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CHAPTER 21

Birth order and sibling competition

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21.1. Introduction

Sibling competition is widespread in the natural world, and sometimes ends in siblicide. Order of birth among siblings affects the outcome of such contests, because it is a proxy for disparities in age, size, power, and opportunity. In our own species, birth order combines with the prolonged period of childhood dependence on parents to promote differences in parental investment. In addition, siblings often occupy different niches within the family and employ differing tactics in competition with one another. These disparate experiences influence personality, sentiments about the family, patterns of motivation, and attitudes more generally.

Historically, birth order has long been important in many social customs, including occupational choices, reproductive opportunities, inheritance practices, and royal succession. Birth order has also been implicated in support for, and opposition to, radical social and scientific revolutions. Although the persistence of birth-order effects in adulthood is well established by numerous studies, the extent and magnitude of these effects remains controversial. Compared with their well-documented manifestations within the family, systematic sibling differences are generally less pronounced when expressed in non-family contexts. Moreover, to manifest themselves in extrafamilial contexts, such birth-order effects often require eliciting factors that are linked with familial sentiments or with the familial context in which these behaviours were originally acquired.

21.2. Biological aspects of birth order and sibling competition

On average in sexually reproducing organisms, siblings share half their genes. Hence, with the exception of identical twins, siblings are twice as related to themselves as they are to another sibling. Drawing on this genetic insight, William Hamilton (1964a,b) realized that full siblings ought to compete for scarce resources whenever the benefits of doing so are more than half the costs to another sibling. From this cost/benefit perspective, sibling competition and parent–offspring conflict are opposite sides of the same biological coin. This is because parents are equally related to all of their offspring—present and future—but offspring are twice as related to themselves as they are to siblings or parents. Hence offspring will tend to disagree with parents about the timing of any curtailment of parental investment in themselves in favour of investment in future offspring. Weaning conflicts are a prime example of such dissensions (Trivers, 1974).

Biologists have documented competition between siblings in mammals, birds, amphibians,

fish, insects, and even plants (Mock and Parker, 1997; Mock, 2004). Such competitive behaviours are particularly common among seabirds and predatory birds and sometimes lead to siblicide. Among African black eagles (*Aquila verreauxii*) siblicidal competition is 'obligate', occurring in nearly every instance. In this avian species parents are generally not capable, for ecological reasons, of raising more than one chick. The second egg, hatched a few days after the first, serves to ensure that valuable time is not lost in the breeding season should the first chick fail to hatch or die shortly after emerging from the egg. Within a few days, the older of the two black eagle chicks pecks the younger to death. "In all siblicidal species studied to date," note Mock *et al.* (1990), "there is a striking tendency for the victim to be the youngest member of the brood" (p. 445). Parents do not intervene in these lethal contests, as it is not in their biological interests to do so.

Among blue-footed boobies (*Sula nebouxii*), siblicide is 'facultative', meaning that its occurrence depends on ecological factors, which vary from one breeding season to the next. Females of this species lay two or three eggs. Aggressive pecking by an elder chick, directed against a younger, begins when the body weight of the elder chick falls below 80% of normal. In a good year, with plentiful food supplies, blue-footed booby parents can successfully raise two or even three chicks. When food is scarce, siblicide regulates clutch size in a generally adaptive manner (Drummond and García-Chavelas, 1989).

Unlike blue-footed booby parents, parents in some avian species regulate sibling competition in order to produce optimal fledgling numbers. Female canaries (*Serinus canaria*) lay four or five eggs, which hatch on successive days. Relative to older chicks, the younger and smaller ones are at a considerable disadvantage in obtaining food. To equalize competition, canary mothers lace each successive egg with greater amounts of testosterone, which promotes neural growth and makes the younger chicks more pugnacious (Schwabl, 1996; Schwabl *et al.*, 1997). American coots sometimes grab an older offspring by the neck and shake it violently–occasionally even killing it. This seemingly strange behaviour makes it easier for parents to feed younger offspring (Mock, 2004).

Evolution has sometimes given rise to specialized adaptations to help offspring to cope with sibling competition. Piglets are born with eight eye teeth—later shed—which they use in competition for the best maternal teats. Earlier-born piglets fiercely and successfully defend access to the anterior-most teats, which are the richest in milk supply, thereby establishing a dominance hierarchy based on teat order. Owing to differences in nourishment, a piglet born in the second half of the litter is only half as likely as its littermates to survive past the third week (Trivers, 1985). Even plants have sometimes evolved specialized adaptations for sibling competition. The Indian black plum (*Syzygium cuminii*) develops seeds with 25 to 30 ovules, which are botanical siblings. The first ovule to be fertilized secretes a 'death chemical' that prevents the metabolism of sucrose and kills off the other ovules (Krishnamurthy *et al.*, 1997).

21.3. Social and economic repercussions

Like many animal species, human offspring are highly dependent on parental investment. As a consequence, sibling strife over parental decisions about how to allocate scarce resources has long been an important consideration in human development. Before 1800, roughly half of all children succumbed to diseases of childhood. Studies have shown that parental discrimination among offspring, by sex and birth order, often affected who lived and who died (Boone, 1986; Voland, 1988, 1990). Having already survived some of the lethal diseases of childhood, elder children were generally better Darwinian bets for passing on their parent's genes to the next generation. In premodern times older offspring generally appear to have been favoured by parents. For example, infanticide is widely practised in traditional societies and is an accepted means of optimally allocating parental investment. No traditional society, however, condones the killing of the elder of two children (Daly and Wilson, 1988).

