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The effects of family size and birth order on an individual's g level

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
CPM	Coloured Progressive Matrices
g	General Intelligence
IQ	Intelligence Quotient
RPM	Raven's Progressive Matrices
SAT	Standard Aptitude Test
SPM	Standard Progressive Matrices
s	Specific Ability
U.K.	United Kingdom
vs.	Versus
WISC	Wechsler Intelligence Scale for Children
WISC – R	Wechsler Intelligence Scale for Children – Revised

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ABSTRACT

The objective of this study was to investigate whether the environment created by being born in a specific birth order and/or family size affects individuals' general intelligence, or **g.** Based on the phenomenon of rising Intelligence Quotient (IQ) scores observed across generations, the fact that IQ and **g** are highly correlated and that most, if not all, between-family variables have been shown not to produce the rising effect, it was hypothesized that there could be a significant difference in **g** scores of siblings of the same family and those of different sized families born in the same position.

Birth order and family size could be argued to encompass most within-family factors that result in influencing the family environment and its influence on each child within it. Each child is part of the same within-family environment, however, within this framework each individual's experience is different, accounting for the non-shared environment effects. This notion is supported by two models which attribute varying levels of IQ to children of the same family based on their birth order and family size. The Confluence and the Resource Dilution Models were discussed as possible explanations of what happens to **g** levels, should any difference between birth order and family size be uncovered.

Raven's Progressive Matrices (RPM) were used to quantify the participants' **g** levels with respect to the two research questions. Girl only families participated in this study to eliminate developmental factors between girls and boys of the same age. Siblings' scores were compared for birth-order effects and the scores of children from the various sized families were compared for family size effects. Repeated measures analysis of variance was applied to test for birth order effects. One-way analysis of variance and one sample t tests were applied to test for family size effects.

No significant birth-order effects were found, however, the pattern of achieved means increased with birth order which is in opposition to both models. The one significant finding for family size came in the form of the second borns of two daughters outperforming the second borns of three daughters. The findings and the trends of the achieved means between all birth order and family size variant groups were examined in light of findings of previous research on this topic.

LITERATURE REVIEW

Intelligence: An Illusive Concept

Intelligence has historically been, and is currently, one of the most philosophically, and resultantly, psychometrically disputed concepts in the field of psychology (Nyborg, 2003). Several theories and independent empirical views regarding the nature and measure of intelligence simultaneously subsist despite relatively little overlap. For example, the theory of multiple intelligences espouses that intelligence can be measured by focusing on several cognitive abilities at one time, responsible in different areas of one's life. Sternberg's triarchic theory of intelligence is more practically orientated in the sense that it quantifies intelligence by how well an individual adapts to changing circumstances in his/her life based on the analysis of the situation and creative approach influenced by contextual fit. Intelligence has also been defined as problem solving ability (Gardner, 1993), "global capacity of the individual to act purposefully" (Wechsler, 1997), "innate general cognitive ability" (Burt, 1972) and giftedness. The newly emerging view expands the intelligence concept to include social, moral and emotional adaptability to the environment which may or may not outweigh practical capability or ability to influence one's circumstance.

The diversity of definitions is spurred on by the range of the human intellectual states: from brain damaged individuals, to savants, to prodigies and the intermediate spectrum amongst these. The inability of the most competent professionals to define what we inherently know to be the root factor in most, if not all, human abilities makes testing, quantifying and applicability of intelligence, with its many facets, problematic. However, the most supported view which joins the divide between the many definitions, and the construct, is defining intelligence as a cognitive ability and testing for IQ through psychometric means based on that definition.

However, at any one point in time, an individual IQ test is only capable of producing a score based on the subject's performance on items of the test assumed to encompass a number of abilities; it is not a comprehensive measurement of all abilities of his or her overall intelligence level. To compensate for this shortfall, researchers have used a battery of tests to test for the most number of abilities that could be defined. Presumably, the sum of all scores would illustrate the resultant and overall intelligence of a person. However, what vicariously emerged from this practice was a high

correlation amongst an individual's scores between the tests which was assumed to point to an overarching mental ability. It was therefore hypothesized that this 'ability' had predictive power for any IQ test.

IQ is positively correlated with scholastic performance (Sternberg, 1990; Jensen, 1998), behaviour patterns (Nyborg, 2003), and impacts on job attainment (Powell & Steelman, 1993).

*Identifying Spearman's **g***

Charles Spearman introduced the construct of general intelligence in 1904 to describe the common variance of scores shared by a battery of cognitive tests (Spearman, 1927). Through the use of factor analysis of scores on various mental tasks, Spearman argued that high correlations of individual's scores could be ascribed to a single, common or general factor he referred to as **g** (Spearman, 1927). General intelligence, or **g,** was described as an overarching mental ability of the mind that played an integrating part in all mental abilities. Spearman's point of view highlights intelligence as more than a product of whatever can be argued as influencing factors, but as an inherent 'power source' for the person's capabilities. General intelligence was introduced as an exploratory and potential explanatory concept of why some people appear to be more 'intelligent' than others. An overwhelming number of factor analytic studies of cognitive ability have yielded a **g,** however, no uniquely defining characteristic of **g** has been given in psychological terms as of yet (Carroll, 1993, Jensen, 1998; Flynn, 1999; Johnson, Bouchard, Krueger, McGue & Gottesman, 2004;). Proponents of multiple intelligences too, have not disproved or displaced the presence of a general factor of intelligence and **g** is considered compatible with most psychometric theories of intelligence (Kline, 2000; Carroll, 1993; Jensen, 1998).

Observation of Two Factors

Observations regarding the similar trend in scores started the inquiry into the correlations calculated between the measurements of different abilities (scores of tests, marks for school subjects). These correlations showed that certain scores of mental tasks correlated more with some than with other task's scores, prompting the idea that **g** might not exert equal influence in all mental tasks (Spearman & Jones, 1951). A mathematic equation, termed the *tetrad equation*, was devised to calculate the 'amount' of presence of **g** and the presence of a more 'specific ability' in

every mental task. From the equation, deductions of two separate entities occurred, both exerting influence on mental ability scores. The equation unearthed the presence of a common factor, **g,** to all scores on different tests, which remained the same for any one individual with respect to all correlated abilities. The equation also expressed a "specific factor" or **s,** which is the remainder of the score and constitutes a factor specific to each individual ability. It is uncorrelated with the common factor or with any other specific factor (Spearman, 1927). The specific factor varies from individual to individual, as does **g,** but **s** varies even between the abilities of an individual. Although both factors occur in every ability, they are most often not equally influential. The very earliest application of the mathematical theorem to psychological correlations showed that **g** had a greater influence in some of the tested abilities than in others. At some extremes, when examining a particular 'skill', the ratio between **g** and **s** was 15 to 1. In a calculation of another skill, the talent for music for example, the ratio was 1 to 4 (Spearman & Jones, 1951). Whatever **g** may be, it is common to all the abilities and its magnitude will tell us a lot about certain abilities of a person and a little bit about all of them. A person's **s** tells us everything about a distinct kind of ability which supplements the amount supplied by **g** to that ability.

