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CHAPTER 2

BIRTH ORDER, SIBLING COMPETITION, AND HUMAN BEHAVIOR

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Abstract: Sibling competition is widespread among bird and animal species and sometimes leads to siblicide. By influencing the strategies that siblings employ in their struggles for dominance, birth order affects the outcomes of such contests. In our own species, birth order is a proxy for disparities in age, physical size, and status, all of which contribute to personality. In addition, birth order is related to the roles and niches available to offspring within the family system. On average, firstborns—who tend to act as surrogate parents—are more conscientious than laterborns, whereas laterborns are more agreeable, extraverted, and nonconforming. As strategies for dealing with rivals in a dominance hierarchy, as well as for optimizing parental investment, these sibling differences are consistent with a Darwinian perspective on family life. So are other links between personality and family dynamics, particularly those associated with parental investment and parent-offspring conflict. In adulthood, human behavior continues to reflect these formative influences, although such behavioral dispositions generally need to be catalyzed by appropriate situations in order to be fully expressed.

1. THE BIOLOGY OF SIBLING COMPETITION

A wide variety of animal species exhibit birth-order differences in behavior, usually in competition for parental investment. These behavioral effects are influenced by two distinct kinds of biological causes: *ultimate* and *proximate*. Ultimate causes include adaptive tendencies that have evolved by natural selection. Proximate causes comprise influences operating during the lifetime of the organism and encom-

pass biological as well as environmental factors, which almost always interact with one another. For example, some avian species possess an instinct to migrate during the autumn and spring, an adaptation that has its ultimate cause in natural selection. Temperature and day length, along with the various neuropsychological mechanisms they trigger, supply the proximate causes of bird migration (Mayr, 1961).

Viewed in these conceptual terms, a biological propensity to engage in sibling rivalry is one of the ultimate causes of personality development. Darwin's theory of natural selection explains this part of the story, which focuses on the biological dispositions that most offspring have to compete for parental favor. As William Hamilton (1964) recognized, natural selection maximizes inclusive fitness. This form of Darwinian fitness can be defined as an organism's own reproductive success, together with its contribution to the reproductive success of close relatives, discounted according to their coefficient of relatedness. On average, siblings share half of their genes. Hamilton's theory asserts that siblings will compete for scarce resources whenever the benefits of doing so are greater than twice the costs. Competition for parental investment is the main cause of sibling rivalry.

From a Darwinian point of view, sibling competition and parent-offspring conflict are flip sides of the same coin. Parents are equally related to all of their offspring and generally favor equal sharing among them, whereas siblings usually prefer a bias in their own favor. Among animals, weaning conflicts are an example of such disagreements. At the time of weaning, offspring want parents to continue investing in them, and them alone, whereas parents are inclined to reserve additional investment for future offspring (Trivers, 1974).

Darwinian and Freudian theory supply contrasting explanations for parent-offspring conflict, as Daly and Wilson (1990) have pointed out. In Freudian theory, such conflicts have their origins in the child's desire for sexual access to the opposite-sex parent—an urge that constitutes the Oedipus complex. In Darwinian theory, sexual desires have nothing to do with these conflicts. Rather, siblings compete to optimize parental investment and hence to get out of childhood alive. Siblings may be inclined to harm their rivals for parental investment, but they have no Darwinian incentive to harm a parent—at least not for the reasons Freud himself envisioned.[1] As Daly and Wilson have argued, Freud systematically misinterpreted evidence for parent-offspring conflict—which is generally nonsexual in nature—to fit his theoretical expectations.[2]

Siblicide

Fatal sibling competition has been documented in insects, fish, and mammals. Even plants exhibit competition that sometimes ends in siblicide. The Indian black plum tree (*Syzygium cuminii*) develops seeds having 25 to 30 ovules—all siblings. Only one ovule survives to become the pit of the mature fruit—usually the ovule that is fertilized first. This first-fertilized seed secretes a "death chemical" that prevents its siblings from being able to metabolize sucrose, causing them to starve to death (Krishnamurthy, Shaanker, & Ganeshaiah, 1997).

Among animals, sibling competition usually centers around parental investment. Among sea birds and predatory birds, siblicide is particularly common (Mock, Drummond, & Stinson, 1990; Mock & Parker, 1998). In some species, such as African black eagles (*Aquila verreauxi*), siblicide is "obligate"—occurring in almost every instance. The female of this species lays two eggs, and the first-hatched chick pecks its younger sibling to death during the first days of life. In one documented case, an elder chick delivered more than 1,500 pecks to its younger sibling during the latter's three-day lifespan. "In all siblicidal species studied to date," report Mock et al., "there is a striking tendency for the victim to be the youngest member of the brood" (1990, p. 445). It is noteworthy that avian parents never intervene when chicks are engaged in siblicidal aggression. The parents' own genetic interests are generally best served by raising one healthy chick rather than two undernourished ones.

Among blue-footed boobies (*Sula nebouxii*), females lay two or even three eggs. Siblicide is conditional in this species, depending on the food supply, which is therefore a proximate cause of siblicide. Aggressive pecking of a younger chick by an elder begins when the elder's body weight drops below 80 percent of normal. In experimental studies in which the necks of booby chicks have been taped to prevent them from ingesting food, aggression increases sharply and is especially pronounced in the elder chick (Drummond & García-Chavelas, 1989).

Hatching order in boobies is associated with learned behaviors. In one experimental study, junior chicks that had developed subordinate behaviors were removed from their nests and paired with smaller dominants from another nest. Size normally decides dominance in boobies. In this experiment, however, smaller chicks that had previously been seniors were successful in achieving dominance over larger but previously junior chicks. The superiority of the smaller senior chicks

owed itself to their refusal to submit when attacked, and by their generally being more capable fighters than chicks that had previously been subordinate (Drummond & Osorno, 1992).

Whether siblicide is conditional or unconditional is determined by various ecological considerations that have shaped the genetic predispositions of each species. Blue-footed boobies do not have fixed territories, and, when the food supply is plentiful, they can generally rear more than one chick in a year. By contrast, African black eagles occupy fixed territories and their young require unusually large amounts of food, circumstances that limit the parents' ability to raise more than one chick, even in a very good year.

Why do avian parents regularly lay more eggs than are needed in any given breeding season? Two adaptive benefits are associated with this practice. First, an additional chick represents an insurance policy, in case an older chick dies of disease or predation. In species in which siblicide is conditional, the parents' reproductive success is enhanced whenever the food supply allows them to raise more than one offspring. Blue-footed boobies, for example, sometimes successfully rear three chicks, and many birds of prey are able to fledge two offspring.

Even in species in which siblicide is absent, proximate-causal mechanisms often regulate sibling competition. Female canaries (*Serinus canaria*) lay four or five eggs, which hatch on different days. Compared with their earlier-hatched siblings, the later-hatched chicks are physically underdeveloped. By lacing each successive egg with greater amounts of testosterone, female canaries even the competition. The fifth egg, for example, may receive twice as much testosterone as the first. Testosterone accelerates neural development and also makes chicks more pugnacious, allowing the later-hatched chicks to compete more effectively for food (Schwabl, 1996; Schwabl, Mock, & Gieg, 1997).

Specialized Adaptations for Sibling Competition

Among species that exhibit intense sibling competition, specialized adaptations have sometimes evolved to enhance the individual's chances of survival. Such adaptations for sibling competition often include weaponry in the form of teeth and other sharp structures. Tadpoles of the spadefoot toad develop teeth with which they cannibalize their broodmates (Bragg, 1954). Piglets are born with eye teeth that they shed after having competed for the sow's most nourishing teats. The earliest-born piglets head directly for the anterior teats,

which are richest in milk supply, and they fiercely defend these teats against encroachment by laterborn piglets. Compared with firstborn piglets, piglets born in the latter half of the litter are twice as likely to die before the third week (Trivers, 1985, p. 23).

Another striking case of adaptation for sibling competition involves spotted hyenas (*Crocuta crocuta*). Sibling competition begins as soon as the second pup is born, and fighting has been observed while the younger pup is still encased in its amniotic sac. Unlike other carnivores, hyena pups are born with fully erupted teeth, which assist them in these brutal struggles. Among spotted hyenas, 25 percent of offspring succumb to sibling aggression. In same-sex litters, the mortality rate is 50 percent. One explanation for this difference in mortality rates draws on theories about adult competition over reproduction (Hamilton, 1967). Female hyenas compete for the right to reproduce, and offspring generally acquire the rank of their mothers. Killing a sister eliminates a close-ranking competitor (Frank, Glickman, & Licht, 1991). This hypothesis works less well for siblicide among males, who disperse in early adulthood, so one must be cautious about endorsing an adaptationist interpretation for both sexes. Still, juvenile males face the task of integrating themselves into a new clan, and physical size is positively correlated with rank and reproductive success. Singleton pups experience greater rapid weight gain during the first year of life. As adults, they may also enjoy a reproductive advantage in competition with other males.

Evolution sometimes leads to specialized adaptations promoting sibling cooperation. In the Taiwanese aphid (*Pseudoregma alexanderi*), offspring exist in two forms, one of which is a soldier caste that defends the other caste from attack. Because members of this soldier caste remain in the first larval stage, they do not reproduce (Trivers, 1985, p. 42). Such morphological adaptations for altruistic behavior are explained by Hamilton's theory of kin selection. Because Taiwanese aphids reproduce parthenogenetically, offspring carry the same genes. The soldier caste's genes are therefore passed on by their reproductively active twins.

Hamilton's theory was prompted by his own study of another particularly altruistic insect group, namely, the social insects. Owing to the unusual genetic system of these species—called haplodiploidy—females are more closely related to their sisters (by 3/4) than they are either to their brothers (by 1/4) or to their own offspring (by 1/2). The unusually cooperative nature of social insect societies revolves around the fact that sisters, who do most of the work, suppress their repro-

ductive potential in favor of a queen, who rewards their self-sacrifice by producing more sisters (Hamilton, 1964).[3]

2. BIRTH ORDER AND SIBLING COMPETITION AMONG HUMANS

Just as with many species of lower animals, human offspring compete for parental favor. Birth order is just one of many factors that influence the ways in which this competition is expressed. By itself, competition among siblings does not cause birth-order differences in personality. But birth order is a powerful proximate (environmental) source of sibling strategies. These strategic variations arise because birth order is correlated with differences in age, physical size, power, and status within the family. These disparities cause siblings to experience family relationships in dissimilar ways and to pursue differing ways of maximizing their parents' investments in their welfare.

Competition for parental love has been an important driving force in human evolution, just as have been parental decisions about how to invest in offspring. Before 1800, half of all children did not survive childhood, and differences in parental favor, mediated through nutrition and health care, influenced which children reached adulthood (Voland, 1988, 1990). Children living long enough to become the eldest in a family were often a better Darwinian bet for their parents. Having survived the most perilous years of life, these children were more likely than their younger brothers and sisters to reach the age of reproduction and to pass on their parents' genes. In every society surveyed by anthropologists, eldest children are accorded higher status (Rosenblatt & Skoogberg, 1974). For example, many traditional societies permit infanticide, especially when a child is deformed or when a slightly older infant is still breast-feeding, but no society allows the killing of the older of two siblings (Daly & Wilson, 1988, pp. 41-46).

Parental investment strategies tend to be variable because parents themselves do not always share the same interests and because birth order is only one of many relevant factors in these decisions. In addition to taking into account the relative quality of their offspring, parents may invest differentially in children based on such considerations as the parents' age and available resources. Leaving property exclusively to the eldest child or son (primogeniture) is a policy that has been practiced by affluent parents in agrarian societies, where wealth is tied to land and where talent does not matter much. This inherit-

ance system is much less common in mercantile societies where wealth can be acquired rapidly through entrepreneurship. Under these conditions, parents tend to invest equally in all of their offspring (Hrdy & Judge, 1992; Sulloway, in press-b).

Even when parents do not favor one child over another, sibling competition influences the dynamics of family life because it promotes diversity. Such competition generally involves the cultivation and exploitation of family niches that correspond to differences in birth order. That families provide offspring with a series of niches is a conclusion that is also suggested by research in behavioral genetics (Plomin & Daniels, 1987). During the last two decades psychologists have discovered that brothers and sisters raised together are almost as different in their personalities as people who grow up in separate families. From studies of twins raised together and apart, behavioral geneticists have concluded that only about 5 percent of the variance in individual personality traits is attributable to the shared environment—that is, growing up in the same family—whereas 35 percent is associated with the nonshared environment. About 40 percent of the overall variance is believed to be genetic, and the remaining 20 percent is attributable to errors of measurement (Loehlin, 1992).