In a survey of 39 non-Western societies, anthropologists have found that firstborns of both sexes are generally given more elaborate birth ceremonies and privileges than other children. They also usually have authority over their younger siblings. In addition, firstborns–especially males–are generally favoured by inheritance practices and tend, in adulthood, to become the leaders

of their family group (Rosenblatt and Skoogberg, 1974). Firstborns are also more likely to be named after a parent, an attribute that is associated with greater parental investment (MacAndrew *et al.*, 2002).

In Western societies, inheritance customs have often reflected discrimination by birth order. Several different systems have commonly been employed, including primogeniture (the policy of leaving all parental assets to the eldest child or eldest son), secundogeniture or (inheritance by the secondborn), and ultimogeniture (inheritance by the youngest child). Local variations in such inheritance strategies are generally understandable in terms of specific geographic and economic circumstances. For example, primogeniture has been common when both land and economic opportunities are limited. Bequeathing all or most of the parental property to the firstborn son avoided the subdivision of family lands and also helped to ensure the survival of the family patronymic (Hrdy and Judge, 1992). Ultimogeniture has usually been practised whenever there are substantial death taxes on property, as inheritance by the youngest child increases the interval between taxations. Equal inheritance is often associated with economic environments in which risk and skill are important factors in success. In Renaissance Venice, for example, economic fortunes were mostly made through speculative trade. Parents wisely gave equal shares to all of their children in the hopes of increasing the chances of having multiple successful offspring, as well as a continuation of the family name (Herlihy, 1977).

21.4. Why are siblings so different?

One of the most interesting questions about siblings is why they are so different (Plomin and Daniels, 1987). Although siblings share half their genes and exhibit similarities in personality based on this shared genetic basis, most parents are struck by how different siblings actually are. Research in behavioural genetics has shed extensive light on this topic. Based on studies of twin and non-twin siblings who have either grown up together or been separated at birth, researchers have determined that about 40% of the total variance in personality is genetic, about 35% is attributable to the non-shared environment, and only about 5% is associated with growing up in the same family. (The remaining 20% of the variance in personality is associated with measurement error—see Loehlin, 1992.)

A considerable surprise from these results is that growing up in the same family exerts only a small influence in making siblings more alike. This conclusion has led some commentators to argue that parents have little or no influence on the personalities of their offspring (Harris, 1998; Pinker, 2002). For several reasons, however, this conclusion is overstated. To begin with, these assessments about the importance of the shared environment underestimate its true influence owing to errors of measurement. In addition, even the seemingly modest amount of variance in personality that is currently thought to be explained by the shared environment (5%) represents a more substantial contribution than most people realize. For example, an influence of this magnitude means that a child growing up with relatively extroverted parents is twice as likely as other children to end up in the upper half of the personality distribution for this particular personality attribute (the odds ratio). Couched in these statistical terms, it is difficult to imagine that parents might have any greater influence on the personalities of their offspring than they actually do.

The real surprise from research in behavioural genetics involves the considerable role of the non-shared environment, which exerts roughly seven times as much influence on personality development as does the shared environment. One response to this unexpected finding has been to conclude that personality is mostly shaped by extrafamilial experiences, such as peer group influences (Harris, 1998). Although Harris, following Rowe (1994), has done a considerable service by calling attention to extrafamilial factors in personality formation, her downplaying of parental influences overlooks the fact that the family is not, in its most essential features, a shared environment. In fact, few aspects of family life are truly shared, other than material circumstances such as the number of books contained in the home and the neighbourhood where the home is located. The same shared events, such as a parental divorce, often elicit differing reactions from offspring.

In addition, because children are genetically different, they evoke somewhat different responses from other family members, including parents. More important, siblings notice these differences in behaviour and are sensitive to them (Dunn and Plomin, 1990). Such differing interpersonal interactions between parents and offspring contribute to the family's non-shared environment, not its shared environment. In short, the most important conclusion from research in behavioural genetics is not that parents have little influence on their offspring but rather that the family exerts the bulk of its environmental influence in a very different way than was previously thought.

21.5. Psychological mechanisms

Birth order is one source among many that helps to explain the extensive effects of the non-shared environment. The environmental sources of birth-order differences are best understood as reflecting the operation of several different principles: (1) differences in parental investment (and a cluster of related mechanisms linked with sibling competition); (2) dominance hierarchy effects; (3) niche partitioning within the family; and (4) deidentification, or the tendency for offspring to strive to be different from one another. Each of these four mechanisms leads to somewhat different predictions about the nature of resulting birth-order effects. In addition, (5) birth-order effects may in part reflect stereotypes, which themselves appear to reflect real differences but which are also capable of influencing behaviour independently of reality-based effects (Table 21.1).