*Present Day Proponents of **g***

Following Spearman's work, and slightly less renowned for his contribution to this debate, was Raymond Cattell with his notion of general intelligence through what he termed 'fluid intelligence' (Cattell, 1987). He determined there to be fluid and crystallized intelligence; fluid meaning the ability to make meaning out of confusion being independent of learning and crystallized intelligence which is dependent on past performance for its operability. Cattell's fluid intelligence is considered to be the same as Spearman's general intelligence being an innate and constant facility throughout one's life. It involves problem solving, memory, learning, pattern comprehension and quantitative reasoning. Crystallized intelligence has a high correlation with verbal ability, language development, reading comprehension, sequential reasoning and general information (Sternberg & Grigorenko, 1997).

Building on from Spearman's and Cattell's work, Jensen has featured as the major present day proponent and contributor to the understanding of the general intelligence concept through his investigations regarding its nature. Jensen started his career by investigating the relationship

between intelligence and a number of reaction time related parameters which expanded into research on positive **g** correlations with biological variables such as glucose metabolic rate, waveform complexity and head size (Jensen, 1998; Vernon 1998). The positive correlations between several biological correlates of **g** and results of other studies led Jensen to focus his energy on investigating the genetic basis of general intelligence. Jensen also argued that because of general intelligence's omnipresence in an assortment of mental ability tests, general intelligence had to be based on an unfaltering factor present in every subject which he argued to be genetic in nature unaltered by environment effects (Jensen, 1998). Jensen considered **g** to be highly heritable.

There are others which seconded this view, some of which were Jensen's former students (Vernon, 1998). Also, a large volume of research was based on the fact that **g** had only a genetic basis although this ideology has shifted to incorporate environmental influences (Duncan, Seitz, Kolodny & Bor, 2000; Sternberg & Grigorenko, 1997).

The Flynn Effect and Its Controversy

In 1984, Flynn published a report which claimed to have unearthed "massive gains in IQ" between 1932 and 1978 based on patterns in 73 intelligence studies performed at that time in the United States (Flynn, 1984, pg. 29; Flynn, 1999). Although the discovery of IQ gains emerged from the work of many scholars, Charles Murray called this gain in IQ over time the "Flynn Effect" as it was Flynn who inferred that these gains were a part of a persistent and perhaps universal phenomenon (Flynn, 1987). Without exception, whenever participants were given the Wechsler Intelligence Scale for Children (WISC) and the Wechsler Intelligence Scale for Children – Revised (WISC-R), they had a higher score on the older version of the test, WISC, with the two versions being highly correlated with each other. If a child averaged 100 on the WISC-R in 1972, they averaged 108 on the WISC normed in 1947. Flynn calibrated the gain at 15 IQ points for the mentioned period and, "the rate of gain was about 0.30 IQ points per year, roughly uniform over time and similar for all ages" (Flynn, 1999, pg. 7). Flynn replicated this finding in research conducted on studies from 14 other developed countries. A string of research followed that claimed to have replicated the Flynn Effect (Teasdale & Owen, 1989; Lynn, 1990; Mahlberg, 1997).

On the other hand, there have been other researchers that contest the effect as being true. Rushton (1999), through a 'method of correlation of vectors' or the association between the vector's **g** loadings and the vector of the same tests' loadings on a variable X, concluded that based on his examination of the WISC battery, that the secular increase in tests scores were not authentic. Rushton (1999) reiterated that scores could therefore not be attributable to **g** and that the Flynn effect is a product of test specificity. Colom and Garcia-Lopes (2003) discredited Rushton's finding due to the fact that the WISC is recognized as a test of crystallized and not fluid intelligence which makes his conclusion both anticipated and logical. Colom and Garcia-Lopes (2003) then applied the same method of correlated vectors to the Culture Fair Intelligence test, designed by Cattell, which measures fluid intelligence. One of this test's favourable points is that it was constructed to eradicate test specificity while testing for fluid intelligence or **g,** whereas the Raven's Progressive Matrices (RPM) only poses questions via a matrix problem format. Some would argue that this format is more suitable for some over others. However, their finding was almost an exact replica of the international data (0.3 IQ points per year); it agreed with the gains obtained by Flynn on the RPM as well as with those from the application of the method of correlated vectors to fluid battery tests.

The troubling part about the Flynn Effect is that the finding coincided with a period in American education where the high school graduates showed a marked decline and lowest levels of attainment on the entrance examination for college, the Standard Aptitude Test or SAT (Rodgers, 1988). The puzzling question was how American students could be getting smarter, as measured by WISC and WISC-R, and be learning significantly less in schools, as measured by SAT. For Jensen and by implication, this was an improbability as IQ is a derivative of **g** and **g** is considered to be unchanging because it is genetic; an increase in IQ indicates a substantial and constant genetic change yet there was nothing to substantiate that something like a genetic renaissance was taking place. When responding to this phenomenon, Jensen was skeptical of the correctness of Flynn's conclusions and cited concern over sample bias, analysis of scaled scores instead of raw scores and advocated testing the past and present generations on the same version of a test in order to see a real effect (Jensen, 1998). Jensen also called for testing to occur on a culture reduced test such as the RPM, which he presumed would show no gains in **g** over time, it being considered the most direct measure of **g.** Jensen's argument was that the WISC, WISC-R and the Stanford –

Binet tests measured intelligence through items that illustrate information taught in school, which can stand to be influenced by either more or less schooling.

Flynn responded to Jensen's other request by administering the RPM on several generations. Data collected from 14 nations and later incorporating 20 nations showed the largest IQ gains were occurring on culture reduced tests such as the RPM (Flynn, 1999). The best data came from military samples from the Netherlands, Norway, Israel, Belgium that comprehensively covered all cohorts of young adults and revealed a monotonic rate of gain between 1952 and 1982.

Exploring Alternate Explanations

Such a conclusive finding carried ramification for the intelligence research field and sparked a variety of debates and questions directly pertaining to the finding. Were the researchers measuring different IQ abilities due to the fact that an array of tests was used in the 73 studies which generated the Flynn Effect finding? Was the resulting effect occurring due to changes at the level of an individual or a family? Was this a period or cohort effect? Most importantly for Jensen and his colleagues, was whether the Flynn Effect was a reflection of an increased **g**? Although these questions are not comprehensively explored in this study it is important to consider their validity in order to exclusively explore the notion of the relation between **g** and IQ.