By suggesting that the family is not a single environment, but rather a collection of microenvironments or "niches," these research findings have begun to reshape the understanding of personality development. The main reason why the shared family environment does not have a substantial impact on personality is that very little of the family experience is actually shared. For example, siblings often interpret shared experiences differently, something that is reinforced by the circumstance that brothers and sisters are at different ages when they experience the same events within the family. One particularly important and systematic source of nonshared experiences is birth order.

3. BIRTH ORDER AND PERSONALITY

Ever since Charles Darwin's cousin Francis Galton (1874) reported that eldest sons were overrepresented as members of the Royal Society, psychologists have been investigating the consequences of birth order. Alfred Adler (1927, 1928) highlighted social influences on personality, including birth order, as part of his challenge to Sigmund Freud's biologically based theory of psychosexual development. Adler regarded firstborns as "power-hungry conservatives," middleborns as competitive, and youngest children as spoiled and lazy.

Psychologists have conducted more than two thousand studies on the subject of birth order since Adler set forth his own theories on the subject. Critics of this literature have rightly argued that the findings conflict and that most studies are inadequately controlled for social class, sibship size, and other background influences that, because they correlate with birth order, can lead to false conclusions. Nevertheless, meta-analysis—a technique for aggregating findings from different studies in order to increase statistical power and reliability—suggests that these differences are robust. If we consider those well-designed studies that control for sibship size and social class, meta-analysis points to consistent birth-order differences for many personality traits. These conclusions may be summarized in terms of the Five Factor Model of personality (Sulloway 1995, 1996, in press-a).[4]

Studies generally show that firstborns are more *conscientious* than laterborns, a difference that is exemplified by their being more responsible, ambitious, organized, and academically successful. Laterborns emerge as being more *agreeable* than firstborns, in the sense of being more tender-minded, accommodating, and altruistic. Differences by birth order are more limited and mixed for the three remaining dimensions of the Five Factor Model. Laterborns appear to be more *open to experience*, as expressed by their being more nonconforming and unconventional; by contrast, firstborns appear to be more open to experience in ways that reflect intellectuality. Compared with laterborns, firstborns also appear to be more *neurotic* in the sense of being temperamental and anxious about their status. Lastly, firstborns are more *extraverted* than laterborns, in the sense of being assertive and dominant; whereas laterborns are more extraverted in the sense of being fun-loving and sociable. Sociability and assertiveness are substantially different personality traits, even though they are classified together within the Five Factor Model.[5]

Firstborns tend to have higher IQs than laterborns, but this difference is small, especially after one controls for differences in sibship size. On average, IQ declines one point with each increase in birth rank. Proponents of the Five Factor Model consider IQ to be a sixth factor, largely independent of personality. The causes of these reported IQ differences are controversial and have given rise to several competing theories. According to the confluence model (also known as the resource dilution hypothesis), firstborns experience an environment that is intellectually richer than the one experienced by laterborns, who progressively dilute this environment with their own relative lack of intellectual ability (Zajonc & Mullally, 1997; Zajonc, 2001; and

Downey, 2001). Considerable evidence—both developmental and cross-cultural—appears to support the validity of this hypothesis in samples fully controlled for social class and sibship size, although some critics remain unconvinced (Retherford & Sewell, 1991; Rodgers, Cleveland, van den Oord, & Rowe, 2000; Rodgers, 2001).

Psychological Mechanisms: A Family Dynamics Model

The personality differences I have just reviewed are consistent with a Darwinian framework, albeit one that gives preeminence to adaptation through learning. Unlike the biologically driven propensity to compete with one's siblings, which is an ultimate cause of sibling conflicts, personality is shaped by various proximate causes that spur individuals to adapt themselves to the surrounding world. Firstborns often seek the favor of their parents by serving as a surrogate parent for their younger siblings. As a result, firstborns tend to be conscientious, parent-identified, and respectful of authority. Laterborns cannot babysit themselves, so they seek out an unoccupied family niche, in part by cultivating latent talents that can be discovered only through experimentation. For these reasons, laterborns are generally more exploratory, unconventional, and tolerant of risk.

Another reason for the disparate personalities of siblings is the different strategies they employ in their relations with one another. These strategies derive from behaviors that are typical of mammalian dominance hierarchies. Because firstborns are bigger than their siblings, they are more likely to employ intimidation and physical aggression; and in general they are more inclined to boss and dominate their brothers and sisters. Laterborns tend to use low-power strategies, such as whining, pleading, humor, social intelligence, offers of reciprocal altruism, and, whenever expedient, appealing to parents for help. Two or more laterborns may also join forces against the firstborn, or laterborns may team up with their elder siblings in an effort to dominate their juniors.

A Darwinian approach to personality leads to specific predictions about middle children, who lack the advantages of being either first or last. Whenever resources are scarce and children are still largely dependent on parental care, parents are expected to invest preferentially in eldest surviving children because they are the first to reproduce. Parents are also expected to invest preferentially in youngest children because these offspring are the most needy and vulnerable to disease and, after parents have ceased reproducing, are the last children they

will ever have. Even when parents treat all of their offspring equally, middle children still receive fewer resources than firstborns and lastborns. This counterintuitive conclusion follows from the fact that firstborns and lastborns generally experience some period as only children, whereas middle children always share parental resources with another sibling (Hertwig, Davis, & Sulloway, 2001).

Middle children often respond to their Darwinian handicap by becoming peer oriented and independent of the family. Compared with firstborns and lastborns, middle children are less closely attached to the family, less likely to turn to their parents for help in an emergency, and less likely to report having been loved during childhood (Salmon, 1999; Salmon & Daly, 1998). Middle children are also likely to live farther away from their parents. In addition, they are less likely than their siblings to visit close kin.

Because only children experience no sibling rivalry, they are not driven to occupy a specific family niche and effectively represent a controlled experiment in birth-order research. Like other firstborns, they are generally achievement oriented and conform to parental authority, because these attributes are esteemed by parents. Contrary to psychological folklore, only children do not appear to be less sociable or more neurotic than other children (Ernst & Angst, 1983, p. 259).

Schachter, Gilutz, Shore, and Adler (1978) found that there is a greater difference in personality and interests between a firstborn and a secondborn child, or between a secondborn and a thirdborn, than there is between the firstborn and thirdborn. The reason is that sibling competition promotes mutual differentiation in order to avoid direct conflicts, and children who are farther apart in age have less need to compete. This process of sibling differentiation (or "deidentification") extends to relationships with parents. When a firstborn identifies more strongly with one parent, the next younger sibling is likely to identify more strongly with the other parent (Schachter, 1982).

Some of these contrasts are remarkable. Although the following evidence is purely anecdotal, it illustrates trends that have been documented in formal scientific studies. The youngest of three children, Voltaire (François-Marie Arouet) had an acrimonious relationship with his elder brother Armand. The elder brother became a follower of the Jansenists, a fanatical Catholic sect. Voltaire was particularly repelled by Armand's attempt to forgo life's pleasures in order to win God's grace. As a leader of the French Enlightenment, Voltaire became noted for his attacks on the Catholic Church. He also chose literature

as a profession in part to spite his brother, whom he had repeatedly defeated in impromptu poetry contests devised by his family.

Another example of sibling contrasts involves the consumer rights advocate Ralph Nader and his three older siblings. In early adolescence, the Nader children divided a globe of the world into four equal portions and assigned one to each sibling. Thereafter, each specialized in the culture, history, and languages of his or her own quarter of the globe. By cooperatively pooling their resources as a family unit, the Naders were able to learn far more about the world than if they had all chosen to compete directly with one another in the same domain. As Darwin recognized in the *Origin of Species* (1859), diversification is an effective way to reduce competition while also realizing the benefits arising from the division of labor.

In addition to affecting personality and interests, sibling deidentification has been shown to influence social attitudes. Among Chinese families living in Indonesia, Skinner (1992) found that traditionalism and filial loyalty were both related to firstborn status. He also found that social attitudes followed a zigzag pattern among siblings, with subjects generally being higher or lower on these attributes in direct contrast to the social attitudes of their nearest siblings in age.

Owing to this general process of sibling deidentification, laterborns may become more socially conservative than firstborns if parents themselves are unusually liberal. This is because the eldest child is likely to adopt the parental perspective on social issues (which, in these families, will be the "conservative" thing to do). If younger siblings wish to be different, they must adopt a more conservative social position. Much of the tendency toward rebellion among laterborns is probably attributable to sibling deidentification rather than to rejection of parental authority. In rebelling, laterborns are often repudiating the "surrogate parental" authority of their elder siblings rather than the authority of parents per se. For this reason, the nature of "rebellion" needs to be considered within the general context of family values (Sulloway, 1996, p. 507).

In sum, at least four causal mechanisms are candidates for explaining the environmental sources of sibling differences in personality and social behavior (Table 1). Some sibling differences are attributable to disparities in parental investment. Other sibling differences are associated with the occupation of disparate family niches. Still other behavioral differences have their origins in sibling-sibling interactions. Lastly, some differences arise because of deidentification among adjacent siblings. Each of these four behavioral mechanisms

Table 1. A family dynamics model of sibling differences in personality and social behavior

Causal Mechanism	Expected Sibling Differences	Direction of Expected Trends
1. Parental Investment	Compared with siblings receiving less parental investment, siblings receiving more investment are expected to be more conscientious, agreeable, and extraverted (in the sense of having positive emotions), less neurotic, and less open to experience (especially in the sense of being unconventional and rebellious). Also, offspring receiving greater parental investment should tend to identify more closely with the family and to be more strongly attached to it.	**Predominantly quadratic trends**, reflecting greater parental investment in firstborns and lastborns; but trends are expected to vary with the age of parents and also with the developmental timing of investments (Sulloway, 1996; Salmon & Daly, 1998; Hertwig, Davis, & Sulloway, 2001).
2. Niche Partitioning (firstborns as surrogate parents, laterborns as family newcomers seeking an open niche)	Siblings who act as surrogate parents should be more conscientious than those who do not. They should also be less extraverted (in the sense of being less fun-loving and excitement-seeking), less open to experience (in the sense of being less unconventional and rebellious), but more open to experience (in the sense of being more intellectually oriented—reflecting Zajonc's [1976] "teaching function"). Surrogate parents should also tend to be more bossy and hence higher in extraversion (in the sense of being more assertive) but lower in agreeableness.	**Predominantly linear trends**, based on differences in opportunities for surrogate parenting. Quadratic trends will be associated with some family niches, such as the middleborn role as "peace-maker" (agreeableness) (Sulloway, 1996, pp. 298-305, 322). Niche partitioning is also expected to occur based on other contingent circum-stances, including genetic dispositions.
3. Dominance Hierarchy Strategies	Compared with nondominant siblings, dominant ones (typically firstborns) should be less agreeable, less open to experience (in the sense of being less rebellious against authority), and less neurotic, but more conscientious and extraverted (in the sense of being more assertive).	**Predominantly linear trends**, based on sibling differences in age and size, but also reflecting individual differences in temperament (Sulloway, 1996, pp. 69, 430-31).
4. Deidentification	Among adjacent siblings, patterns of deidentification should foster small differences on most personality dimen-sions, in social attitudes, and in family sentiments.	**Zigzag trends**, as siblings seek to maximize differences between themselves (Schachter et al., 1978; Skinner, 1992; Sulloway, 1996, pp. 483, 506)

is expected to produce somewhat different trends by birth order. For example, trends associated with parental investment will tend to exhibit quadratic (U-shaped) forms, whereas trends associated with surrogate parenting and dominance hierarchies among siblings will tend to be linear. Finally, behavioral differences that owe themselves to deidentification are expected to follow zigzag patterns. Because the four behavioral mechanisms I have outlined are predicted to engender different birth-order trends, tests for the specific nature of these trends provide a potentially useful way of estimating the relative contribution of each psychological mechanism. For example, a predominantly quadratic trend in birth-order effects is not likely to be the result of differences in surrogate parenting, just as a predominantly linear trend is not likely to be the result of differences in parental investment (Hertwig, Davis, & Sulloway, 2001).