21.5.1. Parental investment

Biases in parental investment are expected to foster quadratic or U-shaped trends in birth-order effects, with middleborns being different from other siblings. Such U-shaped distributions are a consequence of what may be termed the 'equity heuristic' and the counterintuitive results that this heuristic produces over time (Hertwig *et al.*, 2002). A variant of resource dilution hypotheses, the equity heuristic refers to the tendency for parents in modern societies to treat their children in an equitable manner. Because firstborns and lastborns experience a period of exclusive parental investment, when other siblings are not yet born or have grown up and left the home, members of these two sibling positions experience a greater *net* accumulation of parental investment than do middleborns. When a particular parental resource is only important for human development in infancy or early childhood—such as devoting time and financial resources to having offspring vaccinated—the equity heuristic predicts linear rather than U-shaped trends. This is because there is never a period when the youngest child benefits in an exclusive manner from such parental resources, which are no longer developmentally pertinent by the time older siblings have left the home.

In contrast to middleborns, lastborns benefit from another tendency in parental investment. As parents—particularly mothers—reach the end of their reproductive careers, lastborns increasingly represent the last child they will ever have. Under such circumstances, it makes good Darwinian sense to allocate increased parental investment to young and vulnerable offspring that cannot be replaced (Salmon and Daly, 1998; Rohde *et al.*, 2003). Parental favouritism toward lastborns contributes to the U-shaped trends already expected as a consequence of the equity heuristic.

Empirical support for these theoretical perspectives on birth order and parental investment comes from a variety of studies (Hertwig *et al.*, 2002). Lindert (1977) analysed total hours of child care, up to the age of 18 years. In families with more than two children, this investigator found that middleborns were consistently at a disadvantage, receiving about 10% less in cumulative child care relative to firstborns and lastborns. Horton (1988) investigated nutritional status in 1903 Philippine households and found that younger siblings received less total food than older ones, as reflected by their lower height and weight. In addition, several studies have shown that laterborns are less likely to be vaccinated or taken to medical clinics, compared with earlierborn children. One study of 6350 children born in April 1970 in Great Britain found that vaccination rates were 68% for firstborns, 58% for secondborns, 50% for

Table 21.1 A family dynamics model of birth-order differences in human behaviour, health and well-being

Causal mechanisms	Observed birth-order trends
1. Differences in parental investment, which may involve outright discrimination or indirect effects through resource dilution, resulting in unequal *net* investment in offspring owing to the 'equity heuristic'. Historically, such differences in parental investment have often been reinforced by cultural practices such as primogeniture.	Either linear or quadratic (U-shaped) trends, depending on the age at which a parental resource is most important in life. Birth-order differences have been documented for vaccination rates, nutrition, medical care, self-esteem, IQ, and family sentiments (e.g., closeness to parents). See Zajonc and Mullally (1997), Salmon and Daly (1998), Salmon (1999), Hertwig *et al.* (2002)
2. Dominance hierarchy effects.	Linear effects based on sibling differences in age and size, particularly those relating to agreeableness and to some aspects of extraversion, neuroticism, and openness to experience (Sulloway 1996, 2001; Paulhus *et al.*, 1999; Rohde *et al.*, 2003).
3. Niche partitioning within the family system. Niche partitioning reduces competition and sometimes promotes cooperation among siblings.	Predominantly linear trends in attributes related to surrogate parenting, including differences in conscientiousness and in some aspects of extraversion and openness to experience (Sulloway, 1996, 2001).
4. Sibling deidentification.	Pairwise differences, including small zigzag trends, as siblings seek to differentiate themselves from other siblings, especially those who are immediately adjacent in age (Schachter *et al.* 1978; Skinner 1992; Sulloway 1996; Plowman 2005).
5. Birth-order stereotypes.	Stereotypes may create birth-order effects or may reinforce those produced by other mechanisms (Herrera *et al.* 2003).

thirdborns, 39% for fourthborns, and only 34% for fifthborns and higher birth ranks (Lewis and Britton, 1998). Across multiple studies, the odds of being vaccinated decline by 20–30% with each successive child in the family. Not surprisingly, numerous studies have shown that mortality rates in childhood—even in the twentieth century—are typically higher for children of higher birth orders. One study involving 14 192 Swedish children born between 1915 and 1929 found that—compared with firstborns—third- and fourthborns were 2.1 times more likely to die before the age of 10 years (Modin, 2002).

21.5.2. Sibling dominance hierarchies

Siblings reside within a dominance hierarchy based on age, size, and power. In competition,

older siblings can physically intimidate younger siblings. Firstborns, in effect, are the 'alpha males' of their sibling group. Differences in linguistics skills also give older siblings an edge in verbal exchanges. Hence firstborns are expected to be dominant over their younger siblings. Some aspects of personality appear to reflect these differences, which present linear trends in traits such as dominance and assertiveness (see Section 21.6).

21.5.3. Niche partitioning

Sibling differences derive in part from niche partitioning within the family, which entails the adoption of diverse roles and domains of expertise. Differences in niche partitioning owe themselves to multiple factors, including genetic disparities between siblings, differences by sex, and differences by birth order. Niche partitioning is a direct consequence of Charles Darwin's (1859) 'principle of divergence'. Specialization within different family niches reduces competition, leads to a division of labour, and also makes it more difficult for parents to make direct comparisons between offspring. This general principle plays a central role in evolutionary biology, where it explains the process of 'adaptive radiation' among evolutionarily successful species such as Darwin's famous Galápagos finches.