It is plausible that the measured IQ of this generation might be different to the IQ measured between 1932 and 1978, however, considering that most gains were on RPM or like minded tests that do not emphasize one mental ability over another; this question does not appear to be a major threat to the integrity of the Flynn Effect. The notion that gains were a product of varying experimental treatments between now and then can never be completely dismissed. Flynn was one of the first to use the meta-analysis methodology as it was relatively early in its development. However, the overwhelming duplication of this finding following Flynn's work (United States, Africa, Japan, Australia, New Zealand, Britain, Spain and several other countries in continental Europe) makes it unlikely that all of those researchers were using unsound statistical procedures (Lynn & Hampson, 1986; Colom & Lluis-Font & Pueyo, 2005). To respond to the question of whether the Flynn Effect is occurring due to changes at the level of the individual, Flynn's cross-sectional design was inadequate to assess within-individual changes as a number of empirical

research studies maintain the finding that mental ability declines as a person ages (Schaie, 1994). Both considerations would make the assumption of within-individual IQ gains improbable. A study by deLeeuw and Meester (cited in Flynn, 1987), however, showed significant gains on the RPM score of sons compared to their fathers on the same test, tested at the same age. This showed between-generational, within-family effects. This reiterates the fact that genetic influences are one part of the variance with the remainder being attributed to the experience of successive generations which bring about fundamental changes in aspects of cognitive functioning. Flynn himself referred to IQ gains as between-generational, which would infer a period effect but because both period and cohort effects are perfectly masked by the cross sectional design, one cannot be certain whether it is or not. The finding of sons outperforming their fathers implies this to be a between-cohorts effect.

Attempts to Disentangle IQ Gains from the Psychometric g

There are various studies which propose to disentangle the source of IQ gains from the psychometric **g** which need consideration in order to determine whether it is **g** or a single or combination of *other* extraneous variables which are responsible for the increase in IQ.

Blair, Gamson, Thorne and Baker's (2005) inquiry into the possible effects of the rising IQ, other than **g**, stated that the Flynn Effect observation matches to a time in the education area where greater access to schooling was coming into affect. Enhanced test taking ability has been put forth as a possible feature of the environment that could influence the 'reading' of the presence of IQ; more children were able to afford and attend some form of schooling allowing them the opportunity to be more familiar with test taking. However, there are two studies which show that not even nine repeated administrations of the exact same test to children aged between 4 and 28 months during that time period, increased their scores above those of children of the same age tested only twice, at 4 and 28 months (Jensen, 1981). However, it wasn't only the increased access into schools that was cited as a reasonable explanation of increased IQ but the adopted manner of teaching. The schooling system was said to be emphasizing cognitive functions requiring the use and stimulation of the prefrontal cortex that is associated with a high level cognitive performance. Blair et. al (2005) attribute the persistent increased activity of the prefrontal cortex via the change in design of the mathematics curriculum in the middle of the century and the fact that more

children were entering schools during the time period to be responsible for these gains. The notion of neural structure change is a valid one although in order to infer this effect, research has to show that the everyday working of the mathematics curriculum had the effect on all individuals as anticipated. With regard to the concept of more children entering school, being tested and showing a marked increase, the educational psychology studies denounce the effect of additional educational programs or practices as an attempt to raise an individual's overall IQ (Jensen, 1981). The effects are significant although short lived; retesting of individuals indicated the positive effects to be virtually nil one year later. This means that individuals acquired and retained knowledge for a certain period of time but did not acquire *added* intellectual ability permanently.

Some researchers also believe that gains represented the increasing overlap between material on intelligence tests and information common to one's culture and society over the previous one. It is unlikely that the WAIS, developed and used in the United States, would match the culture of Japan or Africa at any point in time. However, it was this test and others like it that were used to uncover the Flynn Effect not only in the United States but in other locations around the world across the generations. Some culture specific tests were used, yet still showed the same pattern observed by Flynn which indicates that this explanation is improbable.

Based on some researchers' findings that the rising IQ scores were primarily occurring on the lower performing half of the population, Colom et al (2005) postulated that a significant change in the quality of nutrition available to this group positively impacted the development of specialized cognitive abilities. This explanation is widely accepted in literature (Neisser, 1998). However, there is at least one study that has shown that even after four years of nutritional treatment to a group of 'underprivileged' individuals, there were no associations between their cognitive and nutritional levels (Bejar, 1981). Likewise, in the early parts of the 20th century, mandatory inoculations of children eliminated or greatly reduced the frequency and intensity of many childhood illnesses that were previously retarding cognitive growth. These were also made more available to the poorer sectors of society and would have therefore impacted these individuals the most (Kane and Oakland, 2000). Better prenatal care has also been cited as an explanation of why children born in the middle part of the century were smarter than children born the decade before. Prenatal care presumably reduced the incidence of fetal loss or brain damage and produced the

resultant effect of rising IQ in the lower or lowest part of the population. All of these explanations represent a large scale, uniform effect which is indeed possible. The troubling feature of these explanations is that the rising IQ effect was not isolated to one time in testing even if such a testing period was defined as a 10 year period. This means that there had to have been something more substantial than a 'once-off' cause and effect relationship, even if the effect of the cause required a period of 10 years to fully manifest (but certainly not half a century). One would imagine that with the nutrition hypothesis, better medical and prenatal care improvement had an effect that one would observe a leveling off of an effect after a certain while. This is because once a proportion of the lower performing end of the population benefits, they are effectively no longer part of the lower performing end of the population and 'join' the higher performing group making the proportion of the lower performing group much fewer in number. So if any of the above mentioned three things were to occur again, the effect would not be as large as it was initially. However, the IQ increase pattern continued well beyond 50 years which effectively means three generations.

Genetic, Environmental and Non-Shared Influences on IQ

Behaviour genetics techniques and heritability studies are the most powerful tool for isolating and quantifying environmental influences on a factor (Duncan, Seitz, Kolodny & Bor, 2000). In this particular research setting, research on environment influences on a genetic trait must control for genetic influences otherwise the results would be genetically confounded. In his book, *The **g** Factor*, Jensen (1998) explored the scores of monozygotic twins reared apart and found them to be highly correlated despite stemming from varying home environments. This indicated a high influence of genetics while at the same time discrediting much of the between-family factors that are argued to contribute significantly to IQ difference between individuals. The genetic component of the monozygotic twins reared apart included some fraction of the genotype environment covariance found in monozygotic twins reared together; the greater similarity in the environment of the latter though makes its genotype-environment covariance larger than the former. Despite the overwhelming similarities posed to the monozygotic twins reared together (identical genetics and highly similar environments) these children differ in certain characteristics, one of them being IQ although these differences tend to be smaller than those found in dizygotic twins reared together (Sternberg & Grigorenko, 2002).

Through a series of similarly designed studies with participants of various ages, the genetic component variance on mental ability was found to increase substantially across the persons' lifespan where heritability for IQ was estimated at 20% in infants, rising in various degrees through early adolescence and middle adulthood and peaking to as much as 80% in adulthood (Bronfenbrenner & Ceci, 1994; Jensen, 1998; Stoolmiller, 1999). Jensen therefore affirmed that the single largest source of individual differences in the factor responsible for IQ was attributable to genetic factors with the remaining influence being environmental in nature acting within rather than between-families. The observation found in monozygotic twins reared apart was also strengthened by results of several large scale studies of adopted children, such as the Texas, Colorado and Minnesota adoption studies, which show environmental influences between-families to account for none or very little of the variation in IQ in adolescent and adults (Sternberg & Grigorenko, 1997).