4. DIRECT SIBLING COMPARISONS

Birth-order differences in personality vary in size, and sometimes even in direction, depending on how they are measured. When assessed by self-report questionnaires, birth-order effects are generally modest and nonsignificant. Yet significant differences are typically found when parents rate their own offspring or when siblings compare themselves with one another. A comparative method of assessment has several advantages over customary methods of self-report. Direct comparison serves to anchor the scales. In addition, comparative judgments among siblings obviate any confounding effects associated with differences between families.

In one study, I employed unanchored as well as anchored scales in a survey involving 660 business leaders (Sulloway, 1999). In self-report personality ratings, firstborn CEOs did not differ from laterborns on 10 of the 11 personality traits included in my survey. After providing these self-assessments, respondents were asked to compare themselves with their siblings, using the same scales. In these direct comparisons, 8 of the 11 scales included in the survey elicited significant birth-order differences. Relative to their younger siblings, firstborn business leaders were more dominant, tough-minded, uncooperative, inflexible, conservative, conventional, temperamental, and lacking in empathy. These comparative ratings produced birth-order differences that were five times larger than those previously obtained, using unanchored scales.[6]

A much larger follow-up study involving 6,053 individuals aged 8 to

95 (M=36.8, SD=17.1) has produced similar results for a broad array of personality traits.[7] Firstborns were asked to rate themselves and an immediately younger sibling, whereas laterborns were asked to rate themselves and an immediately older sibling. Subjects made their assessments on 9-step scales using bipolar adjective pairs. Thirty adjective pairs were selected to represent the 30 facets of the NEO PI-R, a comprehensive personality inventory based on the Five Factor Model (Costa & McCrae, 1992). In direct sibling comparisons, 23 of these 30 bipolar adjective pairs yielded significant differences—all in the expected direction. As anticipated, firstborns were judged to be more conscientious than their younger siblings, whereas laterborns were judged as being more agreeable, extraverted, and open to experience.[8] For Neuroticism, a dimension for which birth-order differences were expected to be minimal and mixed, firstborns were found to be more anxious and quicker to anger, whereas laterborns emerged as more self-conscious (Table 2).[9]

After controlling for age, sex, sibship size, and social class, the partial correlation between birth order and a scale score of predicted differences was .20, with birth order accounting for 4.1 percent of the variance. Two other family background variables—sibship size and social class—each accounted for less than 0.1 percent of the variance in this same scale score of predicted differences, as did age. By comparison, sex accounted for 2.1 percent of the variance.

Controlled for the linear effect in the scale score, there was also a significant quadratic trend in all scale scores except those for Neuroticism: Middleborns scored higher than firstborns or lastborns, particularly on Agreeableness, where the quadratic trend was even larger than the linear trend. As expected, the 548 only children in my study were intermediate between firstborns and laterborns on most personality traits, although they were generally more similar to firstborns on traits associated with Conscientiousness.[10]

When correlated with the overall scale score for expected personality differences, which was designed to test specific predictions about birth order, age and sex both accounted for substantially less variance in personality scores than did birth order. It is important to note, however, that age and sex explain considerably more about personality in general than they do about trait predictions specifically related to birth order. Sex differences in my study accounted for 8.3 percent of the variance in overall dimension scores for the Big Five personality dimensions, and age explained another 2.6 percent of the variance. In accounting for 4.1 percent of the variance in these same dimension

Table 2. Birth-order effects in scale scores for the Big Five personality dimensions, based on direct sibling comparisons (Sulloway, 1999)

Personality dimension[a]	Partial correlation with birth order[b]	N	p<
CONSCIENTIOUSNESS	**-.18**	**4,507**	**.0001**
Firstborns are more *deliberate*, *dutiful*, *effective*, *energetic*,[a] *hardworking*, *organized*, *self-disciplined*, and *under control*[a]			
AGREEABLENESS	**.10**	**4,510**	**.0001**
Laterborns are more *acquiescent*, cooperative, *easygoing*,[a] *modest*, straightforward,[c] *unassertive/ submissive*,[a] *tender-minded*, and *trusting*			
OPENNESS TO EXPERIENCE	**.08**	**4,484**	**.0001**
Laterborns are more aesthetically inclined, *prone to fantasy*, *attentive to inner feelings*, *untraditional*, *attracted by novelty*, and drawn to ideas[c]			
EXTRAVERSION[a]	**.14**	**4,404**	**.0001**
Laterborns are more *affectionate*, *excitement-seeking*, *fun-loving*, and gregarious			
NEUROTICISM	**-.04**	**4,278**	**.001**
Firstborns are more *anxious*, as well as more prone to depression and feelings of vulnerability.[c]	-.04	4,278	.001
Laterborns are more *self-conscious*	.05	3,548	.005
SCALE SCORE FOR PERSONALITY DIFFERENCES, AS PREDICTED[d]	**.20**	**4,177**	**.0001**

a. Each of the 30 bipolar adjective pairs, representing the 30 facets of the NEO PI-R, is classified under the Big Five personality dimension on which it has its highest factor loading. Four of the 30 adjective pairs have their highest loading on a personality dimension other than the one for which they were originally selected. "Assertive (dominant)/unassertive (submissive)" has its highest loading on Agreeableness (-.54) rather than Extraversion (.32). Similarly, "quick to anger/easygoing" has its highest loading on Agreeableness (-.55) rather than Neuroticism (.47). "Impulsive/under control" has its highest loading on Conscientiousness (-.59) rather than Neuroticism (.24). "Energetic/leisurely" has its highest loading on Conscientiousness (.47) rather than Extraversion (.28).

b. A positive partial correlation denotes a higher score for laterborns. For each bipolar trait, I have calculated a sibling difference score using z-scores and have then used this value to compute scale scores for the predicted differences. *Italicized traits* represent significant birth-order differences. (All statistical tests are two tailed.) All partial correlations with birth order (coded dichotomously as firstborn/laterborn) are controlled for age, sex, sibship size, and social class.

c. Four traits, scored as predicted, exhibit nonsignificant partial correlations in a direction opposite to the anticipated one: being straightforward (-.004), prone to depression (-.03), and inclined toward feelings of vulnerability (-.03)—all expected to be laterborn attributes; and being drawn to ideas (.004)—expected to be a firstborn attribute.

d. Some respondents made ratings on fewer than 30 bipolar adjective pairs. In these cases, scale scores have been computed from the observed data.

scores, birth order appears to be substantially more influential than age, but less so than sex. Nevertheless, on two of the Big Five dimensions (Conscientiousness and Extraversion), birth order exerted greater influence than did either age or sex.

Family Niches and Other Moderating Influences

Birth order is just a proxy for the real causes that lie behind sibling differences in personality, namely, disparities in age, physical size, status, and power within the family system. Not all firstborns choose to assume the role of a surrogate parent toward their younger siblings, and some firstborns are less bossy than others. Individual disparities in genetic endowment also help to explain why some people deviate from patterns of personality expected by birth order. In order to test the hypothesis that family niches are a principal source of sibling differences in personality, I asked the subjects in my study to what extent they acted as a surrogate parent toward their siblings during childhood, and also to what extent they bossed their siblings around. From these two variables I constructed a composite indicator, which correlates strongly with birth order (r=-.56). This composite indicator accounts for 10.5 percent of the variance in personality scores, making it a substantially better predictor of personality than any other variable in my study. The greater predictive success of this variable lies in significant part in its ability to account for exceptions based on birth order alone. For example, some laterborns (typically eldest daughters) report having engaged in substantial surrogate parenting of their younger siblings. Such people also tend to describe themselves as having firstborn personality traits.

Additional variables that affect personality and that sometimes modify the effects of birth order include sex, sex of siblings, age spacing between siblings, parental favoritism, conflict with parents, and patterns of deidentification among siblings. For example, the influence of birth order is muted when the age gap between siblings is so large that siblings do not interact much with one another and do not compete directly for the attention of parents (Sulloway, 1996, pp. 119-47).

Parent-offspring conflict and patterns of favoritism are moderately associated with individual differences in personality, in confirmation of the predictions based on a family dynamics model (see Table 1). In the study whose results I have already summarized in Table 2, parent-offspring conflict was negatively correlated with Conscientiousness,

Agreeableness, and Extraversion, and positively correlated with Openness to Experience and Neuroticism (Table 3). A related question in my study asked whether respondents were favored by their parents. As expected, respondents who reported that they were favored attained higher scores on Conscientiousness, and lower scores on Openness to Experience and Neuroticism. Also as expected, middle children were less likely than either firstborns or lastborns to report that they had been favored by their parents.[11]

Genetic factors play a substantial role in personality development (Loehlin, 1992). At least one prenatal factor that is under genetic control is linked with birth order. Among males (but not among females), laterborns are more likely to become homosexuals (Blanchard, 1997; Jones & Blanchard, 1998; and Williams et al., 2000). Unlike other behavioral attributes associated with birth order, tendencies toward homosexuality are influenced by the number of older brothers, not by relative birth rank from eldest to youngest child. In other words, lastborn males who are the eldest of their sex are no more likely to become homosexuals than are firstborns. These findings are consistent with the hypothesis that some mothers develop antibodies either to the hormones responsible for masculinizing the fetus or to one of the male-specific minor histocompatibility antigens. Such immunological responses, Blanchard and his colleagues have argued, prevent male fetuses from being fully transformed from female to male.[12]

Because personality is shaped by so many different influences—

Table 3. Personality, as it relates to parent-offspring conflict and favoritism

Personality Dimension[a]	Partial Correlation with Parent-Offspring Conflict	Partial Correlation with Parental Favoritism	*N*s	*p*s<
Conscientiousness	-.13	.08	4,839/2,112	.0001/.0003
Agreeableness	-.11	-.01	4,783/2,111	.0001/.7722
Openness	.16	-.09	5,001/2,111	.0001/.0001
Extraversion	-.05	.02	5,155/2,111	.0006/.4909
Neuroticism	.20	-.10	5,010/2,108	.0001/.0001

a. The dependent variables represent scale scores of self-ratings on each personality dimension (see Table 2). All correlations are controlled for age, sex, sibship size, and social class.

genetic and environmental—multivariate models are substantially better at predicting personality than are models that rely on single predictors such as birth order. In particular, variables that reflect within-family differences in family environments appear to explain a substantial portion of the variance in personality.[13] We currently know almost nothing about how such within-family differences in home environments interact with genetic factors, a process that is likely to moderate the influence of variables such as birth order. For example, firstborns who are physically big for their age are more likely to be effective in pursuing strategies associated with domination than are firstborns who are physically small for their age.

5. BIRTH-ORDER EFFECTS OUTSIDE OF THE FAMILY MILIEU

The method of direct sibling comparisons does not prove that reported birth-order differences in personality are real, as opposed to being the product of stereotypes.[14] Nevertheless, if the documented birth-order effects within the family are based solely on stereotypes, such stereotypes appear to be surprisingly powerful. Even if they do exist, however, birth-order stereotypes may also contribute to observed birth-order differences in behavior. Comparative assessments of personality by family members may also be susceptible to "contrast effects," whereby small differences are magnified into larger differences (Saudino, 1997). In my own study, contrast effects appear to be small, inasmuch as results are nearly the same even when variance on the scales has been reduced to a bare minimum.[15]

Other evidence, especially from studies that have documented birth-order effects in behavior outside the family, supports the conclusion that birth order is associated with real differences in personality and behavior, not just with stereotypes. In an effort to address this issue, I asked nearly two thousand subjects in my own study the following question: "What would your friends consider to be the two or three most unconventional or rebellious things, if any, that you have done during your life?" Compared with firstborns, laterborns tended to produce significantly longer written responses. They also tended to list more examples of genuinely unconventional behaviors, as assessed by two independent judges.[16] Because these findings are not based on direct sibling comparisons, and because they draw on real-life experiences, they are less likely to be affected either by contrast effects or by birth-order stereotypes. Also, most of the behaviors that sub-

jects reported involved activities occurring outside the family of origin.

Other recent studies using the NEO Personality Inventory and comparable instruments have generally yielded null results for birth order. Most of these studies, however, have possessed only moderate statistical power and only one of them has used the method of direct sibling comparisons.[17] Basing their conclusions on similar discrepancies between self-report ratings, which often yield meager results, and more substantial differences as judged by family members, some researchers have argued that birth-order effects are *parent specific* and do not hold up outside the family (Ernst & Angst 1983, p. 171).