Within the family, birth order is relevant to niche partitioning because the age differences between siblings affect the kinds of niches that are usually open to them. Similarly, siblings tend to diverge because they are they use different age-based strategies in dealing with one another. Because niche partitioning is substantially based on differences in age, most birth-order effects deriving from this psychological process are expected to display linear trends. Evidence for such trends is seen in some aspects of personality, such as conscientiousness, extraversion, and openness to experience.

A classic example of niche partitioning involves the consumer advocate and American presidential candidate, Ralph Nader. When Nader was a child, he and his three siblings divided a globe of the world into four sections. Each sibling took one-quarter of the world and thereafter specialized in its languages and history. What the Nader siblings appreciated was that they would all benefit more by cooperatively sharing their diverse domains of world expertise than by competing to know the most about any single domain (Sulloway, 1996). In general, there is greater pressure on laterborns than on firstborns to diversify their interests and abilities, because firstborns have usually already nailed down the family niche of surrogate parent as well as other parentally valued roles such as being the 'studious' and 'responsible' child.

21.5.4. Deidentification

A fourth class of birth-order effects reflects yet another cause of mutual divergence as sibs seek to differentiate themselves from one another, especially from their immediately adjacent brothers and sisters. This process has been called 'deidentification' (Schachter *et al.*, 1978). The same differentiation process extends to patterns of identification with parents. If one sibling identifies closely with one parent, another sibling will often identify more closely with the other parent (Schachter, 1982). Patterns of deidentification are expected to produce small zigzag trends as adjacent siblings differentiate themselves from one another (Skinner, 1992).

21.5.5. Birth-order stereotypes

There is some evidence that stereotypes about birth order play a role in creating and reinforcing birth-order differences. It should be kept in mind that stereotypes often reflect a perceived reality about the world that is substantially based on valid evidence. Moreover, socially accepted stereotypes, which serve to nurture expectations, exert a considerable influence on human behaviour. Birth-order stereotypes have been shown to exist in a number of different studies (Baskett, 1985; Musun-Miller, 1993; Nyman, 1995; Herrera *et al.*, 2003). These stereotypes about personality and intellectual ability correspond closely with the kinds of birth-order differences that are actually reported in within-family studies. For example, firstborns are widely believed to be more intellectually oriented and conscientious than younger siblings, and to be more likely to attain high occupational status. Considerable evidence supports the higher educational and occupational status of firstborns, as well as the association between these outcomes and the psychological attributes (conscientiousness and intelligence) that are typically assigned

to firstborns in studies of birth-order stereotypes (Herrera *et al.*, 2003).

21.6. Human behaviour and personality

More than two thousand publications on the subject of birth order have yielded a sometimes confusing pattern of results, especially about personality. As Ernst and Angst (1983) have rightly pointed out, many of these studies fail to control for differences in family size and social class. Lower-class families are biased for large sibships, so uncontrolled studies showing that laterborns differ from firstborns on some attribute may have detected a spurious cross-correlation rather than a valid birth-order effect.

Even in controlled birth-order studies there is considerable heterogeneity in outcomes. This circumstance has led some commentators, including Ernst and Angst (1983), to dismiss the importance of birth order. The majority of controlled birth-order studies, however, lack sufficient statistical power to demonstrate such effects. When these disparate findings in controlled studies are subject to meta-analysis—a technique for amalgamated findings of a similar nature to gain statistical power—they reveal modest but consistent birth-order differences (Sulloway, 1995, 2002).

Psychologists have usefully classified personality differences under what are known as the 'Big Five' personality dimensions—also sometimes referred to as the 'Five Factor Model' of personality (Costa and McCrae, 1992). These dimensions include Conscientiousness, Agreeableness, Extraversion, Openness to Experience, and Neuroticism. When assessed in terms of the Big Five personality dimensions, research on personality generally reflects the kinds of birth-order trends that are expected based on a family dynamics model.

In within-family studies, firstborns tend to be higher than laterborns in virtually all aspects of Conscientiousness. When siblings rate one another or when parents assess their own offspring—thus controlling for between-family differences—firstborns are described as being more deliberate, organized, dutiful, and self-disciplined than their younger brothers and sisters, and they are also generally considered the 'achiever' of the family (Paulhus *et al.*, 1999; Plowman, 2005; Sulloway, 1996, 2001). Similarly, firstborns are overrepresented in *Who's Who* and in other standard measures of social and intellectual attainment, including becoming famous writers, world leaders, and winners of prizes for achievement. In addition, firstborns have slightly higher IQs than laterborns. (IQ declines about 1 point with each successive birth rank.) Such differences in intelligence appear to reflect a dilution of intellectual resources: as families increase in size, parents have less time to devote to each child, and children themselves diminish the overall level of the family's intellectual environment (Zajonc, 1976; Zajonc and Mullally, 1997). Some researchers nevertheless maintain that these well-documented effects, which have not been observed in some within-family studies, are artefacts stemming from differences between families (Wichman *et al.*, 2006). In spite of inconsistencies and some unanswered questions, these collective findings appear to reflect the fact that firstborns experience a different family environment than do laterborns. In particular, firstborns often act as surrogate parents toward younger siblings and reap greater parental investment and rewards by occupying this 'responsible' family niche. Owing to their relative immaturity, younger siblings are at a considerable disadvantage in competing for this family role and must generally seek parental favour in other ways—for example, by being affectionate, humorous, or athletic.