A more recent study, by Petrill and Deater-Deckard (2004) examined the heritability of general cognitive ability in a within-family adoption design. The researchers found a statistically significant correlation between a mother's score on the Stanford-Binet Intelligence Scale and her biological child on the same test but not the same parent and her adoptive child. The researchers hypothesized that if genetic influences were significant, the result would be the one that was found but also that if shared influences were at play on the children, whether biological or adopted, the parent IQ would be equally correlated to the adopted children. This was not observed in this particular study. This finding emphasizes the influence of the non-shared environment over the shared environment on cognitive ability as at any point in time a phenotypic ability can be measured through the three proportions contributing to cognitive ability: genetic, shared environment and the non-shared environment. The non-shared environment refers to within-family aspects which subsequently manifest or are imparted differently between the family members.

Stoolmiller (1999), however, motivated that most environment facets can simultaneously be shared and non-shared influences. What was described as a non-shared factor in the last paragraph is in this instance shown to be a shared factor – parenting skill and style can differ for each individual but can also be common for all children in terms of approach. He also argued that the families which adopt are of upper socioeconomic standing and therefore have a high income, education

levels and occupational prestige and that resultantly value these things. These characteristics indicate that the parental behaviours would uphold the values of education and disciple equally regardless of whether the child is biological or adopted. Another study found parental education levels to be instrumental in their children's post secondary education whereby the parents' attitudes and behaviours heralded importance of secondary and post secondary schooling for all their children (Finnie, Lascelles & Sweetman, 2005).

A string of other studies within the last decade (Bronfenbrenner & Ceci, 1994; Dickens & Flynn, 2001; Petrill & Deater-Deckard, 2004) have explored the heritability versus environmental effects on IQ. According to Bronfenbrenner and Ceci (1994), heritability – "the proportion of total phenotypic variance that is due to additive genetic variation….describes only the extent to which genetic endowment contributes to observed differences in developmental outcomes between individuals growing up in the same environment " – occurs through the means of "proximal processes" responsible for its actualization (Bronfenbrenner & Ceci, 1994, p. 568). The proximal process and the principal proximal setting discussed in the mentioned study refers to the characteristics of and interaction with people, objects and symbols present in the immediate environment in which the child is growing. This notion feeds into the neural plasticity model of intelligence which states that intelligence is created when neural connections in the brain are changed in response to environmental cues (Duncan, Seitz, Kolodny & Bor, 2000; Garlick, 2002). Proximal processes have to be quite 'near' to the individual in order to be able to have this effect. This theory of constructed intelligence feeds back to the idea of varying **g** levels in individuals living within the same family because of their subjective experiences of all non-genetic factors within a family, otherwise referred to as the non-shared environment. Generally speaking, each individual has a different interaction with his proximal environment or perceives the same objects or behaviours, such as parenting style, differently (Garlick, 2002). This explains how genetically identical twins living in the same household with the same objects, people and experience around them are still different on certain factors.

*Implication for Spearman's – Jensen's **g***

The Flynn findings on the RPM dealt a blow to the Spearman - Jensen theory of general intelligence that sustained **g** solely on the basis of its genetic component, and particularly so to the

notion that the environment exerts a non-significant impact on **g.** The disagreement between Flynn and Jensen lies in Jensen interpreting the absence of gains in real-world cognitive abilities to imply that there could not be genuine **g** gains. However, Jensen remained puzzled on how we can explain one generation outscoring the previous one by 15 to 18 points on tests such as the RPM and claim that the same individuals are not superior for the psychometric **g** to some extent (Jensen, 1989)? Flynn's response was that "IQ gains are *prima facie* gains in terms of the psychometric **g** and… have a significance too limited to signal an increase in real-world mental ability" (Flynn, 1999, pg. 9). The debate created consensus on the possibility of an underlying influence of **g** on rising IQ scores and, resultantly, the possibility of influencing **g** levels (at least between generations as shown) pointed the intelligence research field to investigating and deciphering the role of genetics and social influences on **g.** Flynn (1999) proposes either parents or schools, in terms of enhanced problem-solving ability, could enhance IQ (inadvertently meaning **g,** since **g,** in the strictest sense, means integrating ability of other specific abilities). Flynn means to suggest that **g** can be partially 'taught' or 'learned' and such a suggestion implies that an increase of a person's **g** can be enhanced by a type of within or between-family environment. As seen by the unsuccessful supplemental educational programs' attempts to raise the IQ of the lower performing half of the population (described above), such attempts to permanently affect IQ are transient and impermanent.

There are two long standing theories that describe the varying levels of IQ between and within-families: the Confluence and Resource Dilution models, which can perhaps describe the fluctuation of **g** within these contexts and are based on the variables in the non-shared environments. We need to consider whether the overall environment, made specific to each child born in a different order or within a specific size family, could potentially be representative of varying **g** levels that in turn varies the IQ amongst individuals. Therefore, all results pertaining to birth order and family size obtained in this study will be discussed in the framework of these two models.

Description of Birth Order, Family Size and IQ Models

Confluence Model

When considering the intellectual development of children within the family, it is clear that each successive child enters into a different environment and adds to the already existing environment of that family as the child begins a particular cycle of growth. The Confluence Model considers the intellectual aspects of siblings' changing environment and its impact on intellectual levels and was so named because the "mental maturation of children growing up in the same family, flow together over time in their influence on each other, changing constantly over time and changing most profoundly when new offspring join the sibship or some family members leave" (Zajonc, 2001, pg. 491). This model states that each successive sibling is born into a weaker intellectual environment as quantified by combining the intellectual levels of members within the same family. For example, if both parents have an IQ of 100, the level of the intellectual environment for the first born will be (100+100+0)/3=67 whereas the intellectual average for the second born, considering that the first born has obtained an IQ of 40 by the time of the second child's birth, is (100+100+40+0)/4=60. The average of the intellectual environment is reduced with the entry of each child because the child's mental age or intellectual level is considered to be zero. However, this does not mean that each subsequent child is less smart than the previous; the obtained value of the intellectual environment (i.e. 67 or 60 as calculated above) is representative of the richness of the family environment. Therefore any comparisons and observations are within the context of the latest point of confluence within each family. Once the second child enters the equation of calculating the overall intellectual atmosphere, the first child's circumstances are changed deeming any influence of being an only child ineffective if the difference between children is within a certain year range; that is four to five years. Before the birth of other children, the first borns are exposed to the sophisticated and diverse language of their parents, whereas the second borns are exposed to the verbal output of their parents but also to verbalization of older siblings. This language environment was termed as the "lexical surround" by Zajonc and accounts for environmental influence as being more or less mature depending on the age gap between the siblings as well as the birth order of the children, as previously stated (Zajonc, 2001). If a family has two children that are born in close chronological proximity, maximum of about a year, both children would then be regarded as first borns as they are both exposed to their parents similarly: a singular outlet of stimuli. There are no older siblings, with their own behaviour, intellectual and

speech level, adding another level of engagement with the environment to the equation. This is exactly the reason why the second borns benefit more from their birth positions than the first borns at a later stage (two to three years after birth of the second child): the second borns have two mature outlets of speech, ideas, language, etc. This is despite the intellectual environment of the firstborn, according to the equation used above, surpassing that of the second born at birth. When both siblings are tested at the same age (and under the age of +/- 11), the benefit goes to the younger child because the later born has an older sibling, whereas the firstborn has had a less mature sibling and influence throughout growing up – a configuration that reverses the birth order effects. This pattern is observed only until the first sibling is +/- 11 years of age after which the teaching function negates the weaker intellectual environment that affects the first born's intellect inversely. Age 11 is chosen because this indicates the start of adolescence where the intellectual development of a child is considered to have stabilized. Zajonc (2001) stated that the teaching function reaches equality with the level of intellectual environment (which is prior to this negatively impacted on by the increased number of members for the oldest sibling) in a family at age +/- 11 years.

