family data exist that document an *increase* in intelligence over birth order, suggesting that its source derives from outside the family and will only manifest in data and analyses that account for between-family variance (such as cross-sectional data).

The FE was occurring in post-WWII in The Netherlands when the Belmont and Marolla data were collected. In a study that appears to be entirely separate from birth order research, but which is actually quite relevant to this research arena, te Nijenhuis and van der Flier (2007) used empirical and norming data from The Netherlands in the 1940's/50's and showed an FE of 3.15 IQ points per decade on fluid intelligence, and .45 IQ points on a verbal subscale. Raven (2000) identified an FE of similar magnitude in both Belgium and Scotland during this same period. These studies establish the existence of the FE in and around The Netherlands when the Belmont and Marolla data were originally collected. Flynn (1987) documented even greater Raven IQ gains in and around The Netherlands over the next three decades. Using longitudinal data from the same Dutch conscripts on which the Belmont & Marolla (1973) analysis was based, he estimated an 18.5 IQ point increase between 1954 and 1981, a 27.5 year interval, which rescales to 6.7 IQ points per decade. He estimated a gain of around 7 Raven IQ points over a nine year period between 1958 and 1967 in Belgium, and a 25 point Ravens IQ gain between 1949 and 1974 in France.

4. How does the Flynn Effect appear as a birth order effect?

Fig. 2 demonstrates how a cross-sectional sample can confound birth order and temporal change. This figure is a re-portrayal using modern graphical methods of one that appeared in my dissertation (Rodgers, 1981). It was published there prior to the re-discovery and popularization of the FE by Lynn (1982) and Flynn (1984), and fully anticipated the current argument: "Thus, if firstborns [in a cross-section] are used to draw inferences to all firstborns, secondborns to all secondborns, etc., any factor changing systematically with time will contaminate these data in ways that cannot be controlled without longitudinal information" (p. 50). More specifically, this figure demonstrates (through the arrows and annotation at the top of Fig. 2) that the parents of first-borns in a cross-section start having children later in time on average than parents of second-borns, etc. Under a period-effect interpretation of the FE that assumes that the effect is acting systematically on parents, children, and/or families, the FE perfectly explains the direction of the Belmont and Marolla patterns. Secular increases in IQ will manifest in a cross-sectional sample as an apparent (but artifactual) birth order effect, with higher IQ scores for lower birth orders.

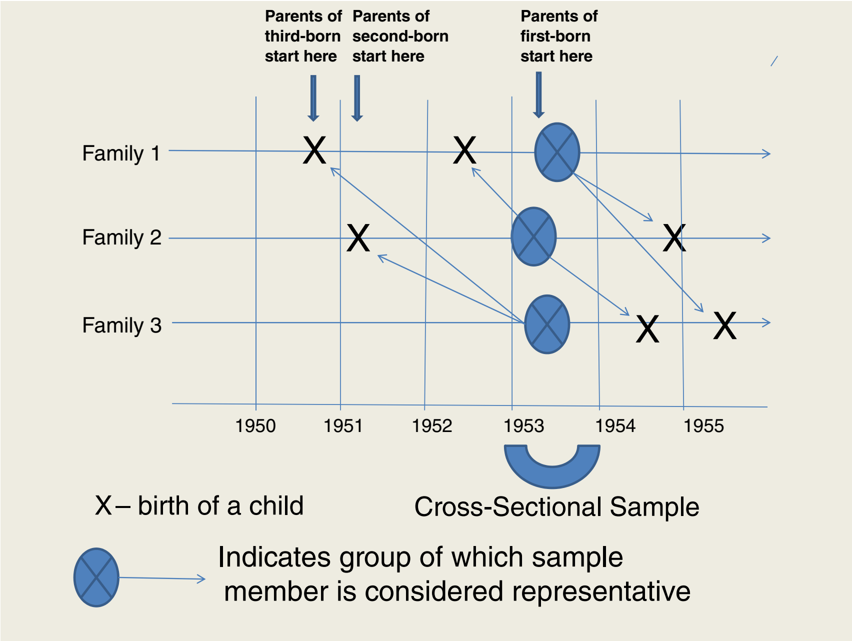

Fig. 2. Demonstration of the secular-change by birth order confound in cross-sectional data (figure revised from Rodgers, 1981, p. 51).

If the FE explains the direction of the pattern in the Belmont and Marolla (1973) data, can the magnitude also be accounted for? The Belmont and Marolla IQ scores were based on Raven's matrices, administered in an environment in which te Nijenhuis and van der Flier (2007) estimated an FE rate of 3.15 for fluid intelligence and .45 for crystallized intelligence. The Ravens IQ scores are heavily loaded on fluid intelligence, leading to an estimate of a Ravens FE of between 2.5 and 3.2 as the prevailing FE in The Netherlands during the period when the Belmont and Marolla data were collected.