Turning to birth-order results for Agreeableness in within-family studies, we find that laterborns tend to score higher than firstborns on most facets of this dimension. Because firstborns are physically bigger and stronger than their siblings, it is easier for them to employ high-powered strategies. By contrast, younger siblings tend to cultivate appeasement strategies and other low-power tactics, including whining and pleading and, when necessary, appealing to parents for protection and assistance.

The unusual status of middleborns, sandwiched between siblings of greater and lesser age and power, appears to lend itself to cooperative and diplomatic skills. Based on within-family assessments, middleborns generally score higher on Agreeableness than do firstborns and lastborns (Sulloway, 2001). Martin Luther King, Jr, the middle of three children, began his career as

a champion of non-violent reform by intervening in his younger brother's relentless teasing of their elder sister (Sulloway, 1996).

Traits related to Extraversion exhibit significant heterogeneity by birth order. As expected, firstborns in within-family studies are typically described as being more extraverted in the sense of being assertive and dominant, whereas laterborns are described as being more extraverted in the sense of being fun-loving, affectionate, and excitement seeking. Laterborns also employ humour as a sibling strategy, which exemplifies another facet of Extraversion. One well-designed study of Columbia University students ($N = 1967$) found that laterborns were 1.6 times more likely than firstborns to engage in dangerous sports such as football, rugby, and soccer. These findings appear to reflect laterborn deidentification and divergence from the elder offspring's choice of relatively safe sports such as track, tennis, and swimming (Nisbett, 1968).

Like Extraversion, Openness to Experience exhibits considerable heterogeneity by birth order, especially in within-family studies. Firstborns are more open to experience in the sense of being intelligent and intellectually oriented (reflecting achievement by academic conscientiousness and hence by conformance with the norms of society), whereas laterborns are more open to experience in the sense of being untraditional, unconventional, prone to fantasy, and attracted by novelty. In one study, subjects were asked to list 'the two or three most unconventional or rebellious' aspects about their lives. Laterborns listed more examples than firstborns, and they also listed more behaviours, experiences, and interests that were assessed as being truly unconventional by two independent judges (Sulloway, 2001).

Birth-order differences on the Big Five dimension of Neuroticism are minimal, as expected, because most neurotic traits are not adaptive, and most birth-order differences in personality are expected to reflect a functional—and hence adaptive—role in family dynamics. An exception to this last assertion, however, involves birth-order differences that arise from disparities in parental investment. Biases in parental investment are expected to affect self-confidence. Reduced parental investment, for example, may explain why laterborns—particularly middle children—display somewhat lower self-esteem than do firstborns (Kidwell, 1982).

In studies of birth order, singletons need to be distinguished from other firstborns. Singletons are a controlled experiment—what it is like to experience childhood without sibling competition or parental discrimination in favour of another sibling. As a result, singletons tend to be intermediate between firstborns and laterborns in many aspects of personality. Owing to greater parental investment than is received by children who have siblings, singletons tend to resemble other firstborns in attributes such as being conscientious and parent-identified, as well as by exhibiting above-average levels of achievement. A portion of these effects can be attributed to small family size rather than to birth order *per se*.

In general, birth-order effects appear to be most pronounced when the age spacing between successive children is 2–4 years, enough to produce inequality in age and size, but not enough to disrupt the competitive dynamics that go on between siblings who are reasonably close in age. Helen Koch's (1955, 1956) pioneering researches on birth order documented the moderating effects of age spacing, as well as sex and sex of sibling. Such moderating effects were generally modest in magnitude and often complex.

In considering birth-order differences in human behaviour, it is important to distinguish between functional and biological birth order. A large age gap between a firstborn and the next younger sibling can effectively transform the younger offspring into a functional firstborn or singleton. Divorce and remarriage, resulting in blended families, can also create disparities between biological and functional birth order. It is functional birth order, not biological birth order, that is important in most aspects of personality development.

Because there are no genes for being a firstborn or a laterborn, most birth-order effects are believed to be environmental in origin. Environmental factors, however, can also be biological, and at least one birth-order effect has been convincingly linked to prenatal biological influences. Among males, the number of older brothers is linearly correlated with a propensity toward homosexual inclinations. These findings, which have been replicated in numerous studies, are consistent with the hypothesis that

some mothers develop antibodies to male-specific minor histocompatibility antigens during pregnancy and that these antibodies interfere with the masculinization of subsequent fetuses (Blanchard, 2004).