The teaching function describes the benefits that accrue to older siblings from being tutors (Zajonc 2001). From an age of 2 or 3, the eldest of the children assumes a tutorial function to the younger sibling's enquiries – a function that benefits the tutor as much as the tutee. The older child has the chance to verbalize ideas, formulate responses and develop thought organizing skills, amongst other things, when being questioned by their siblings. The older child also has the advantage of more mature and complex explanations from its parents.

The addition to the overall intellectual environment through the birth of another child, termed (a), and the teaching function, termed (b), contribute opposingly to the growth of intellectual maturity of each family: (a) contributes negatively and (b) contributes positively. The quality of intellectual environment is considered the sum of (a) and (b) at each given age. Therefore, as the family size increases, (a) is dominant over (b) and the quality of the intellectual environment of the family declines. The exception to this is when the teaching function mitigates the negative effects of an expanding family; this only occurs when a sibling reaches age 11. Therefore, considering the interaction of (a) and (b), in a family of two children, only one (the older child) will have the

benefit of the teaching function whereas the only child will never have this experience. Hence, the only child is predicted to score lower on an IQ test than the firstborn in a family of two children. By this token, smaller families should have an advantage over larger families but this in fact is not the view of this model. Because the above equation talks to the direct family environment and its decline with each subsequent addition, this is seen as diluting the capacity of the environment to accrue a positive affect on intellectual development. Empirical studies published by Retherford and Sewell (1991) and Pedersen, Plomin, and McClearn, (1994) support the finding that the older children have the advantage after they are 11 and that the family environment prior to the pivotal age is advantageous to the younger children. It is important to highlight that a study by Zajonc and Mullaly (1997) measured the only child to score lower than the first born from both a two and even a three-child family. It appears that the negative family size impact only emerges with subjects of 17 or 18 years old.

A criticism of this theory is that there are many more variables at play within a family setting other than (a) and (b). The theory omits explanations or acknowledgement of influences on each individual, at their various points of development, even to the extent of stating that other influences did not measure up to feature in the summing explanation. This, though, calls for a difficult task of unraveling a highly entangled relationship of influences.

The most relevant criticism of this theory pertains to how the sum principle describes something that is of interest in this study: deciphering IQ patterns amongst varying birth ranks, if any difference exists. The explanation of a sum of (a) and (b) appears to speak to the maturity level of a *family environment* but not automatically to the members of the family; it does not automatically explain how benefit or disadvantage is inferred onto each individual member of a family as a result. It does explain what happens when a second child is born into the family but not when the third born is, nor can that be easily deduced from the statements of the sum. What happens to the dynamic between the first and second child and its effect on the third? Are the mutterings and observer learning from the first and second child examples for the third born and if so, how does the overall decreased family environment weigh in: should the third outperform the other two? How about the scenario when the second child is approaching 10 and the first is already 14: which one of these two should be performing better according to the teaching function? In a family of

three daughters, it is possible that the older child is 'teaching' younger children than in a family of two daughters? These answers are not very clear if one considers the substance of this theory. Nevertheless, it gives us some explanation as to what might be happening in the instance when the first borns outperform their siblings on IQ tests.

To a very large extent, the highest concentration of research on birth order and family size emanates from the '40s, '50s and '60s due to the boom in interest on this topic at that time. The volume of research on these aspects has tapered off in the last two decades to a substantial extent, the focus being more on the neuropsychological aspects of intelligence. The fact that so much research was conducted at a time when not much was known on how best to conduct the research in order to obtain credible results inevitably worked against the researchers and the field. There were many studies which proclaimed significant results that unfortunately emerged from a faulty design and reached spurious conclusions, many of them published in the renowned intelligence book written by Cecile Ernst and Jules Angst published in 1983, entitled *Birth Order*. Birth-order effects were studied between unrelated individuals, stemming from uncontrolled family sizes and different social classes. Consequent to this, research was restructured to control for these factors and there were a few studies from this period that were structurally sound (Cecile & Angst, 1983).

In 1947, Roberts tested 504 pairs of siblings and found a non significant difference of one IQ point between the first and second born. Likewise, a French survey of national intellectual levels reported data of siblings in intact two-child families that showed that the IQ of the second born surpasses that of the first born for ages six and seven, is about the same for ages eight and nine and falls bellow that of the first born afterwards (Tabah, 1954; cited in Ernst & Angst, 1983). In Birmingham in the 1950's, a sample of 5 094 consecutive siblings were compared controlling for social structure although not for family size and illustrated a mean one point IQ difference in the favour of the older child. Jensen too conducted a birth order study in 1974 on all sibships from kindergarten to sixth grade in a Californian school district and found no significant difference between the siblings of sibships of two to six. The only exception was that the first borns of a four child family performed better than their younger siblings (Ernst & Angst, 1983).

A study by Dolph, (1966) compared first and second born children from the ninth grade (approximate age of 15 years) from 36 families of three. Both children were tested at school at the same age and found no significant difference in IQ levels of siblings born in specific order. Also, IQ was found not to vary with birth order in a study performed by Wolf (1967) on 83 single sex families of three attending public schools in an unspecified American town.

Resource Dilution Model

The Resource Dilution Model implies the availability of resources, measured in quantity and not necessarily observing the quality of the available resources, to be capable of shaping the way in which advantages and disadvantages are conferred to children. It differs from the Confluence Model in that it addresses the effect of sibship size on educational attainment, via available resources set aside for it, which in itself promotes intellectual growth apart from mental skill realization from within the family environment. The model highlights how presence of certain resources influences intellectual skill. Those resources are: 1) necessities of life such as the type of home, a specific space to study, a daily newspaper, books, pictures, an encyclopedia a pocket calculator and other cultural objects; 2) personal attention, intervention and teaching; and 3) opportunity to engage in various aspects of the 'outside world' including attending dance, art or music lessons outside of school (Blake, 1981). In brief, the theory states that access to fixed or shared resources shape educational opportunity and that children with fewer siblings should enjoy greater educational success than those with many siblings as they will have spent more proportional time with the available resources either at home or educational stimuli outside of the family environment. The decline in resources available to a target child (y) as the number of children in the family (x) increases can be illustrated and approximated via a non-linear $y = 1 / x$ form according to this model. Downey (2001) found that the nonlinear model provides little to no predictive value for most parental resources (such as the frequency in which parents talk with their children about school related matters, parental expectation and knowledge of the child's friends, etc), but it still provides a good fit for money saved for college and cultural activities such as art, dance and music lessons. This model does not directly focus on the resultant intellectual family environment but the consequence of its size on resources available to each child and for opportunities outside the family bound by resource availability within the home.