There is considerable plausibility to this last viewpoint, which has also been argued by Harris (1995, 1998) in connection with her theory that personality is mostly shaped by peer groups. In support of this position, studies in which family members rate one another exhibit more confirmatory findings, and larger effect sizes, than do other kinds of studies. But studies involving assessments by nonfamily members also exhibit more confirmatory findings than would be expected by chance. In addition, significant findings are especially likely to occur whenever studies involve real-life behavior rather than self-report (Sulloway, in press-a). Also, if birth-order effects are specific to childhood and the family milieu, one might well expect these differences to diminish with age, which is not the case (Sulloway, 1999).

Spousal Ratings

In order to ascertain whether birth-order differences in behavior are recognized by people other than siblings, I asked respondents to my survey to rate a variety of other people, including spouses, roommates, and friends. Among spouses, birth-order differences emerged in the expected direction, although the magnitude of these effects is smaller than it is for direct sibling comparisons by the same individuals. After one controls for age, sex, sibship size, and social class, the partial correlation between birth order and a scale score for predicted personality differences among spouses is .12 (N=822, p<.001). Significant differences in the expected direction were found for Conscientiousness, Agreeableness, and Extraversion. These findings suggest that the behavioral differences that are associated with birth order within the family are also being expressed, at about half the magnitude, in marital relationships.

Analysis of scores for individual traits reveals that subjects are

detecting the same birth-order differences in their spouses that they do when they compare themselves with a sibling. An effective way of demonstrating this point is to compare the within-family effect sizes for birth order, trait by trait, with the effect sizes for the same traits as judged by spouses. These two sets of effect sizes are strongly correlated (r=.63, N=30 traits, p<.001). In other words, those traits that are the most strongly associated with birth order in sibling relationships are the same traits that are the most strongly associated with birth order in married couples (Figure 1).[18]

Roommates

Spousal ratings of personality might be affected by birth-order stereotypes being communicated to subjects by the spouse's family. Alternatively, spouses may have the opportunity to observe real birth-order differences as they watch one another interacting with their siblings. These two possibilities are less likely, however, among the college-age roommates in my study (mean age 20.5 years). After one controls for age, sex, sibship size, and social class, the partial correlation between birth order and a scale score for predicted personality traits among roommates is .16 (N=165, p<.05). As with ratings of spouses, there is substantial consistency between the birth-order effects observed among roommates and those observed among siblings (r=.76, N=30 traits, p<.0001—see Figure 1).

In short, birth-order differences do not appear to be restricted to family members or confined to childhood, as Ernst and Angst (1983) and Harris (1998) have asserted. Rather, these differences seem to manifest themselves in a variety of intimate living situations. It might still be argued that birth-order stereotypes are somehow exerting an influence on ratings by roommates and especially by spouses, and that the observed birth-order effects are therefore artifacts of these stereotypes. If this is the case, however, the same stereotypes ought to be operative in my study among those people who rated a close friend. For these peer ratings (N=1,002), birth-order effects are negligible.[19] For this reason, it seems likely that most of the birth-order effects documented in this study owe themselves to the interpersonal context in which they are being measured. In particular, birth-order effects seem to emerge most clearly in relationships where people are living together. Unlike friendships, for example, intimate living relationships share important commonalties with the behavioral circumstances under which siblings strategies were originally learned. These

Effect Sizes for Birth Order and Personality Traits: Direct Comparisons by Siblings versus Ratings by Spouses and Roommates

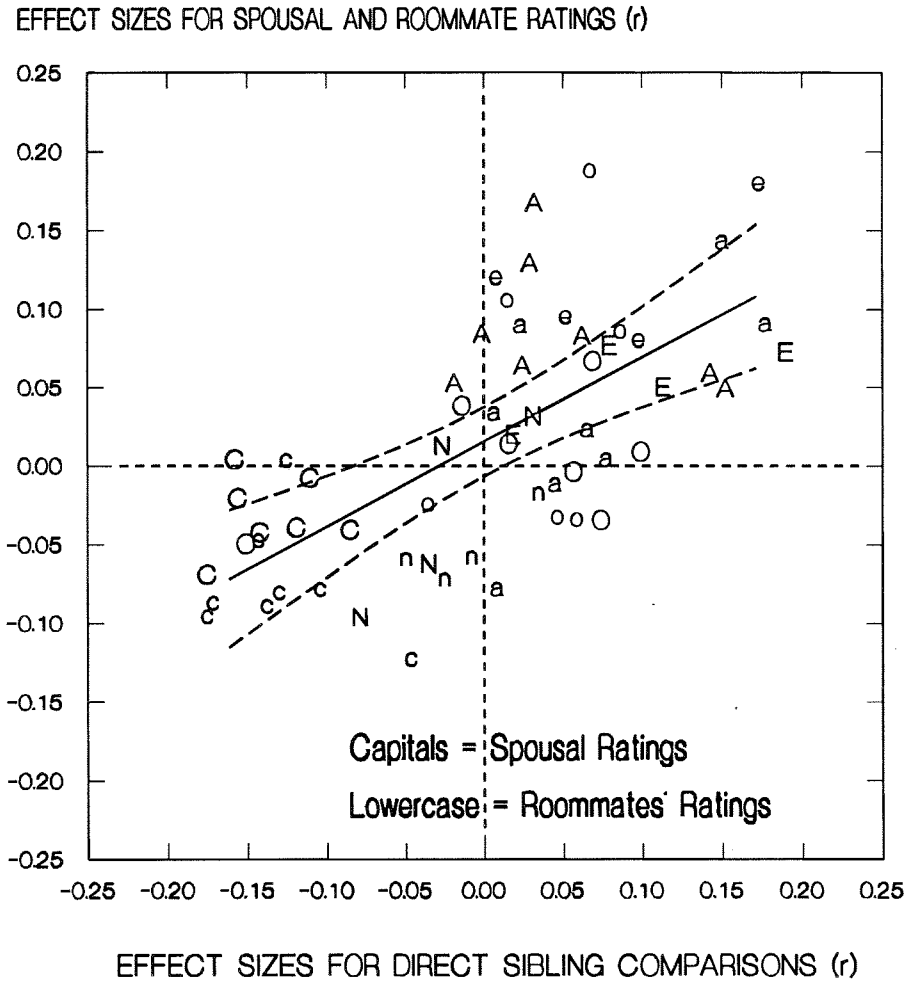

Figure 1. Birth-order effect sizes (partial correlations) for personality traits, as manifested in self-ratings based on direct sibling comparisons (N=4,177) and in ratings of spouses (N=822) and roommates (N=165). Results for 30 bipolar adjective pairs are indicated by the letter of the personality dimension on which each trait has its highest factor loading in the Five Factor Model: **C**=Conscientiousness, **A**=Agreeableness, **E**=Extraversion, **O**=Openness to Experience, and **N**=Neuroticism. Findings for spouses are indicated by capital letters; findings for roommates are indicated by lowercase letters. Within each sample, the two sets of effect sizes are strongly correlated (r=.63, p<.001, for spouses; and r=.76, p<.0001, for roommates). Traits that produce the largest birth-order effects in ratings by siblings also produce the largest birth-order effects when people rate a spouse or a roommate. Congruent clustering is particularly evident for traits related to Conscientiousness (*displayed on the left*). All correlations are controlled for age, sex, sibship size, and social class.

common elements include a shared living space, competition over shared resources, and features of a dominance hierarchy.

Perhaps the most compelling evidence supporting the existence of birth-order effects outside the family of origin comes from a meta-analytic review of the birth-order literature. More than two thousand published studies on birth order, which have most of which have been conducted outside the family of origin, have consistently shown small but significant effects (Sulloway, 1995, 1996, in press-a). What is most noteworthy about these collective findings is how closely they resemble the basic pattern of birth-order effects that I have documented in Table 2, using within-family data. For example, the correlation between the birth-order effect sizes in Table 2 and the proportion of significant results found in the overall birth-order literature for each dimension of the Five Factor Model of personality is .92. This statistic reflects more than two hundred and fifty meta-analytic outcomes (and more than nine hundred individual findings).[20]

Some critics of birth-order research, such as Harris (1998), may argue that such a high level of concordance is mostly or entirely attributable to results from *within-family* studies. For the more than two hundred meta-analytic outcomes that do not involve within-family comparisons, the correlation between the proportion of confirming outcomes for each of the Big Five personality dimensions and the results set forth in Table 1 is .95. Hence the conclusions drawn from extrafamilial studies agree closely with those based on within-family designs.

Understanding the Importance of "Small" Effect Sizes

Another common objection to arguments about the influence of birth order centers around the interpretation of "small" effect sizes. Harris (1998, p. 19) exemplifies this line of argument with her claim that "a correlation of .19, even if it is significant in the statistical sense, is all but useless." Since most birth-order effects for personality are about half the size of the particular correlation that Harris dismisses as useless, it is important to address this issue. Just how useless is a correlation of .10? Squared, a correlation of this magnitude may be said to explain one percent of the variance in the attribute being studied. Considering that about 40 percent of the variance in most personality traits appears to be genetic in origin and that another 20 percent of the variance is generally associated with errors of measurement, any nongenetic finding that explains 1 percent of the variance in a particu-

lar personality trait leaves only 39 additional influences of this magnitude before we know everything there is to know about the environmental sources of that trait. Given what is already known about the influence of age, sex, social class, and other determinants of behavior, the number of additional influences that actually explain this much environmental variance in personality has to be substantially fewer than 39.

Some behavioral scientists have effectively argued that "variance explained" grossly underestimates the importance of most behavioral phenomena (Rosenthal & Rubin 1982; Ozer, 1985). A much better way of conveying the importance of small correlations is to convert them to odds ratios, as is generally done in medicine to illustrate the effectiveness of drugs. A correlation of .10, for example, is equivalent to a medicine that increases survival among treated individuals by 49 percent. By this general metric, even very small correlations can be said to represent impressive effects. For instance, a correlation as small as .05 is equivalent to a 26 percent increase in survivorship among individuals receiving medical treatment. Most behavioral scientists would consider it noteworthy if birth order, which regularly produces correlations of this magnitude and larger, increases the likelihood of a person behaving in a certain manner by 26 percent over the base rate for this behavior. In short, most critics of birth-order research fail to understand just how substantial supposedly "small" effect sizes really are. When we are able to document such seemingly modest effects in large controlled studies, we generally ought to point to them with pride and to affirm that they are not so small after all.

It is largely because of Harris's (1995, 1998) own failure to understand the meaning of "small" effect sizes that she has put forward her dramatic thesis that the family exerts little influence on personality. Properly understood, the accumulated evidence belies her claims. Behavioral genetic studies indicate that about 5 percent of the variance in personality is attributable to the shared family environment (Loehlin, 1992). Interpreted by means of odds ratios, this particular influence is equivalent to a medicine that would increase survival among treated individuals by a factor of 2.5. In other words, siblings who grow up with warm and affectionate parents, for example, are 2.5 times more likely to partake of these traits than are children who have not done so, based on environmental influences alone. This particular measure of *shared* family influences does not even begin to take into account the even greater influence that can be ascribed to the *nonshared* family environment. (As a whole, the nonshared environment appears

to exert about seven times the influence on personality that the shared environment does.) Such nonshared experiences are equivalent to a medicine that would increase survival in a medically treated population by a factor of 15. Although it has not been established exactly what proportion of these nonshared environmental influences stem from experiences within the family, this proportion is probably much greater than the 5 percent that can generally be ascribed to the shared environment. In short, the family clearly matters in personality development, in part by causing siblings to share the personality characteristics of their parents, but even more so by causing siblings to become different from one another. The influence of the family on social attitudes and values is another matter entirely, and here the effects are even more substantial, regularly explaining 30 percent or more of the variance (Eaves, Eysenck, & Martin, 1989, p. 363). Hence, based on common environmental influences, siblings from the same family are at least 12 times more likely than nonfamily members to share the same social attitudes.

Radical Revolutions in History

Other compelling evidence for birth-order differences in behavior comes from intellectual and social history. Considerable research shows that laterborns are more inclined than firstborns to change their views during times of radical political, social, or intellectual change, a tendency that reflects birth-order differences in the nonconformist component of openness (Sulloway, 1996). During the Protestant Reformation, for example, laterborns gave their lives to bring about theological change and firstborns did so to preserve orthodoxy. Compared with firstborns, laterborns were nine times more likely than firstborns to suffer martyrdom in support of the Reformed faith. In countries that turned Protestant, such as Henry VIII's England, firstborns were five times more likely than laterborns to suffer martyrdom by refusing to abandon Catholicism. (These statistics are corrected for the greater number of laterborns in the population.)