21.7. Radical revolutions and world history

Historically, laterborns have been more likely than firstborns to question the status quo. The Protestant Reformation, for example, was more strongly supported by laterborn rulers and their subjects than by firstborns. Leaders of radical political revolutions, such Fidel Castro, Georges-Jacques Danton, Vladimir Lenin, Ho Chi Minh and Leon Trotsky, have also tended to be laterborns (Sulloway 1996, 2000). There is some historical evidence that middleborn revolutionaries are less prone to violent tactics than either firstborns or lastborns, which is consistent with within-family assessments of middleborns being higher on Agreeableness. For example, during the French Revolution, which was preferentially supported by laterborns, middleborn deputies to the National Convention were more likely than other deputies to oppose the extreme measures that launched the Reign of Terror (Sulloway, 1996).

Birth order has sometimes been a factor in the instigation and reception of radical scientific innovations. Most radical revolutions in science have been led by laterborns, such as Charles Darwin, who was the fifth of six children. 'Radical revolutions' are defined here as those conceptual transformations that have substantial religious or political implications, that often take many decades to resolve, and that engender extensive public controversy both within and outside of the scientific community. Other radical revolutionaries in science include Copernicus (the youngest of four children), Bacon (the youngest of eight), Descartes (the youngest of three), and Alfred Russel Wallace (the fifth of six). It was Wallace who, in 1858, pushed Darwin into finally publishing the *Origin of Species* after Wallace anticipated the theory of natural selection during a malarial fit in the jungles of faraway Malaysia, where he was collecting natural history specimens. It is noteworthy that laterborn scientists have not only been more likely than firstborns to support radical conceptual innovations, but they have also been more likely to travel to remote and dangerous parts of the world—as both Darwin and Wallace did.

Although numerous firstborns, including Kepler, Galileo, Newton, Lavoisier, Lyell and Einstein, have led important revolutions in science, the revolutions they have championed have tended to be more technical and less ideologically loaded than those typically championed by laterborns. In addition, compared with first born opponents of scientific revolutions, firstborns who propose or support radical scientific ideas have tended to be young, socially liberal, and to have experienced high levels of conflict with one or both parents—factors that, independently of birth order, are also significant sources of support for radical conceptual innovations (Sulloway 1996, 2001).

In times of 'normal' science, when pushing the dominant paradigm is the usual route to success (Kuhn, 1970), firstborns appear to be favoured over laterborns. Controlled for sibship size, firstborns have won more Nobel Prizes than laterborns (Clark and Rice, 1982). This tendency is more pronounced among laureates in science than it is among those in literature or among winners of the Peace Prize—less structured areas of achievement where laterborns have held their own. Also of interest is the fact that, compared with firstborn scientists, laterborns have tended to have broader interests, as reflected by the number of different fields in which they have achieved distinction (Sulloway, 1996). Darwin, for example, made important contributions to geology, evolutionary biology, botany, ecology, ethology, and psychology.

These birth-order effects in the historical record are confirmed by some contemporary evidence. Salmon and Daly (1998) asked a Canadian sample of middle-aged subjects, "Do you think that you are open to new and radical ideas (such as cold fusion)?" Controlled for age, sex, and sibship size, laterborns were 2.3 times more likely than firstborns to respond in the affirmative to this question ($r = 0.38, N = 100, P < 0.001$). In a series of four within-family studies ($N = 951$), Paulhus *et al.* (1999) found that laterborns were 2.0 times more likely than firstborns to be described as the rebel of the family (see also

Rohde *et al.* 2003, where the corresponding odds ratio was 1.8 to 1). In a real-life study, Zweigenhaft and Von Ammon (2000) found that laterborns were 2.2 times more likely than firstborns to undergo multiple arrests for their involvement in a labour dispute occurring at a Kmart in Greensboro, North Carolina.

In contrast, one well-designed study involving an analysis of social attitudes held by subjects in the General Social Survey showed only three significant birth-order effects out of 33 measures. These three effects were all modest in size and, more notably, were opposite to the predicted direction—laterborns were more patriotic than firstborns and also scored higher on two measures of political tough-mindedness (Freese *et al.*, 1999). In spite of such inconsistent findings about social attitudes, the overall literature on birth order generally supports the existence of modest birth-order differences. In a meta-analysis of 20 relevant studies, including seven studies besides that by Freese *et al.* that have reported non-significant findings, I found a mean-weighted correlation of 0.09 (n = 11240) between being laterborn and supporting the radical alternative. Among the eight real-life studies included in this meta-analysis, the effect size was r = 0.20 (n = 1952). Discrepancies between various study outcomes, including those mentioned here, may reflect the methodological issues discussed below.

21.8. Ongoing methodological considerations

Documentation of significant birth-order effects in human behaviour is most consistent when siblings rate one another, or when parents rate their own offspring (Ernst and Angst, 1983). In such studies, birth order typically accounts for about 1–2% of the variance in predicted scores for specific dimensions of the Five Factor of personality and as much as 4% in predicted scores involving multiple dimensions. Such differences may seem modest or even trivial to some, but 'variance explained' often provides a misleading notion of the real-world consequences of supposedly small effect sizes. For example, a correlation that accounts for just 2% of the variance in some particular attribute is equivalent to a medicine that increases the one's odds of surviving a deadly disease by a factor of 1.6. Most sources of individual differences in personality, including individual genes, explain less than 1% of the variance. It is also important to bear in mind that sex differences, which explain about 2% of the variance in personality traits, are one of the largest known sources of individual differences (Feingold, 1994; Hyde, 2005). Almost no one would argue that sex differences in personality are trivial. In short, in behavioural research, the documentation of any influence on human behaviour that explains just 1% of the variance is a noteworthy result that often has considerable practical importance for people's lives (Rosenthal and Rosnow, 1991).