The constant in the equation represents the collective body of shared and non-shared resources; the equation is only a theoretical one as one cannot 'add' the value of the presence of all resources available to a child into a number. Theoretically, an addition of one sibling should have a 50 % reduction in familial resources whereas the addition of the seventh child should have a relatively smaller impact on the resource distribution: the relative negative effects of sibship size on resources should diminish as sibship size increases. The availability of certain individual resources, however, can be measured using this nonlinear form, such as dividing one rand between three children. However, if one is not able to obtain the value of all parental resources to place into this equation to be divided by the children present, and this form can only be used for calculation of availability of individual resources, how does one know which resource and its availability holds more weight? Is having money more important to intellectual development than owning books or talking with a parent? A study by Downey (1995) showed that economic resources diminish at a faster rate than interpersonal resources like time and attention. This poses the question: How does one know what the interrelation or the resultant effect of all individual resources and factors is in each family which translates itself to an advantage or disadvantage to a child? The constant in the equation can not at the same time represent two very different resources, such as one hour or one rand. The equation is simplistic in that one is tempted to say that it can only apply to cases of financial matters and in that event would be perfectly correct in predicting resource dilution. This critique is supported by Blake (1989), Baydar, Hyle and Brookes-Gunn (1997) who have found that only children perform comparatively on test scores to the children from two-child families, a finding that is inconsistent with the 1 / x expectation and that supports the claim that this functional form can only be ascribed to the financial resources in a family.

The equation does not account for the fluctuation and intensity of presence of shared and non-shared resources which are not necessarily divisible into smaller elements equally; resources are often not divided equally as more benefactors are added to the group. A parent's ability and time to read a bedtime story does not decrease if there are two or seven children: all the children would be hearing the same story, told in the same way and, as the teaching function of the Confluence Model indicates, other children can learn from each other's questions and analysis of the story. However, this does not mean that parents do not individually read to their children; the argument is that the model always assumed that the parents do not combine efforts with regards to resources.

The Dilution Model predicts advantages to the earliest born children since at some point of their lives available resources were not as diluted as when additional siblings entered the family dynamic. Closer spacing of siblings is more damaging than wide spacing, presumably because of the greater competition of resources (Downey, 2001). The model dismisses the concept of children being an added resource and asset to the family environment and intellectual development of all siblings. This model maintains quantity as a pivotal aspect of resources where quality is not considered and needs to be factored into the equation. This model's central tenet – assuming the parental resources to be finite and fixed throughout the upbringing period of all children involved – exposes the theory to scrutiny (Downey, 2001). Resources being finite might well be true although the limit of resources could either be increased or decreased and cannot account for the parent's preference of resource distribution. Likewise, external resources are emphasized as pivotal to intellectual development through the guarantee of educational opportunities and resultant effect on IQ. This model is valid to place in conjunction to this study since it is drawing attention to an external factor, a potential influencer that could be decided by a within-family factor, namely family size.

A longitudinal study by Baydar, Hyle & Brooks-Gunn (1997) reported that access to wide-ranging resources provided to the older child did not reduce with the entry of another child with the exception of the parenting style of the mother that was directly affected by the birth of another child. The reason provided for the finding of no negative impact on resources to the first born is because the resources provided to the first born child may be established early in the child's life and continues on through the birth of the second child. Another pertinent finding of this report was that the self-perception and self-esteem of older children declines with the birth of a new sibling.

The close spacing of siblings has been seconded by several prior studies: Powell & Steelman (1993) and Galbraith (1982). The effect of the close spacing constrains the allocation of family resources in the lower to middle class families, increases the likelihood of drop out of high school in these families and decreases the likelihood of attending post secondary education.

Rationale of the Study

Despite the many criticisms it evoked and the numerous critics it created, the finding of the Flynn Effect had vast ramifications for the intelligence focused researchers and the intelligence testing field. The aspect of this finding which commanded the biggest consequence for the intelligence field was that the observed gains were taking place on culture reduced tests such as the RPM (Nyborg, 2003). This finding coincided with a period in the American history which saw a decline in the attainment of SAT scores in comparison to other periods by college entering students. This gain signaled the purported fundamental transformation of an overarching mental ability that was believed to have a purely genetic basis. Jensen thought **g** to be unalterable and unsusceptible to environmental change. The finding puzzled Jensen; how could one generation outscore the previous one by 15 to 18 points on tests such as the RPM and *not* be superior for the psychometric **g** to some extent? The Flynn Effect had a profound impact on the conceptualisation of the general intelligence theory.

Following the observation of rising IQ scores, there were many attempts to first, discredit the finding; second, to disentangle the effect from any fundamental changes in **g** and third, to explain away the effects due to certain improvements in the environment that acted unilaterally across the population. Some of these theories were the improved test taking ability, the fact that a larger proportion of the child population was attending school (Blair, et al, 2005) and that the overall quality of the nutrition had increased contributing positively to the development of cognitive abilities (Colom et at, 2005). Some of these alternative explanations certainly had points of merit in explaining the increases in cognitive ability other than a positive shift in **g** and could still be considered as contributing some part of the observed effect. However, it was the genotype – phenotype heritability studies which came to the forefront in illuminating how the environment impacted on genetics, how genetics impacted on the selection of one's environment and resultantly how the environment influences could be impacting **g** levels (Gottfriedson, 2001; Nyborg, 2003;). Monozygotic twins reared apart illustrated the effects of environment quite poignantly although it was adoption studies that contributed a vital piece of information on which part of the environment was actually responsible for differences in cognitive abilities. Expectedly, a mother was more closely correlated on cognitive abilities to her biological child than to her adopted child emphasizing the role of genes on abilities (Petrill & Deater-Deckard, 2004). However, it was

postulated that if the shared environment also had a significant effect that the mother and the adopted child would likewise be highly correlated. This effect was not found in this or other studies of this nature (Dickens & Flynn, 2001). The finding illustrated the important effect of the non-shared environment which is the third component to the expression of any gene, the three components being genetic, shared and non-shared influences. The non-shared environment refers to within-family aspects which subsequently manifest or are imparted differently between the family members. For example, parenting skill and style can impress on each individual differently (which would be considered the non-shared influences) but can also be common for all children in terms of approach (which would be considered a shared influence). When testing for environment effects, the genetic influences have to be kept constant which focus the research towards influences contained within-families.

Therefore, when assessing the available within-family factors that could potentially be contributing to the difference in cognitive abilities, one would have to look for something that is overarching and all encompassing between the siblings. In the field of IQ testing, two prominent models – the Confluence and the Resource Dilution Models – have emerged to explain the sum of difference between children within a family due to the person's position and perspective. The models attempt to look at each individual's set of circumstances that are stemming from birth order and the size of the person's family. They do not necessarily focus on one within-family factor over another but rather the effect of a conglomerate of factors.

Considering IQ and **g** to be highly correlated, looking into the effects of birth order and family size was decided on as a focus of the study in order to assess whether there were any differences in **g** levels of individuals. Birth order and family-size effects essentially represent the effect of all variables within a family because each child's perspective is different and their interaction with the environment is not the same despite it appearing homogenous for all individuals of a family. In short, birth order and family size encapsulate the sum of all non-shared variance in a family, which is subjective for each sibling. This research study was geared towards researching whether a differing level of **g** exists amongst the siblings of a family and amongst children born in different sized families and whether this pattern fits either the Confluence or the Resource Dilution Models or elements of both.