Responses of scientists to radical conceptual changes show similar differences by birth order. The Copernican revolution overthrew church doctrine by asserting that the earth rotates around the sun. During the first half-century of this controversy, laterborns were five times more likely than firstborns to endorse this heretical view. Nicholas Copernicus himself was the youngest of four children. In the period before Darwin himself became an evolutionist, younger siblings were nearly ten

times more likely than eldest siblings to endorse that theory. Darwin himself was the fifth of six children, as was Alfred Russel Wallace, who codiscovered the theory of natural selection (Figure 2).

During other notable revolutions in science, including those led by Bacon, Descartes, Newton, Einstein, and Heisenberg, laterborns have generally been twice as likely as firstborns to initiate or to endorse the new point of view. This trend holds true even when the initiators of revolutions, such as Newton and Einstein, happen to be firstborns. Laterborns are more likely to endorse radical revolutions even when scientific stance has been controlled for social attitudes (which are themselves a good predictor of the acceptance of such events). Accordingly, such birth-order effects cannot be reduced to attitudinal differences, although birth order does appear to influence social attitudes, which in turn influence openness to radical innovations.[21]

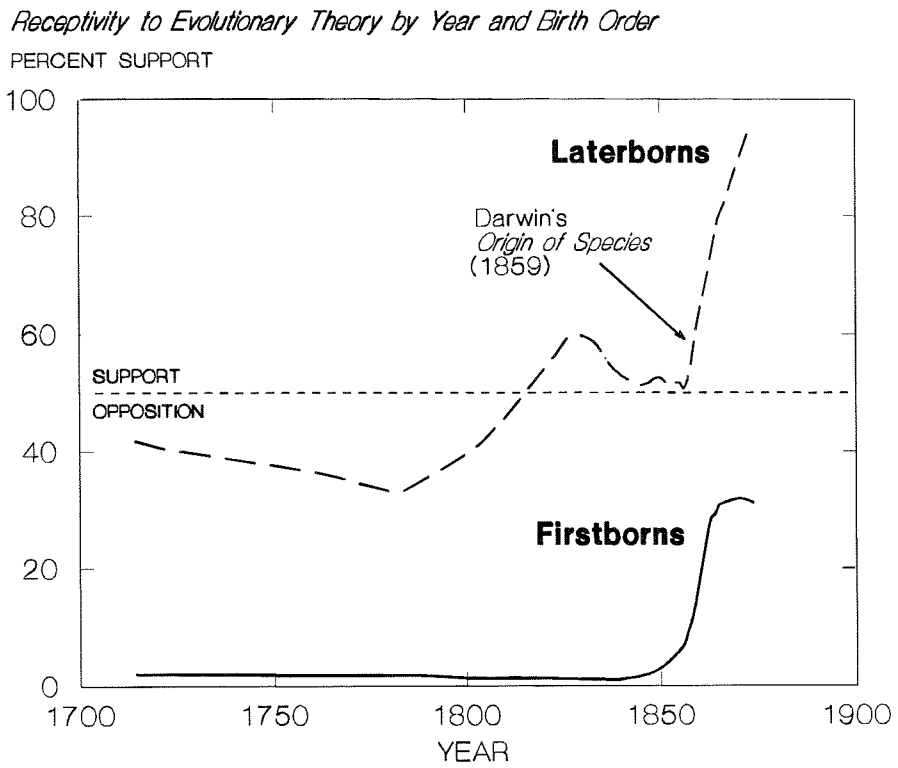

Figure 2. The reception of evolutionary theory from 1700 to 1875 by birth order (r=.35, N=263, p<.0001; controlled for sibship size and social class). During the long period of debate preceding publication of Darwin's *Origin of Species* (1859), individual laterborns were 9.7 times more likely than individual firstborns to endorse evolution. These group differences are corrected for the greater frequency of laterborns in the population. (From Sulloway, 1996, p. 33.)

Consistent with their tendency to ally themselves with their peers rather than with the family, middle children in history appear to have been particularly inclined to engage in diplomacy, cooperation, and nonviolent kinds of reforms—strategies that seem to reflect previously learned proclivities for mediating disputes between their siblings. Martin Luther King, Jr., the middle of three children, first developed his penchant for nonviolent reform by trying to prevent his younger brother from teasing their older sister (Lewis, 1970). During the French Revolution middleborn deputies within the National Convention were more likely than either firstborns or lastborns to resist the extreme measures imposed during the Reign of Terror, and I have documented a similar trend in the rejection of violent methods of reform during the American Abolitionist cause (Sulloway, 1996).

Several recent studies have confirmed these historical trends. My own findings on the Darwinian revolution have been replicated by Ronald Numbers (1998), who systematically examined those members of the National Academy of Sciences who spoke out on Darwin's theories, and by Michael Ruse, who rated 84 prominent participants in this scientific revolution drawn from his 1979 book on the subject (Sulloway, in press-a).[22] Using a contemporary sample, Salmon and Daly (1998) asked 100 middle-aged Canadian subjects, "Do you think that you are open to new and radical ideas (such as cold fusion)?" Of the firstborn respondents, 47 percent answered "yes" to this question, whereas 86 percent of the middle children answered in the affirmative, and 89 percent of the lastborns did so (partial r=.38, p<.001, controlled for age, sex, and sibship size). In another recent study Zweigenhaft and Von Ammon (2000) found that laterborns were more likely than firstborns to engage in civil disobedience during a labor dispute taking place in Greensboro, North Carolina. These two investigators also found that laterborns were more likely than firstborns to undergo multiple arrests as a result of their protests (pr=.24, N=73, p<.05; controlled for sibship size).

The tendency for middleborns to behave differently from firstborns and lastborns, seen in history during radical reforms, has also been documented in contemporary samples. Using an experimental format, Salmon (1998) found that middle children were more likely than firstborns or lastborns to identify with political speeches that employed peer-group terms such as "friend." By contrast, firstborns and lastborns preferred political speeches that appealed to them as "brothers" and "sisters." Salmon and Daly (1998) have also shown that middleborns

are less invested in the family than their siblings generally are, as indicated by a variety of different measures.

It is useful to sum up the results of all known studies that have dealt with the relationship between birth order and social attitudes, or between birth order and responses to social or intellectual change. Based on 27 controlled studies involving these topics, I have found a mean-weighted correlation of r=.09 (N=11,240) for the 20 studies that reported an effect size (Sulloway, in press-a).[23] These collective findings indicate that laterborns are 43 percent more likely than firstborns to hold liberal social attitudes or to campaign for a liberal or unconventional social change. It is noteworthy that reported effect sizes appear to be substantially larger for real-life studies than they are when ascertained from self-report surveys. For the eight real-life studies, laterborns are 2.3 times more likely than firstborns to support the radical social alternative (r=.20, N=1,952).

Birth order is only one of many predictors of individual responses to social, political, or intellectual change. Being young and socially liberal are two other good predictors. So is parent-offspring conflict, which, by causing people to reject parental authority, makes some firstborns into "honorary laterborns" in their tendency toward nonconformity (Sulloway, 1996, pp. 120-33). Compared with laterborns who join radical revolutions, firstborns who do so are roughly twice as likely to have experienced high conflict with a parent.[24] History abounds with biographical examples illustrating the liberalizing consequences of parent-offspring conflict. Mao Zedong, the eldest of four children, was radicalized by strife with his father, a cruel and tyrannical man who mistreated his wife, his children, and the workers on his farm. There were two parties in his family, Mao once said, and he was the leader of the opposition (Rejai & Phillips, 1979, p. 177). In contrast to firstborns, laterborns tend to rebel even if they do not have Attila the Hun for a father or the Wicked Witch of the West for a mother. They have their older brothers and sisters to induce them to identify with the underdog.

As with multivariate models of personality, models that employ many predictors of openness to radical innovation are substantially more powerful than models using single predictors. In my own study of 28 scientific innovations during the last four centuries, the following six variables were the best predictors of scientific stance: social attitudes (pr=.24), birth order (pr=.22), age (pr=-.19), personal friendship with the leader of a revolution (pr=-.19), national differences (pr=.14), and parent-offspring conflict (pr=.07).[25]

These findings do not mean that young people, laterborns, social liberals, and people who have experienced serious conflicts with their parents have a monopoly on scientific creativity or truth. For example, laterborns and social liberals run the risk of accepting new and radical ideas too quickly, just as firstborns and social conservatives run the risk of resisting certain kinds of necessary changes until the mounting evidence in their favor can no longer be ignored. Laterborns were nine times more likely than firstborns to support Franz Joseph Gall's false theory of phrenology—the notion that character can be read by examining bumps on the head. Firstborns correctly opposed this theory as pseudoscientific. (They also rejected phrenology because of its materialistic implications.)

In the case of everyday "normal" science, firstborns possess a small but consistent advantage over laterborns. They tend to be more successful academically and are more likely to become scientists in the first place. In addition, firstborns win more Nobel prizes, which are generally awarded for creative puzzle-solving (openness in the sense of "intellect") rather than for radical innovations (openness in the sense of "nonconformity"). With their discovery of the double helix structure of DNA, Watson and Crick (both firstborns) revolutionized the field of molecular biology, but the particular form of this "revolution" is very different from most radical revolutions in science (Sulloway, 1996, pp. 330-36). A good indicator of a truly radical scientific revolution is the widespread opprobrium, not the accolades, that initially greets the instigators. Owing to publication of the *Origin of Species*, Charles Darwin lost a knighthood that he had previously been slated to receive, and he was never subsequently knighted in his lifetime. Although Darwin did receive other notable recognition (culminating with his burial in Westminster Abbey), his ultimate scientific acclaim should not obscure the essential point. Darwin's success would not have been possible without the many anxious years that he spent developing a theory whose public revelation he once compared to "confessing a murder" (Darwin, 1887, 2:23).

6. SITUATIONAL INFLUENCES

Historical Context

Whenever scientific innovations have involved ideologically conservative implications—as occurred, for example, with various vitalistic doctrines during the seventeenth and eighteenth centuries—firstborns

have led the way. Firstborns readily adopted eugenics and spiritualism, theories that likewise appealed strongly to religious and political conservatives. Similarly, firstborns have repeatedly championed new theories, such as idealist theories of biological classification, that bolstered God's role in the Creation. By contrast, laterborns have gener-

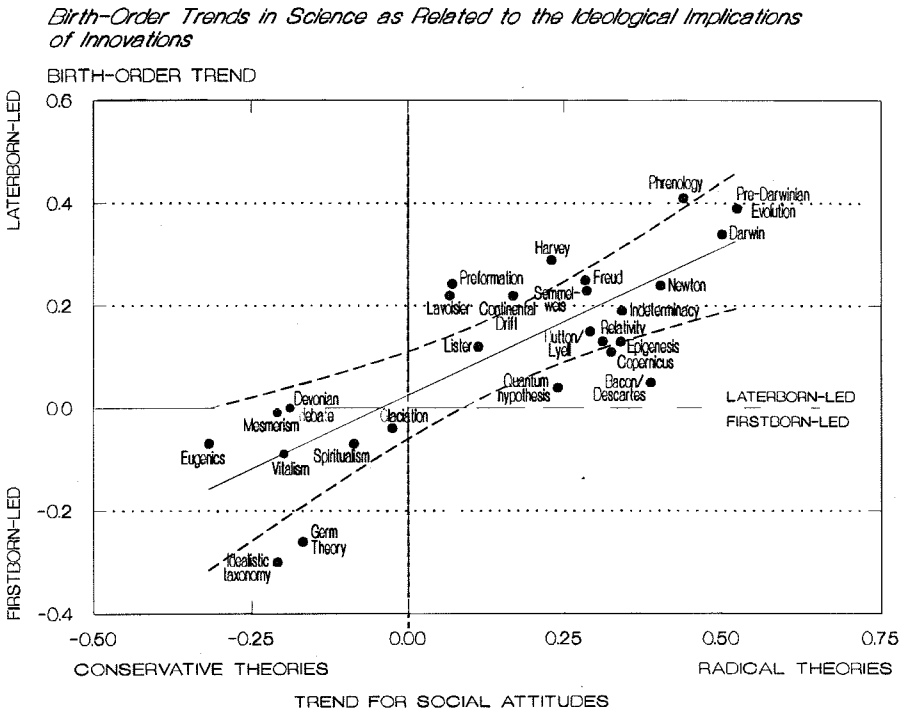

Figure 3. Birth-order effects in science, as they relate to the religious and political ramifications of 26 different innovations. The vertical axis depicts the correlation of *birth order* with support for scientific innovation (N=2,232). All events above the horizontal line (0.0) were generally endorsed by laterborns and generally opposed by firstborns, whereas all events below that line drew greater support from firstborns. The horizontal axis depicts the correlation of *social attitudes* with support for each innovation (N=1,881). Events to the left of the vertical line (0.00) were generally endorsed by social conservatives and were generally rejected by social liberals. Events to the right of this vertical line reflect support by social liberals and opposition by conservatives. Assessments of social attitudes involve more than 19,000 ratings made by expert historians, who judged the religious and political attitudes of participants in these 26 debates. The dashed lines indicate the 99-percent confidence limits for the regression line.