There are nevertheless reasons for believing that within-family studies of birth order may overestimate effect sizes. In such studies, some of the variance accounted for by birth order may reflect what are known as 'contrast effects'. Such effects denote the tendency for parents and siblings to magnify real differences when making direct comparisons (Saudino, 1997). Another methodological possibility is that within-family evidence on birth order and its relationship to personality may be confusing a difference between personality and family roles. Firstborns may be the most conscientious sibling within the family simply because the task of being a surrogate parent generally falls to them, with all of the customary behavioural expectations that go with this 'responsible' role. What also remains unresolved is whether, independently of personality (or in combination with it), adult firstborns and laterborns retain predilections for adopting certain adult roles, and occupying certain adult family niches, in accordance with role specializations acquired during childhood.

Equally unresolved in birth-order research is the importance of birth-order effects outside the family milieu. Standard personality tests generally indicate little or no birth-order effects when subjects are not comparing themselves with their siblings (Ernst and Angst, 1983; Harris, 1998; Jefferson *et al.*, 1998; Parker, 1998). Such null findings may be contrasted, however, with the documentation of modest but consistent birth-order differences that are found when spouses and room-mates rate themselves, especially in the context of intimate living situations (Sulloway, 2001). In these cases, birth-order

effects are about one-third to one-half the magnitude that we typically observe when siblings rate one another. More notably, the birth-order effects found in this class of studies correlate strongly (0.65) with the birth-order effects reported for the same personality attributes in direct sibling comparisons, thereby exhibiting considerable consistency from one behavioural context to another.

21.9. Situation-specific behaviour

Such collective findings suggest that birth-order effects are substantially latent in adult behaviour, expressing themselves only when a specific situation triggers a response based on behavioural repertoires previously learned within the family. As Cervone and Shoda (1999), among others, have shown about personality, much of its expression is subject to context-sensitive effects. This interactionist perspective on behaviour helps to explain some of the otherwise puzzling disparities in the outcomes of birth-order studies. For example, in friendships, dominance is usually not a socially advantageous trait; but, in intimate living situations, differences in dominance are likely to assert themselves in disputes over shared resources. This contextual difference was shown in one study in which subjects were asked to rate themselves and their friends on a measure of dominance (Sulloway, 2001). No birth-order effects were found. Yet when other subjects in the same study rated themselves and either a room-mate or a spouse, firstborns described themselves as more dominant than laterborns.

Unfortunately, only a few birth-order studies have attempted to test this situation-specific behaviour hypothesis. Using an experimental approach, Salmon (1998) played an electronically recorded election campaign speech to 112 college undergraduates. In one version of the speech, the speaker used terms such as 'brothers', 'sisters', and 'brethren' to evoke familial sentiments. In a second version of the speech, references to family terms were electronically replaced with references to 'friends'. As expected based on patterns of cumulative parental investment, firstborns and lastborns preferred the speech with references to family terms, whereas middleborns preferred the speech containing references to 'friends.' Similarly, in a survey of 236 genealogical researchers in their mid-40s, Salmon and Daly (1998) found that middleborns were significantly underrepresented and were also less likely to nominate their mother as the person to whom they felt closest (for a replication, see Rohde *et al.*, 2003). Such studies show that birth-order effects do manifest themselves outside of the family milieu when the behavioural context provides a link with familial sentiments, motives, or patterns of identification. More studies of this nature are needed to clarify the precise mechanisms, in adulthood, that appear to catalyse the transformation of latent family-based dispositions into manifest behaviour.

The role played by family-related self-conceptions and sentiments in eliciting birth-order effects may explain why evidence from social and scientific controversies is relatively consistent in producing birth-order effects (Sulloway, 1996, 2000, 2001; Numbers, 1998; Salmon and Daly, 1998; Zweigenhaft and Von Ammon, 2000). Many radical social and political revolutions have entailed direct implications for family life. During the Protestant Reformation, Martin Luther called for the abolition of celibacy for nuns and priests, which mainly impacted on laterborns, who were typically shunted into the clergy or the military under the system of primogeniture (Boone, 1986). Leading Protestants also considered primogeniture to be 'un-Christian'. Even in science, radical revolutions often touch on important values and social policies that concern the family. The Copernican and Darwinian revolutions both challenged deeply held religious convictions, which are passed from parents to offspring with a high degree of fidelity (Sulloway *et al.*, 2006). As Darwin himself noted, the Darwinian revolution also gave strong support to equitable parental investment—as opposed to primogeniture—since arbitrary parental favouritism limits the role of competitive superiority in natural selection. To the extent that radical social and scientific revolutions have led to within-family conflicts, or have touched on inequities in parental investment, these sources of controversy are likely to have tapped latent birth-order differences among adults. If this hypothesized

mechanism is in fact operative in adult behaviour, then the route by which birth-order effects have expressed themselves in history may depend less exclusively on personality than on a combination of personality differences, familial sentiments, patterns of identification, and consequent differences in motivation, perhaps reinforced by birth-order stereotypes (Plowman, 2005).