Although the present research did not focus on determining whether the Flynn Effect is occurring on a family unit level, an important premise which emerged from the Flynn Effect held implications for the further research on **g:** that **g** can be influenced by environmental factors. The two models described above, illustrate the potential patterns and reasons why IQ patterns should vary in a family. These models were carried forward to explain differences were any to be found.

The research study presumed that the genetic factors, which support the theory of **g,** have remained and are/were constant for all the siblings of a family and that whatever environmental influences might have been present could be attributed to the factors being testing.

Research Aims

This research study aimed to unearth whether or not the level of a general factor, **g,** differs amongst individuals born in various birth orders and family sizes, with a purpose of determining whether or not the emerging pattern of **g** levels amongst these participants could be matched to the models ascribing birth order and family-size effects on IQ. The two models in question are the Confluence and Resource Dilution Models.

Research Questions

Birth Order Effects

To determine whether a child's **g** is significantly influenced by its family environment arising from its position in the family. 'Position' refers to whether the child is a first, second or third born, or the only child in the family. This research question examined whether there were significant within-family birth-order effects on **g** levels and if so, how they might be explained by the stated models. Specifically, the following questions were examined:

A) First born vs. second born vs. third born vs. first born (within three daughter)
B) Oldest vs. youngest (within two daughter families)

The scores of girls born as the only children in their families did not have a comparative within-family measure and their scores were therefore not considered in this research question.

Family Size Effects

To determine whether the difference in **g** levels among participants coming from a small (single child) or large (three child) family environment is noteworthy in assigning significance to family-size effects on **g** levels. Specifically, scores of the following groups of participants were explored:

C) Only child vs. first born of two girls vs. first born of a three girls vs. the only child
D) Last born of a two-girl family vs. second born in a three-girl family.

The scores of the last born children of three daughters did not have a comparative measure and were not utilized to address this question of the research study.

Similarly, the mean of each individual group (such as the first borns of two girls) was compared against the overall mean for that birth order group regardless of family size (such as all first borns). Specifically, the following questions were examined:

E) The overall mean of the first borns vs. scores of the only children;
   The overall mean of the first borns vs. scores of the first borns of two girls;
   The overall mean of the first borns vs. scores of the first borns of three girls.

F) The overall mean of the second borns vs. scores of the last borns within a two-girl family;
   The overall second born mean of second borns vs. scores of the second borns of a three-girl family.

The third born children of the three-girl families did not have a comparative measure and were therefore not utilized in this part of the analysis.

METHODOLOGY

Research Design

This research study was a quantitative one examining relations between participants' **g** scores with respect to the research questions. The SPM and the CPM of the Raven's Progressive Matrices were used to quantify the participants' **g** levels (Jensen, 1998). A cross-sectional, within-family design was used to determine birth order and family-size effects on children born into different environments of the family (Jensen, 1998; Sternberg and Grigorenko, 2002). Participants were chosen to be of the same socioeconomic group in order to keep the between-family factors constant and congruent when testing for family-size effects (Fischbein, 1980; Turkheimer, Haley, Waldron. D'Onofrio, Gottesman, 2003). Only girls were selected for the sample in order to eliminate development effects between girls and boys (van der Sluis, Posthuma, Dolan, de Geus, Colom & Boomsma, 2006). Of those, only one, two and three-girl families formed part of the study as this was both feasible in terms of level of effort required to locate the families of this description but also due to the need to examine several points exemplified in the Confluence and Resource Dilution models.

Procedures

Gathering a sample

Three private schools in the northern suburbs of Johannesburg – Kingsmead College, St. Mary's College and Roedean School – were approached as a starting point in gathering a sample for the study because of their girl-only status and because all three are considered to attract families of similar socioeconomic standing (i.e. upper middle to upper class families). The school psychologists at the aforementioned schools were contacted and briefed on the study's purpose, participant involvement and overall procedure in order to gain entry into the schools. During the initial consultations, various technical questions arose and follow up meetings were arranged to iron-out details of how the research would be conducted. Questions that arouse, for example, were, how anonymity would be guarded, what the direct benefit to the families would be, if any, and included guidance on how best to present the study to the parents to optimize interest and resultantly participation. One school psychologist suggested that the research be described as an abstract reasoning study versus a general intelligence enquiry as the latter suggested scientifically proving one daughter to be smarter than another or that a family was smarter (or not) than the next.

Consequent to the meetings, the school psychologists relayed pertinent information of the research study to their respective headmistresses and obtained permission on behalf of the researcher for the research to proceed.

Once the schools granted permission, a Cover Letter (Refer to Appendix A and Appendix B for Cover Letters sent to Kingsmead, and Roedean, respectively) and a Family Background Questionnaire (Refer to Appendix D) was modified to include and exclude certain types of information based on the recommendations made by the school psychologists. The researcher worked in conjunction with the respective school psychologists to determine the best manner through which to distribute the Cover Letter and Family Background Questionnaire, which contained the Consent Form, to the parents.

At Kingsmead College, only the learners from girl-only families were sent the research documentation. The school psychologist acquired this information through the school management and information system and delivered the Cover Letter and Family Background Questionnaire to the oldest daughter in each of the identified families attending the school. These families were completely anonymous to the researcher as the returning Consent Form that contained the names of parents and their children were retained by the psychologist and any identifying information in the Family Background Questionnaire removed by the school psychologist prior to handing over of these forms to the researcher. The school psychologist replaced the names of families and children with a letter and number code. Immediately prior to testing, the school psychologist marked each child's answer sheet with the same letter and number combination so that the children could be linked to each other and to a Family Background Questionnaire.

At St. Mary's School, a research synopsis (Refer to Appendix C), or a summarized version of the Cover Letter, was posted in the school newsletter; a letter which reaches all parents of learners in the senior school at the end of each school term. The timing of the search for participants coincided with end of school term hence this use of this method of distribution. This approach was more 'diluted' or indirect when compared to what was done at Kingsmead as the synopsis was not addressed to anyone in particular; it did not require an immediate response and could therefore be

more easily ignored. Most of the St. Mary's families were obtained through word-of-mouth and not through the school newsletter.

At Roedean School, all 458 learners in the senior school received the Cover Letter and the Family Background Questionnaire. A letter from the school psychologist was stapled to the front of these forms explaining the focus of the study, the type of participants needed, and the school's involvement in the study. The school psychologist made several announcements at assemblies reminding interested learners to return the documentation to their respective Form Teachers. The Form Teachers handed these forms to the school psychologist who collected the forms on behalf of the researcher.

Following these attempts, the target of 12 families per family type (12 of single child, 12 of two-girl families and 12 of three-girl families) was not reached in any category and alternative methods of recruiting families had to be pursued. Once families started volunteering, particularly from Kingsmead as this approach proved to be most direct in finding the profile families, the researcher asked the already participating families to assist with identification of other girl only families that matched the profile criteria, either from one of the daughter's schools or their neighbourhood. The latter prerequisites were stated in order to keep the socioeconomic status of the families the same as the families already partaking in the study. Due to sensitivity of releasing personal contact information, some parents opted to phone the nominated families in order to brief them on the research study and to ask permission for the researcher to make a follow up phone call. In most cases, however, the researcher followed up directly. This effort resulted in the remainder of families being recruited into the study through word-of-mouth or snowballing (Sternberg & Grigorenko, 1997).