This analysis illustrates a general pattern: *The more socially radical the innovation, the more it is likely to be supported by laterborns and opposed by firstborns* (r=.80, N=26, p<.0001). Generally missing from the history of science are two classes of potential events. Within expected margins of statistical error, there appear to be no radical revolutions that are backed primarily by firstborns, just as there are no conservative theories that are backed primarily by laterborns.

ally led radical revolutions, such as Copernicanism and Darwinism, that strongly challenged social and religious authority. Thus the relevance of birth order to scientific innovation is highly dependent on the nature of the innovation (Figure 3).[26]

Considerable evidence reinforces the importance of situational factors in the emergence of birth-order effects. During radical scientific revolutions, birth-order effects tend to fade, as new and initially controversial ideas become more widely accepted. In addition, some new ideas are more controversial than others, and they tend to evoke correspondingly larger birth-order effects. National differences sometimes mediate these controversiality effects. Given their support of Descartes's rival theory of celestial mechanics, French physicists—especially firstborns—manifested strong opposition to Isaac Newton's theory of universal gravitation. By contrast, British scientists, including firstborns, welcomed Newton's ideas. Ultimately, the relationship between birth order and openness to experience appears to be strongly mediated by the nature of the innovation, as well as by the social and intellectual contexts in which such innovations arise.

Other Context-Sensitive Influences

Evidence from history reaffirms a particularly useful lesson about birth-order effects. As a rule, the consequences of birth order almost always depend on the behavioral context, which is one of the most important moderators of human behavior. Because of this circumstance, overt behavior—although generally a better indicator than self-report measures—can still be a problematic guide to birth-order effects. For example, a firstborn may take greater risks than a laterborn in an effort to impress an authority figure, whereas a laterborn may take greater risks in order to help a friend. Similarly, firstborns might be expected to dominate their inferiors, act graciously toward peers, and behave in a subordinate manner toward their superiors—a behavioral style known as a "pecking order personality" (Block, 1995). Personality tests are not particularly effective at capturing such context-sensitive dispositions, which means that the influence of variables such as birth order will tend to be underestimated.

Social categories such as gender, social class, marital status, and job status entail standards of behavior that often affect the expression of personality in context-sensitive ways. In connection with the extensive questionnaire study I have discussed in this chapter, more than a thousand respondents assessed the personality of a close friend

who was neither a spouse nor a roommate. Overall, there were no significant differences by birth order—a confirmation of the null hypothesis. Significant birth-order differences did emerge, however, in interaction with other variables. Respondents saw their peers as exhibiting the kinds of differences expected by birth order if these peers were from middle- and especially upper-class families. In addition, birth-order effects emerged in older subjects more strongly than they did in younger (college-age) subjects.[27]

These kinds of contradictory results are perhaps best understood by considering the attributes that are important for success within each socioeconomic class, and during different stages of life. College students, especially from lower-class backgrounds, are likely to prefer friends who are sociable and who know how to have a good time. These criteria for popularity will tend to encourage the projection of an appropriate "persona"—one emphasizing agreeableness, extraversion, and openness to experience rather than conscientious dedication to work or career. When people graduate from college, take a job, and finally marry, they assume new life roles and greater responsibility. Within these maturing populations, birth-order effects in personality increasingly appear to conform to the expected pattern as the behavioral context becomes more consonant with their expression.

Firstborns appear to be especially affected by such life transitions. Compared with other subjects in my study, firstborns were significantly more variable in how their personalities were perceived across the social categories of age, class, and marital status. The more responsibility and status firstborns accrued—for example, by getting married—the more they were seen by their friends as manifesting a typical firstborn personality.[28] Firstborns therefore appear to conform more strongly than laterborns to age-related social expectations.

Another good example of such context-sensitive results is provided by data on dominance in interpersonal relationships. In relationships with peers, firstborns do not appear to be more dominant than laterborns. In marriages, however, spouses appear to reveal a different side of themselves because they report this expected birth-order difference. Similarly, college-age roommates report that firstborns are more dominant than laterborns.[29] In short, birth-order differences do not appear to be parent specific; but they are often situation specific, and they also seem to be catalyzed in varying ways by different stages of the life course.

These findings make sense from the perspective of evolutionary

psychology (which, at the proximate-causal level, is a form of social psychology). Personality traits associated with birth order develop in the service of competition for scarce resources, principally parental investment. Adolescents do not usually command scarce resources, and adult friends do not generally compete over them. For these and other reasons, the behavioral priorities of adolescents and adult friends are substantially different from those of siblings. Similarly, in college-age populations dominant behaviors are not particularly effective routes to popularity, even if these same traits once brought success in sibling competition and may do so again in corporate board rooms, politics, and military life.

7. CONCLUSION

In species that reproduce sexually, sibling competition is widespread. Paradoxically, so is a disposition for siblings to behave altruistically toward one another. As William Hamilton (1964) has argued, these alternating behavioral dispositions are to be expected in organisms that are genetically related, but not genetically identical. Sibling competition is particularly prevalent in species that care for their young, and these conflicts sometimes lead to siblicide. By serving as an effective proxy for differences in age, physical size, and power, birth order among animal species often determines the outcomes of these contests.

Human beings are no exception to these behavioral trends. By influencing the choice of adaptive strategies within the family system, birth order and sibling competition contribute to personality in modest but apparently enduring ways. This is a Darwinian story, albeit one with a predominantly environmental twist. Siblings may be predisposed to compete for parental favor, but the particular strategies they adopt within their own family are shaped by the specific niche in which they have grown up. In general, firstborns tend to be more conscientious than their younger siblings—mainly because they serve as surrogate parents—whereas laterborns tend to be more agreeable, extraverted, and open to experience (in the sense of being unconventional). Measured as direct sibling comparisons, birth-order differences in personality are somewhat larger than those associated with age but somewhat smaller than those associated with gender. The extent to which these birth-order effects may be inflated by stereotypes is still an open question. So too is the question of whether such stereotypes reflect real behavioral propensities, and whether these stereotypes may also augment these propensities.

An even better predictor of personality than either birth order or sex is the kind of family niche that a person has occupied during childhood. This finding follows logically from the fact that birth order is an imperfect proxy for the many contingent experiences associated with family life. These experiences, not birth order, are the key to how personality develops in individual cases. Hence birth order and family niches more generally are part of a larger and still inadequately understood story about the nature of sibling interactions and their effects on personality development.

Birth-order studies that employ direct sibling comparisons produce significantly larger effects than do self-report measures using unanchored scales. This circumstance is sometimes taken as evidence that birth-order effects are confined to behavior within the family. Nevertheless, ratings by roommates and spouses reveal similar results by birth order, although effect sizes for these relationships are generally smaller than are found using direct sibling comparisons. In ratings of peers, where birth-order effects are smaller still, the effects nevertheless appear to be moderated by variables such as age and social class, emerging most strongly among upper-class subjects and among older subjects in all social classes. Such disparities in the findings for various subpopulations suggest that traits related to birth order are closely associated with the behavioral context, especially contexts involving intimate living situations and dominance hierarchies.

Given this kind of evidence, it would seem that a particular behavioral situation is likely to elicit birth-order effects in adulthood if it resembles situations previously experienced within the family. For example, firstborns do not usually dominate their adult friends and peers; but when placed in a position that calls for the exercise of authority, these same firstborns might be expected to behave more assertively than younger siblings generally would. It also seems likely that birth-order differences will manifest themselves in adult behavior whenever patterns of identification dating from childhood—either with parents and authority or, conversely, with the underdog—are tapped by real-life situations. Radical revolutions in history, which have regularly involved challenges to family authority, provide repeated demonstrations of this assertion.

In adult behavior, a particularly important key to documenting the influence of birth order and family niches is to examine people in multiple contexts. This conclusion is consistent with a Darwinian perspective on human behavior, which sees personality as a collection of strategies for dealing with the diverse problems associated with sur-

vival and reproduction. As adults, we are far more flexible in our strategies than we once were as children, but we still seem to take advantage of childhood experience whenever it suits our purposes. The elusive continuity between early family experience and how we behave as adults appears to lie in these strategic and context-sensitive links.

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NOTES

[1] As Trivers (1974) has argued, offspring do sometimes have Darwinian reasons to harm their parents, by increasing their own fitness at the expense of their parents' fitness. See also the work of Haig (1993), who has shown how the fetus competes with its mother (and future siblings) for nutritional resources—by secreting hormones, for example, that block the mother's production of insulin and thus increase the amount of sugar that the fetus receives through the mother's blood.

[2] Freud's error about the sources of parent-offspring conflict was part of a

more extensive series of mistakes stemming from his considerable reliance on nineteenth-century biology. Although Freud's overall thinking about human development was deeply imbued with evolutionary ideas and assumptions, his most important theoretical assumptions were non-Darwinian. In particular, Freud's theory of psychosexual development was fundamentally compromised by its reliance on Lamarckian theory and the biogenetic law (Sulloway, 1979, 1982; see also Gould, 1977).

[3] Although haplodiploidy has facilitated the evolution of cooperative behavior in social insects, this genetic peculiarity is neither necessary nor sufficient for the evolution of social organisms. Some bird species (for example, bee eaters) and mammals (for example, naked mole rats) have evolved a high degree of cooperation in their breeding systems without haplodiploidy, and many haplodiploid insects have not done so (Krebs & Davies, 1997).

[4] On the Five Factor Model of personality, see McCrae and Costa (1987), John (1990), Costa and McCrae (1992), McCrae and John (1992).

[5] For critical discussions of the meta-analytic findings on birth order, see Modell (1997), Harris (1998), Townsend (in press), and Sulloway (in press-a).

[6] In my study of CEOs, birth order was significantly correlated with only one variable using unanchored scales—laterborns were more socially liberal than firstborns (r=.12, N=623, p<.005; controlled for age, sex, sibship size, and social class). In addition, birth order was not significantly correlated with a scale score of predicted outcomes for all 11 of the self-reported personality differences (r=.04, N=592; controlled for the same background variables). When I administered direct sibling comparisons with these same subjects, however, the scale score for the same 11 variables yielded a substantially larger partial correlation (r=.20, N=524, p<.0001; controlled for age, sex, sibship size, and social class). The three variables that did not exhibit significant birth-order differences by either method of assessment were being disorganized, sociable, and feminine (predicted to be laterborn traits).

[7] The 6,053 subjects in this study are drawn from 47 different samples from the United States, Canada, Latin America, and Germany (Sulloway, 1999). Thirty-one of these samples comprise people who attended a lecture by the author on the subject of birth order (N=3,269). All questionnaires were filled out before the lecture. Responses from another 2,784 subjects were collected by colleagues at 15 different universities and professional organizations, and through a mailing by the Skeptics Society to 10,000 nationally representative addresses. The two major subsamples make it possible to test for (1) possible inflation of birth-order effects by stereotypes and (2) possible self-selection bias among people who specifically came to hear a lecture on the subject of birth order. To test for these possible effects, I have conducted formal tests of heterogeneity on all of the samples. Overall, there is no significant heterogeneity in the birth-order findings from the individual subsamples. More specifically, there is no significant heterogeneity between the results for subjects who attended a lecture on the subject of birth order and subjects

who did not. In addition, subjects who reported having previously heard about my birth-order research in the news media responded similarly on their surveys compared with other subjects.

Of the 6,053 questionnaires that were collected, 726 (12 percent) contained insufficient data to provide usable responses. Also excluded from the statistical analyses in Table 2 were (1) 71 twins; (2) 112 subjects who reported an age gap of more than nine years between themselves and the sibling they also rated; (3) 86 subjects who reported that their functional birth orders differed from their biological birth orders (owing to adoption, the acquisition of stepsiblings, or the death of a sibling); and (4) 548 only children. As expected, birth-order effects were significantly reduced among the first three groups compared with other subjects. The findings for only children are discussed in note 10.