One other group of findings is relevant to this discussion about theories and methods in birth-order research. When studies of birth order are collectively examined for the moderating effects of the testing context, several noteworthy trends emerge. First, extrafamilial studies consistently yield smaller and less consistent birth-order effects than do within-family studies. In particular, self-report personality tests conducted without direct sibling comparisons yield the smallest birth-order effects, although these effects are sometimes statistically significant—if not particularly impressive—in samples that are large enough to have adequate statistical power to measure correlations in the range of 0.10 and smaller. Among extrafamilial studies, however, it is notable that experimental designs, which often try to emulate real-life behaviour, exhibit larger and more consistent effect sizes than do self-report personality tests. Finally, studies that involve emotionality and controversy, such as participating in a political protest, also tend to involve larger effect sizes than do studies that use paper-and-pencil methods (Sulloway 2001, 2002). Collectively, these meta-analytic patterns, together with other evidence reviewed here, suggest that birth-order effects—although latent in much of adult behaviour outside the family of origin—are sometimes strongly elicited by situations that involve heightened emotions, controversy, or direct links with familial sentiments. Additional research is needed to answer some of the intriguing questions raised by such methodological trends in birth-order research.

To the extent that the influence of birth order in adult life may turn out to be substantially a matter of person-by-situation interaction effects rather than fixed personality attributes acquired in childhood, then standard psychological tests may often miss these effects. The dilemma facing behavioural scientists is heightened by considerations of statistical power. Given that birth-order effects obtained in within-family assessments typically amount to effect sizes of $r < 0.20$, and given that effects in extrafamilial behaviour are likely to be smaller than these ($r < 0.10$), experimental approaches face the following statistical reality. For an experimenter to be 80% confident of obtaining an expected effect size of $r = 0.10$, the sample size needs to be at least 783 subjects. Expressed another way, experimental designs encompassing only 200 subjects (a reasonably large sample by most experimental standards) risk obtaining a misleading null outcome for such expected effects at least 71% of the time (Cohen, 1988). From a literature exhibiting such a high proportion of null results, most researchers would incorrectly conclude that there was nothing of interest to pursue. Perhaps the use of Internet samples in combination with experimental designs will help to overcome these basic issues of statistical power and thereby shed more light on one of the pressing questions of human psychology, namely, the diverse and so far largely elusive sources of the non-shared environment.

21.10. The overall influence of the family: an evolutionary perspective

One should bear in mind that the influence of birth order is only one component of the overall influence that the family system exerts on children as they are growing up. Although it has become fashionable in the light of recent behavioural genetic studies to minimize the influence that parents and the family have on offspring, researchers are at a considerable disadvantage in assessing all of the varied psychological influences that actually operate within the family. In most behavioural genetic studies, the non-shared environment is not directly measured but is simply what remains statistically unexplained by the effects of genetics and the shared environment (see, however, Reiss *et al.*, 2000). The study of birth order—however modest its effects may seem—provides a useful example of the operation of one systematic within-family dynamic among many. Until behavioural scientists develop new and better methods by which to capture the endless succession of unique and largely non-systematic interactions that characterize the family environment, we can have only

a rudimentary idea about how much of the non-shared environment actually resides within the family, as opposed to outside it (Turkheimer and Waldron, 2000; McGuire, 2001; Plomin *et al.*, 2001; Turkheimer, 2004). Based on the amount of time that most family members spend with one another prior to adulthood, the family's total influence—through both shared and non-shared environments—may well amount to 15–20% of the overall variance in personality. An effect of this magnitude would be equivalent to a drug that quadruples one's likelihood of surviving a deadly disease (and hence that quadruples one's likelihood of displaying, or not displaying, a particular personality attribute owing to within-family influences). In the domain of values and social identifications, the influence of the family appears to be even greater (Dunn and Plomin, 1990).

To evolutionary psychologists, as well as to social psychologists, it will come as no surprise that the importance of experiences acquired in early life, and through interactions with other family members, may only be manifested conditionally in interactions occurring later in adulthood—especially with non-family members. Personality substantially reflects adaptation to peer groups, teachers, and other sources of extrafamilial experience. An adaptationist perspective on human behaviour expects just such forms of continuing, context-dependent learning and behaviour. Even blue-footed boobies do not engage in siblicidal aggression unless they are significantly undernourished. Similarly, adult human beings do not generally act towards acquaintances and strangers in the same intimate ways as they do toward siblings and other family members. In adulthood, people appear to carry with them a Darwinian toolkit of learned strategies—some dating from childhood, others acquired subsequently as a result of extrafamilial experiences. We appear to draw as needed on this behavioural toolkit, but only when the tool matches the situation.

Despite many unresolved questions about human development and the role of birth order in this process, one general conclusion has become increasingly certain: the sources of human personality and behaviour, and the story of their expression in the course of development, are much more complex than most of us previously thought. In this revised and multifaceted view of human development there nevertheless appear to be significant and lasting explanatory roles for birth order, sibling competition, and family dynamics more generally.

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