The question is whether the Belmont and Marolla birth order patterns themselves are quantitatively consistent with this FE target? To estimate the size of the FE that would be necessary to reproduce the Belmont and Marolla patterns requires birth spacing information. de Haan (2010) estimated mean birth spacing in The Netherlands during the 1940's to be 33.8 months (2.8 years), with a standard deviation of 17.1 months. I applied this estimate to the patterns from Belmont and Marolla's Table 3. Between birth order one and two in families of size two there was 1.0 IQ point difference (after converting Ravens scores into the standard IQ metric).

Table 1
Belmont and Marolla IQ (Ravens) differences, adjusted by birth intervals and rescaled into a ten-year effect.

Birth order comparison	Mean age gap	IQ difference[a]	IQ difference per decade
1–2	2.8	1.0	3.6
1–3	5.6	1.4	2.5
1–4	8.4	2.1	2.5
1–5	11.2	2.7	2.4
1–6	14.0	3.5	2.5
Unweighted mean			2.7
Weighted mean			2.6

[a] IQ differences are obtained from Belmont and Marolla (1973), Table 3.

Extrapolating the 2.8 years (on average) between first and second-borns to a decade produces an estimate of 3.6 IQ points. Using the same reasoning for larger families produces estimates of IQ change per decade of 2.5 for three-child families (a 1.4 point IQ change in 5.6 years), 2.5 for four-child families (a 2.1 point IQ change in 8.4 years), 2.4 for five-child families (a 2.7 point IQ change in 11.2 years), and 2.5 for six-child families (a 3.5 point IQ change in 14.0 years). The unweighted mean of these five estimates is 2.7, and the mean weighted by number of children is 2.6, both consistent with the [2.5, 3.2] interval estimated from the te Nijenhuis and van der Flier (2007) results. (These estimates occur within the context of a median raw score standard deviation of 15, and a median standard error of the IQ means of .1 in standard IQ units.) This analysis, summarized in Table 1, demonstrates that the FE is capable of explaining both the direction and size of the birth order patterns in the Belmont and Marolla data.

5. Discussion

Several methodological and empirical implications emerge from the current paper. The first is to repeat the often-stated (but not always appreciated) desiderata that no research using birth order as an independent variable (on any outcome, intelligence, personality, delinquency, etc.) can be properly conducted without explicit attention to within-family versus between-family variance. Second, unless other methodological approaches are used involving design innovation or statistical control (e.g., instrumental variable methods, propensity score matching, etc.), cross-sectional data should simply be taken off the table as acceptable for birth order research. The occasional use of one or a few linear covariates or blocking variables in cross-sectional datasets (e.g., Belmont & Marolla, 1973, separated their results by levels of SES) is not an effective adjustment methodology in cross-sectional datasets for the potentially dozens of between-family processes that are confounding such data. Finding these typical patterns in cross-sectional data, and labeling them birth order effects, is a risk that has had substantial costs and few benefits during the past 40 years. Third, despite their innate fascination and large body of past research, the confluence and dilution models should not be given credit for explaining patterns that, in fact, were not really there. Both were built to explain how intelligence (and other child quality indicators such as completed education) declines with increasing birth order among developing children within families, as Belmont and Marolla (1973) stated that their results demonstrated. Rather, the FE was creating the appearance of birth order effects on intelligence that did not really exist at any meaningful level within the Belmont and Marolla families, but instead were emerging from between-family differences. To summarize, whatever is causing generally increasing IQ shows up in cross-sectional data as apparent birth order effects, because of the inherent confound in cross-sectional data between secular trends (like the FE) and birth order patterns.

The current findings motivate several future doctoral dissertations and research studies that focus on re-interpretation of other cross sectional birth order patterns besides those in Belmont and Marolla (1973). Zajonc published many cross-sectional findings in his articles, as did others. Does the FE succeed in explaining these patterns as well? This is still an outstanding and unresolved research question for many cross-sectional data sources. One important dataset does have relevant information. The FE has been identified over the period of 1986 to 2004 in the NLSY-Children data by Rodgers and Wanstrom (2007) and Ang et al. (2010). This same dataset was used by several birth order researchers (Guo & VanWey, 1999; Rodgers et al., 2000; Wichman et al., 2006), though in each case these investigators used the within-family structure of this data source to effectively partition and separate the within- and between-family data. Both Rodgers et al. (2000) and Wichman et al. (2006) showed that without such adjustment, a cross-sectional version of the NLSY-Children data showed the typical declining pattern of IQ scores across birth order. In retrospect, we can attribute this cross-sectional decline to our knowledge that the FE was affecting these data patterns in the cross-section (and more specifically to the one or several causes of the FE). Retherford and Sewell (1991) also compared a cross-sectional version of their Wisconsin data to within-family patterns obtained from the same data, and found almost exactly the same divergent results found by Rodgers et al. and Wichman et al.