[8] As McCrae (1994) has shown, Openness to Experience exhibits two general components—openness in the sense of "intellect" and openness in the sense of "nonconformity." The "intellect" component of openness is more strongly correlated with IQ and years of education than is the second, or "nonconformist," component. Because firstborns tend to have higher IQs than laterborns, and because firstborns also tend to excel at academic pursuits, they are expected to score higher than laterborns on openness in intellect, reflected most strongly by the Ideas facet of the Five Factor Model. By contrast, laterborns are expected to score higher on the other facets of this dimension, especially Values. On some questionnaires I included the additional adjective pair "unintelligent/intelligent," which loads highly on Openness to Experience (r=.40). As expected, firstborns were rated as being more intelligent than laterborns (pr=-.15, N=1,641, p<.0001; controlled for age, sex, sibship size, and social class, and based on sibling difference scores). Ratings for this adjective pair also load highly on Conscientiousness (r=.58).

[9] All of the five scale scores except Conscientiousness exhibit significant heterogeneity for their component trait scores. In some cases, these heterogeneities are capable of canceling out birth-order effects, or even reversing them, unless proper adjustments are made. For example, if the trait "assertive (dominant)/unassertive (submissive)" is grouped in my study with the bipolar markers used to define Extraversion (for which it was originally picked as a marker), birth-order effects almost vanish, declining from r=.14 to r=.04 (see Table 2, note a). If the adjective pair "unintelligent/intelligent" is included with Openness to Experience, the scale-score correlation changes from a significant .08 to an equally significant -.08. Hence birth-order effects for this particular dimension can be positive or negative, depending on the degree to which "intellect" is emphasized over "unconventionality." In short, researchers who wish to investigate the influence of birth order on personality should exert caution when combining trait markers within higher-order scales, and should also first test for possible heterogeneity among the individual traits. The absence of birth-order effects in some large studies, such

as that by Ernst and Angst (1983) involving 7,696 Swiss subjects, may be due in part to such scale heterogeneities.

[10] Comparisons involving only children are based on absolute scores for predicted differences rather than on sibling difference scores. On an aggregate measure of these scores, only children are significantly different from laterborns. For the only child/laterborn contrast, r=.06 (N=2,955, p<.001). For the firstborn/only child contrast, r=.04 (N=2,185, p<.09). Both tests are controlled for age, sex, sibship size, and social class.

[11] For parental favoritism and being a middle child, r=-.07 (N=2,047, p< .005; controlled for age, sex, sibship size, and social class).

[12] These results regarding male homosexuality suggest that other aspects of behavior besides sexual orientation might also be influenced by the prenatal environment. If such biological effects exist, they appear to be sufficiently small that they are difficult to detect, even in large populations. In this connection, meta-analysis of the birth-order literature reveals no difference in the frequency of birth-order effects by sex, including for behaviors such as agreeableness, extraversion, and neuroticism that are closely linked to sex differences. In the study I have reviewed in Table 2, birth-order effects are just as frequent and substantial among women as they are among men. For males, moreover, number of elder brothers is not associated with gender-related traits after the analysis is controlled for birth order. In short, the link between number of elder brothers and gender-related traits appears to reflect a developmental outcome of nonpsychological origin that is confined to male homosexuals.

[13] In a canonical correlation model that includes five dependent variables (one for each of the dimensions of the Five Factor Model), the following independent variables are all significant predictors of personality and explain the amount of adjusted variance indicated in parentheses, measured via direct sibling contrasts: birth order, including linear and quadratic trends (4.3 percent of the variance), degree of bossiness toward one's siblings (16.2 percent), acting as a surrogate parent (6.8 percent), parent-offspring conflict (3.2 percent), parental favoritism (2.7 percent), closeness to parents (1.8 percent), and closeness to one's siblings (2.8 percent). These 7 predictors are all controlled for sex (which explains 7.9 percent of the variance), age (2.0 percent), sibship size (0.4 percent), and social class (0.3 percent—N=3,683 [the harmonic mean]). Note that between-family measures (such as social class and sibship size) contribute very little to the model, whereas predominantly within-family differences (birth order, sex, parent-offspring conflict, and closeness to siblings) collectively explain more than thirty times as much variance.

For 10 of the 11 predictors in this canonical correlation model (all but birth order), we cannot unambiguously infer cause and effect. For example, people who are genetically predisposed to act in a bossy manner during childhood are also likely to express aggressive traits in adulthood. Similarly, adults who are genetically predisposed to be conscientious are likely to have taken on

greater responsibilities as surrogate parents during childhood. Behavioral genetic studies are needed to resolve these causal issues.

[14] Nyman (1995) has documented significant differences in the personalities that people associate with differing birth orders, which may be considered "stereotypes." Such stereotypes may also have a basis in reality (as do gender stereotypes) and may also influence behavior in their own right. Not surprisingly, the birth-order differences documented by Nyman resemble those documented in Table 2.

[15] The following formal test suggests that "contrast effects" are modest for the results presented in Table 2. Sibling-difference scores were recoded on a three-step scale, depending on whether subjects rated themselves higher, lower, or the same as a sibling on each given personality attribute. (This procedure truncates the variance at each end of the scales, thereby limiting the expression of contrast effects.) Based on this method of data coding, the partial correlation of birth order with a scale score for all predicted personality differences is reduced from .20 to .19 (controlled for age, sex, sibship size, and social class). Another test for contrast effects is supplied by using absolute scores from self-ratings rather than sibling difference scores. Using this metric, the partial correlation between birth order and a scale score for all predicted personality differences is reduced from .20 to .16 (controlled for age, sex, sibship size, and social class).

[16] Controlled for age, sex, sibship size, and social class, birth order exhibits the following correlation with length of response about "unconventional" or "rebellious" behavior (r=.05, N=2,034, p<.02). For the content of responses, rated by two independent judges, r=.06 (N=2,034, p<.01; the interrater reliability between judges is .92). For both measures combined, the partial correlation with birth order is .07, compared with a partial correlation of .08 for birth order and openness to experience measured via direct sibling comparisons (Table 2).

[17] See Parker (1998); Jefferson, Herbst, and McCrae (1998); Phillips (1998); Paulhus, Chen, and Trapnell (1999); Beer and Horn (2000); and Nicholson (2001). The study by Paulhus et al. (1999) employed direct sibling comparisons for role descriptions, such as the "rebel" of the family, and documented birth-order differences similar in magnitude to those reported here. The other five studies employed unanchored scales and produced mostly null findings.

[18] To avoid plotting some overlapping data points directly on top of one another, I have randomly displaced the data in Figure 1 to a very small degree using SYSTAT's "Jitter" command (Wilkinson & Hill, 1994). All statistical tests are based on the undisplaced data points.

[19] The partial correlation between birth order and a scale score of expected personality differences among close friends is -.02 (N=1,002, p<.50, controlled for age, sex, sibship size, and social class). For the contrast between birth-order effects in ratings of peers and those found in ratings of spouses and roommates, z=2.99 (p<.005) and z=2.14 (p<.05), respectively.

[20] The correlation (.92) between the findings reported in Table 2 and the overall pattern of birth-order outcomes for each dimension of the Five Factor Model of personality, as reported in the birth-order literature, employs the meta-analytic data summarized in Sulloway (in press-a, Table 3). Note: Correlations that are based on aggregate data for each dimension of the Five Factor Model tend to be much larger than correlations based on individual data.

[21] Evidence conflicts regarding whether laterborns are more liberal than firstborns in contemporary populations. In my study of 660 CEOs mentioned earlier, laterborns rated themselves as being significantly more liberal than firstborns (r=.12, N=623, p<.005; controlled for age, sex, sibship size, and social class). Also, in my study of 6,053 subjects from the United States, Latin America, and Germany, I obtained the following partial correlations between birth order and self-reported traits, based on direct sibling contrasts, with a positive correlation denoting higher laterborn scores for the right-hand alternative in the following bipolar adjective pairs: traditional/untraditional, pr=.08 (N=2,357, p<.001); conventional/unconventional, pr=.11 (N=590, p<.01); conservative/liberal, pr=.03 (N=2,317, p<.17). All three correlations are controlled for age, sex, sibship size, and social class. In a study that did not employ direct sibling contrasts, Freese, Powell, and Steelman (1999) found almost no significant results among approximately 1,200 subjects included in the General Social Survey.

[22] The partial correlation between birth order and support for Darwinism in Number's (1998) sample is .27 (N=66, p<.05; controlled for age, social class, and social attitudes). Controlled for social class and sibship size, the partial correlation between birth order and support for evolutionary theory in Ruse's sample is .35 (N=63, p<.005)

[23] The mean-weighted partial correlation I have reported (.09) is controlled for sibship size in all 20 instances and for social class in 17 of the 20 instances. For the 27 studies as a whole (N=14,608), the mean-weighted correlation is .07 (which conservatively assumes a correlation of .00 for all nonsignificant studies that failed to report an effect size). All 27 of these studies are controlled for sibship size, but only 19 of the 27 studies are controlled for social class.

[24] This conclusion about birth order and parent-offspring conflict among radicals is based on a reanalysis of my own data on participants in 28 major scientific controversies (r=.13, N=252, p<.05; for these data the odds ratio is 1.8 to 1 in favor of high parent-offspring conflict having occurred among radical firstborns rather than among radical laterborns, with high conflict being defined as the 75th percentile or higher, based on ratings by independent judges).

[25] These partial correlations are controlled for sibship size (pr=.00) and social class (pr=.01), neither of which variable is statistically significant. For the overall model, the adjusted multiple correlation is .46 (N=1,858 [the harmonic

mean], $p<.0001$). It is important to note that willingness to accept a radical innovation is different from either the inclination or the ability to *initiate* radical intellectual change. Still, those people who are the most likely to support radical changes are also more likely than average to instigate such changes. Hence a willingness to endorse heterodox ways of thinking is a necessary, but not a sufficient, condition for intellectual discovery.

[26] In Figure 3, birth order has been operationalized as the linear trend in relative birth rank, from first to last. The trend for social attitudes is based on expert ratings by 95 historians. Two controversies that span more than a century (preformation/epigenesis and evolutionary theory) have been subdivided into the two major debates that occurred regarding the various theoretical alternatives. The data for two sets of closely related controversies (Hutton/Lyell and special and general relativity) have been combined. In the case of two controversies for which sample size was 20 or less (Devonian theory in geology and preformation theory) I have plotted the effect sizes given by the Estimation-Maximization algorithm, which draws on more information than do bivariate correlations (Sulloway, 1996:389-93; Schafer, 1991). Owing to the use of some new data for birth order and social attitudes, and to an alternative method of operationalizing birth order, the results presented in Figure 3 differ slightly from those presented in Sulloway (1996: Figure 14.1).

[27] For the partial correlation between birth order and ratings of personality among friends, $pr=-.02$ ($N=1{,}002$, $p<.50$; controlled for age, sex, sibship size, and social class; based on the scale score for all predicted attributes). For the interaction between birth order and age, $pr=.08$ ($N=1{,}002$, $p<.01$). For the interaction between birth order and social class, $pr=.06$ ($N=1{,}002$, $p<.05$; both partial correlations are controlled for the specified background factors and main effects). At the personality dimension level, significant interaction effects were found for openness to experience and neuroticism.

[28] For the interaction between birth order and marital status as they relate to perceived personality among friends and spouses, $pr=.05$ ($N=1{,}756$, $p<.05$; controlled for age, sex, sibship size, social class, and both main effects). Longitudinal studies would be particularly useful in providing further tests of these kinds of context-sensitive relationships and hypotheses.

[29] For the relationship between birth order and dominance in marriages, $pr=-.07$ ($N=780$, $p<.05$). Among roommates, firstborns were also more likely than laterborns to be rated high in dominance ($pr=-.16$, $N=165$, $p<.05$). Both partial correlations are controlled for age, sex, sibship size, and social class.

REFERENCES

Adler, Alfred. 1927. *Understanding Human Nature*. New York: Greenberg.

Adler, Alfred. 1928. "Characteristics of the First, Second, and Third Child", *Children*, 3, 14-52.

Beer, Jeremy M. & Horn, Joseph M. 2000. "The Influence of Reading Order

on Personality Development within Two Adoption Cohorts", *Journal of Personality*, 68, 789-819.

Blanchard, Ray. 1997. "Birth Order and Sibling Sex Ratio in Homosexual versus Heterosexual Males and Females", *Annual Review of Sex Research*, 8, 27-67.