The current methodological argument does not, in and of itself, obviate the possibility of real within-family birth order patterns related to intelligence (or other outcomes as well). The large body of within-family research from the U.S. raises skepticism about such a correlation, but other findings in Scandinavia regarding both birth order and the FE show differences compared to results from other parts of the world. For example, Sundet, Barlaug, and Torjussen (2004) found a decline in the size of the FE in Norway that has not matched results in other places, and Bjerkedal et al. (2007) found one of the few consistent within-family birth order effects in their Norwegian data. Thus, although real birth order effects could still exist, the important methodological point – and one ignored by many birth order researchers since Belmont and Marolla – is that such patterns cannot be claimed unless modern methodological innovations are accounted for (see Wichman et al., 2007, for expansive discussion of this point; also see Bard & Rodgers, 2003; Rodgers et al., 2008; Rodgers, Rowe, & Harris, 1992, for empirical demonstrations in the context of designs and analyses that partition within- and between-family variance of intelligence and other outcomes). Researchers must use methods that can separate within-family and between-family variance, and must account for the many between-family confounds that we know to exist (both measured and unmeasured) before claims of within-family birth order effects can be considered legitimate. The current paper highlights how time-related changes in outcomes can stand-in for other apparent causal factors.

As an important methodological point, there are many ways that time effects can show up and interfere with the internal validity of causal inference; the FE is only one of those. Another FE-related effect is identified in a paper by Wicherts et al. (2004), who assessed whether part of the cause of the FE is due to measurement invariance across time. Genovese (2002) demonstrated how the meaning of the term “intelligence” can change dramatically over time. The careful modeling of the underlying latent variable that we call intelligence, and the expectation that this term likely means different things at different times and in different scholarly treatment of intelligence gains, is a critical contextualizing feature of all modern longitudinal research on human intelligence. Another example of a time-related effect that has surprising longitudinal implications is one documented in Flynn (2009) and Gladwell (2008), related to the timing with which children begin school. Children who are old within their school grade have considerable sports advantages compared to those who are young in their grades, and these can be observed empirically well into adolescence. Flynn noted that the same kinds of advantages likely accrue as regards intellectual development, and casts that consideration in the context of the Dickens and Flynn (2001) theory of intellectual niche-picking by intellectually advantaged individuals. This type of time effect is entirely different from the FE, as it occurs as a within-individual effect rather than as a period effect across individuals/families. But the importance of carefully modeling time-related phenomena as potential threats to internal validity is a broad and important theme.

In conclusion, the FE existed in The Netherlands in the 1940's (and likely before and definitely after, as well). The FE patterns are sufficient to explain the direction and magnitude of the Belmont and Marolla (1973) results. The FE does not obviate the interpretation of other between-family variables explanatory of the apparent IQ-birth order patterns, such as maternal IQ and household SES, as these are likely part of the (still not fully specified) cause of the FE. Indeed, given that the cause of the FE itself is not fully specified (but likely is embedded within the various sources reviewed earlier in this paper), the particular one or multiple causes underlying the cross-sectional confound is also unspecified. Emerging from this new explanatory framework, however, is awareness that explaining increases in IQ patterns has broader implications than originally believed. In studying the FE, researchers are also providing potential explanations for the ubiquitous (but largely artifactual) relation between intelligence and birth order in cross-sectional data. The FE explains and accounts for the nature of the artifact in the Belmont and Marolla data that contaminated their cross-sectional data, and likely many other similar sources, in a large body of birth order research conducted over the past 40 years.

Acknowledgments

This article has been in development for a very long time. It was originally prepared as an invited address to the University of North Carolina Psychology Department in February, 2012, to support the author's recognition for a Distinguished Alumni Award. This work began in the late 1970's, when I was a graduate student at UNC. Retired UNC faculty Vaida Thompson, Lyle Jones, and Ron Rindfuss served on my dissertation committee in 1981 (and Vaida and Lyle were in the audience when I presented this work in 2012). Others who contributed directly include Tom Wallsten, who helped to get me started thinking about birth order and intelligence, and Bill Revelle, with whom I discussed the possibility that birth order effects might be caused by the Flynn Effect at a conference a number of years ago.

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