Block, Jack. 1995. "A Contrarian View of the Five-Factor Approach to Personality Description", *Psychological Bulletin*, 117, 187-215.

Bragg, Arthur N. 1954. "Further Study of Predation and Cannibalism in Spadefoot Tadpoles", *Herpetologica*, 20, 17-24.

Costa, Paul T., Jr. & McCrae, Robert R. 1992. *NEO PI-R Professional Manual.* Odessa, Fl.: Psychological Assessment Resources.

Daly, Martin & Wilson, Margo. 1988. *Homicide.* New York: Aldine de Gruyter.

Daly, Martin & Wilson, Margo. 1990. "Is Parent-offspring Conflict Sex-linked? Freudian and Darwinian Models", *Journal of Personality*, 58, 163-89.

Darwin, Charles R. 1859. *On the Origin of Species by Means of Natural Selection*. London: John Murray.

Darwin, Charles R. 1887. *The Life and Letters of Charles Darwin,* 3 vols. London: John Murray.

Downey, Douglas B. 2001. "Number of Siblings and Intellectual Development", *American Psychologist*, 56, 497-504.

Drummond, Hugh & García-Chavelas, C. 1989. "Food Shortage Influences Sibling Aggression in the Blue-Footed Booby", *Animal Behavior*, 37, 806-18.

Drummond, Hugh & Osorno, Jose Luis. 1992. "Training Siblings to Be Submissive Losers: Dominance between Booby Nestlings", *Animal Behavior*, 44, 881-93.

Eaves, L.J., Eysenck, H.J., & Martin, N.G. 1989. *Genes, Culture and Personality*. London and San Diego: Academic Press.

Ernst, Cécile & Angst, Jules. 1983. *Birth Order: Its Influence on Personality.* Berlin and New York: Springer-Verlag.

Frank, Laurence G., Glickman, Stephen E., & Licht, Paul. 1991. "Fatal Sibling Aggression, Precocial Development, and Androgens in Neonatal Spotted Hyenas", *Science*, 252, 702-704.

Freese, Jeremy, Powell, Brian, & Steelman, Lala Carr. 1999. "Rebel Without a Cause or Effect: Birth Order and Social Attitudes", *American Sociological Review,* 64, 207-231.

Galton, Francis. 1874. *English Men of Science*. London: Macmillan.

Gould, Stephen Jay. 1977. *Ontogeny and Phylogeny*. Cambridge and London: Harvard University Press.

Haig, David. 1993. "Genetic Conflicts in Human Pregnancy", *Quarterly Review of Biology*, 68, 495-531.

Hamilton, William D. 1964. "The Genetical Evolution of Social Behavior", I and II, *Journal of Theoretical Biology*, 7, 1-16; 17-52.

Hamilton, William D. 1967. "Extraordinary Sex Ratios", *Science,* 156, 477-88.

Harris, Judith Rich. 1995. "Where Is the Child's Environment? A Group So-

cialization Theory of Development", *Psychological Review*, 102, 458-89.
Harris, Judith Rich. 1998. *The Nurture Assumption: Why Children Turn Out the Way They Do*. New York: Free Press.
Hertwig, Ralph, Davis, Jennifer, & Sulloway, Frank J. 2001. "Parental Investment: How an Equality Motive Can Produce Inequality", manuscript submitted for publication.
Hrdy, Sarah Blaffer & Judge, Debra. 1992. "Darwin and the Puzzle of Primogeniture", *Human Nature*, 4, 1-45.
Hunter, John E. & Schmidt, Frank L. 1990. *Methods of Meta-Analysis: Correcting Error and Bias in Research Findings*. Newbury Park, CA: Sage.
Jefferson, Tyrone, Jr., Herbst, Jeffrey H., & McCrae, Robert R. 1998. "Associations between Birth Order and Personality Traits: Evidence from Self-reports and Observer Ratings", *Journal of Research on Personality*, 32, 498-509.
John, Oliver P. 1990. "The 'Big Five' Factor Taxonomy: Dimensions of Personality in the Natural Language and in Questionnaires", in Pervin, L.A., ed., *Handbook of Personality: Theory and Research*. New York: Guilford, pp. 66-100.
Jones, M.B. & Blanchard, Ray. 1998. "Birth Order and Male Homosexuality: Extension of Slater's Index", *Human Biology*, 70, 775-787.
Koch, Helen. 1956. "Attitudes of Young Children Toward Their Peers as Related to Certain Characteristics of Their Siblings", *Psychological Monographs*, 70, 1-41.
Krebs, John R. & Davies, Nicholas B. 1997. *Behavioural Ecology: An Evolutionary Approach,* 4th ed. Oxford: Blackwell.
Krishnamurthy, K.S., Shaanker, R. Uma, & Ganeshaiah, K.N. 1997. "Seed Abortion in an Animal Dispersed Species, *Syzygium cuminii* (L.) Skeels (Myrtaceae): The Chemical Basis", *Current Science*, 73, 869-73.
Lewis, David L. 1970. *King: A Critical Biography*. New York: Praeger.
Loehlin, John C. 1992. *Genes and Environment in Personality Development*. Newbury Park, CA: Sage Publications.
Mayr, Ernst. 1961. "Cause and Effect in Biology", *Science*, 134, 1501-1506.
McCrae, Robert R. 1994. "Openness to Experience: Expanding the Boundaries of Factor V", *European Journal of Personality*, 8, 251-72.
McCrae, Robert R. & Costa, Paul T., Jr. 1987. "Validation of the Five-Factor Model of Personality across Instruments and Observers", *Journal of Personality and Social Psychology*, 52, 81-90.
McCrae, Robert R. & John, Oliver P. 1992. "An Introduction to the Five-Factor Model and Its Applications", *Journal of Personality,* 60:175-215.
Mock, Douglas W. & Parker, G.A. 1998. *The Evolution of Sibling Rivalry*. New York and Oxford: Oxford University Press.
Mock, Douglas W., Drummond, Hugh, & Stinson, Christopher H. 1990. "Avian Siblicide", *American Scientist*, 78, 438-49.
Modell, John. 1996. "Family Niche and Intellectual Bent", review of *Born to Rebel*, by Frank J. Sulloway, *Science*, 275, 624.

Nicholson, Nigel. 2001. "Personality and Birth Order—Is There a Relationship? An Evolutionary Analysis", unpublished manuscript.

Numbers, Ronald. L. 1998. *Darwinism Comes to America*. Cambridge and London: Harvard University Press.

Nyman, Lawrence. 1995. "The Identification of Birth Order Personality Attributes", *Journal of Psychology*, 129, 51-59.

Ozer, Daniel J. 1985. "Correlation and the Coefficient of Determination", *Psychological Bulletin*, 97, 307-315.

Parker, Wayne D. 1998. "Birth Order Effects in the Academically Talented", *Gifted Child Quarterly*, 42, 29-36.

Paulhus, Delroy L., Chen, David, & Trapnell, Paul D. 1999. "Birth Order and Personality within Families", *Psychological Science*, 10, 482-88.

Phillips, Suzanne M. 1998. "Birth Order and Personality—Not Again!", paper presented at the 69th Annual Meeting of the Eastern Psychological Association, February 1998, Boston.

Plomin, Robert & Daniels, Denise. 1987. "Why Are Children in the Same Family So Different from One Another", *Behavioral and Brain Sciences*, 10, 1-60.

Retherford, Robert A. & Sewell, William H. 1991. "Birth Order and Intelligence: Further Tests of the Confluence Model", *American Sociological Review*, 56, 141-58.

Rogers, Joseph Lee. 2001. "What Causes Birth Order-Intelligence Patterns? The Admixture Hypothesis, Revisited", *American Psychologist*, 56, 505-510.

Rodgers, Joseph Lee, Cleveland, Hobart H., van den Oord, Edwin, & Rowe, David C. 2000. "Resolving the Debate Over Birth Order, Family Size, and Intelligence", *American Psychologist*, 55, 599-612.

Rosenthal, Robert. 1987. *Judgment Studies: Design, Analysis, and Meta-analysis*. Cambridge: Cambridge University Press.

Rosenthal, Robert & Rubin, Donald B. 1982. "A Simple, General Purpose Display of Magnitude in Experimenter Effect", *Journal of Educational Psychology*, 74, 166-69.

Salmon, Catherine A. 1998. "The Evocative Nature of Kin Terminology in Political Rhetoric", *Politics and the Life Sciences*, 17, 51-57.

Salmon, Catherine A. 1999. "On the Impact of Sex and Birth Order on Contact with Kin", *Human Nature*, 10, 183-97.

Salmon, Catherine A. & Daly, Martin. 1998. "Birth Order and Familial Sentiment: Middleborns are Different", *Human Behavior and Evolution*, 19, 299-312.

Saudino, Kimberly J. 1997. "Moving beyond the Heritability Question: New Directions in Behavioral Genetic Studies of Personality", *Current Directions in Psychological Science*, 6, 86-90.

Schachter, Frances Fuchs, Gilutz, Gabi, Shore, Ellen, & Adler, Michelle. 1978. "Sibling Deidentification Judged by Mothers: Cross-validation and Developmental Studies", *Child Development*, 49, 543-46.

Schachter, Frances Fuchs. 1982. "Sibling Deidentification and Split-parent Identifications: A Family Tetrad", in Lamb, M.E. & Sutton-Smith, B., eds., *Sibling Relationships: Their Nature and Significance Across the Lifespan.* Hillsdale, NJ: Lawrence Erlbaum, pp. 123-52.

Schafer, Joseph L. 1991. "Algorithms for Multiple Imputation and Posterior Simulation from Incomplete Multivariate Data with Ignorable Nonresponse", Ph.D. Dissertation, Department of Statistics, Harvard University.

Schwabl, Hubert. 1996. "Environment Modifies the Testosterone Levels of a Female Bird and Its Eggs", *Journal of Experimental Zoology*, 276, 157-63.

Schwabl, Hubert, Mock, Douglas W., & Gieg, Jennifer A. 1997. "A Hormonal Mechanism for Parental Favouritism", *Nature*, 386, 231.

Skinner, William G. 1992. "Seek a Loyal Subject in a Filial Son: Family Roots of Political Orientation in Chinese Society", in *Family Process and Political Process in Modern Chinese History.* Taipei, Republic of China: Chiang Ching-kuo Foundation for International Scholarly Exchange, pp. 943-93.

Somit, Albert, Arwine, Alan, & Peterson, Steven A. 1996. *Birth Order and Political Behavior.* Lanham, MD: University Press of America.

Sulloway, Frank J. 1979. *Freud, Biologist of the Mind: Beyond the Psychoanalytic Legend.* New York: Basic Books.

Sulloway, Frank J. 1982. "Freud and Biology: The Hidden Legacy", in Woodward, W.R. & Ash, M.G., eds., *The Problematic Science: Psychology in Nineteenth-Century Thought.* New York: Praeger Publishers, pp. 198-227.

Sulloway, Frank J. 1995. "Birth Order and Evolutionary Psychology: A Meta-analytic Overview", *Psychological Inquiry*, 6, 75-80.

Sulloway, Frank J. 1996. *Born to Rebel: Birth Order, Family Dynamics, and Creative Lives.* New York: Pantheon.

Sulloway, Frank J. 1997. *Born to Rebel: Birth Order, Family Dynamics, and Creative Lives,* revised ed. New York: Vintage.

Sulloway, Frank J. 1999. "Birth Order", in Runco, M.A. & Pritzker, S.R., eds., *Encyclopedia of Creativity*, 1:189-202.

Sulloway, Frank J. (in press-a). "*Born to Rebel* and Its Critics", *Politics and the Life Sciences.*

Sulloway, Frank J. (in press-b). "Sibling-Order Effects", *International Encyclopedia of the Social and Behavioral Sciences.*

Townsend, F. (in press). "Birth Order and Rebelliousness: Reconstructing the Research in *Born to Rebel*", *Politics and the Life Sciences.*

Trivers, Robert L. 1974. "Parent-offspring Conflict", *American Zoologist*, 14, 249-64.

Trivers, Robert L. 1985. *Social Evolution.* Menlo Park, CA: Benjamin/Cummings.

Voland, Ekart. 1988. "Differential Infant and Child Mortality in Evolutionary Perspective: Data from the late 17th to 19th Century Ostfriesland (Germany)", in Betzig, Laura, Mulder, Monique Borgerhoff, & Turke, Paul,