In the initial phone call made by the researcher, the parents were told about: the purpose of and the level of involvement required in the study, the testing date and time procedure, the researcher's and supervisor's contact information. More importantly, the researcher asking the questions found on the Family Background Questionnaire to ensure the family was of the required profile. At the time of testing, however, the parents of these families were given the same forms to complete as

the ones handed out in schools. In this way, the required information and consent forms were obtained in written form from every participating family.

All families attained through word-of-mouth matched the requisite criteria. The parents were then contacted for a testing time and place via the contact information provided on the Family Background Questionnaire. There was an excess of two-girl families that had returned the forms at Roedean in order to participate in the study: the forms of these families came to the attention of the researcher after the testing had been concluded. The ten families in question were told that the required family quota has been reached and that their willingness to participate was appreciated although no longer necessary.

Testing location and conditions

A total of eight families of the overall participating sample were tested at the three schools. The daughters of four families were tested at Kingsmead; two families were tested at St. Mary's as well as another two families tested at Roedean. There was only one testing session per school held on a day which suited the above number of families that volunteered from that particular school. The siblings were, therefore, tested at the same time, in a quiet classroom, after school hours and in the presence of the school psychologist. The completed consent form and Family Background Questionnaire of families tested at the schools were received prior to testing. The identifying information of families at Kingsmead was removed and replaced with a code according to the arranged agreement between the researcher and the school. All testing materials were provided to the participants by the researcher. No parent attended the testing, nor did the researcher physically meet any of the parents.

The remaining 29 families were tested in their own home in the late afternoon or early evening as this proved to be the most convenient time for both the family and the researcher. The testing conditions per family differed as they took place at the family's home but a consistent testing procedure was followed throughout. One parent was requested to be present in the home at the time of testing in order to be able to sign the consent form and complete the Family Background Questionnaire. These forms were not gathered prior to testing although suitability to participate was obtained in the initial telephonic conversation.

The place of testing was chosen to be in a well-lit, comfortable, quiet room in the house where all daughters could work on a table. Space permitting, the siblings were seated in the same room with adequate space to work individually or, wherever this was not possible, were spaced in adjacent rooms. All testing materials were provided to the participants by the researcher. The parents were asked not to assist their children in any way.

Obtaining participant and parental consent

Once seated at their test locations, the participants were briefed on the structure of the test and what was expected of them in terms of their participation. For families that were tested at home, the parents were invited to sit in on the briefing. The participants were acquainted with the technicalities involved: such as the overall design and duration of the test, the test booklet, the answer sheet and how it corresponded with the test booklet, how answers needed to be marked, and how corrections were to be made. The purpose of the study was never directly stated to the participants, emphasis was instead placed on the conditions under which testing and participation was to occur. Following this briefing and prior to the start of the test at each site, each stipulation of the Assent Form (Refer to Appendix E) was read and explained by the researcher to the participants. Participants were given the chance to ask for any clarification. Children older than eight years of age were asked to sign the Assent Form if they understood and agreed with the conditions thereof. Participants younger than eight, however, were verbally asked to give their consent rather than signing the form. Parents were asked to sign a Consent Form (Refer to Appendix C) prior to the start of the test. Parents were also asked to answer a few additional questions (Refer to Additional Questions Form in Appendix F) regarding their background essentially additional information and an extension of the Family Background Questionnaire.

Explaining the test logic & taking the test

Once the procedure was explained and consent obtained, the researcher explained the logic of doing and completing the test as well as the procedures concerning it. The correctness of each possible answer to the first question (A1) of the test paper (the same question appeared first in both the SPM and the CPM) was scrutinized with respect to the matrix, as an example of how the matrices should be analyzed. The logic of why the fourth choice was the correct answer was

explained. The same way of explaining was used in all testing sessions. The participants were given a chance to ask questions and any common questions were answered in a standard manner. The participants were advised to ask for clarity on any technical issues and informed that the researcher would not provide any clues so as to illuminate the correct answer. The test commenced after the question and answer session was concluded. The researcher indicated the passing of every 15 minute interval and alerted the participants when only ten and five minutes remained. The total time allocated for the both versions of the RPM was 45 minutes. The answer sheets were marked directly after the testing was concluded at each site.

Recording of pertinent participant data

Once all test papers were marked, pertinent (although not identifiable) details of participants were recorded in a spreadsheet according to the letter-number combination unique to each participant. A letter was assigned to each family and this letter preceded the number ascribed to each member of a family, which indicated the position of the child in that family. Therefore, G3 indicated the third born in the 7th family that was recorded in this study.

The following information was recorded per participant:

- Their code;
- The birth order;
- The family size;
- The participant's age in years;
- The SPM or CPM raw score;
- The Conversion to SPM Score, where applicable; and
- The resulting Grade assigned according to the age-score relation as yielded from a UK standardized norm table.

This information was used to classify and describe the sample and assist in interpreting results. The remaining family and participant information that was compiled and collated through the Family Background Questionnaire and the Additional Questionnaire forms was recorded in another document and analyzed per question.

General results of the study were provided to the families that participated and any individual feedback on the children's performance, if requested, was provided.

Sample

A total of 37 families with only daughters as children in the family participated in this research study, amounting to a total of 73 daughters. The number was comprised of twelve (12) families with only one daughter, fourteen (14) families with 2 daughters only and eleven (11) families that consisted of 3 girls only. The participant pool contained families with female siblings only in order to eliminate any gender effects (van der Sluis et al, 2003). All participants came from nuclear families where both parents are the biological parents of all the daughters. Every participating family has lived as a contained unit since the birth of the first child to the time of testing, except for one family (the Family Background Questionnaire indicated that the father was no longer living with the child and mother). The two daughters of the one family that were no longer living with both parents were tested although their results were not included. This means that no member of the immediate family had ever lived apart from the family for longer than two years and that no member of the extended family (such as an uncle, aunt or grand parent) had lived with the nuclear family for more than two years either. No daughter was more than 5 years apart in age from her immediate sibling (from one child to the next) although the total age difference between the first and the third daughter was as large as seven years and seven months and as little as fourteen months with the exception of one family of three girls that contained a pair of twins (second and third born). This family could have been classified as a two girl family but was slotted in the three girl family category. Families that had a sibling more than five years older than their consecutive sibling were not included due to lack of ability to test for the teaching function emphasized in the Confluence Model. This was the case in only one family that volunteered.

The age range of participants was between five years and four months and 17 years and seven months. The mean average for the participant pool was 10 years and nine months. The following table outlines the number of participants per age range, the total number of participants per group, and the mean age for that group.

Table 1: Number of participants per age range

	First Born Children			Second Born Children		Third Born Children	
Age Range	# Single Daughters	# First Born of Two Girls	# First Born of Three Girls	# Second Born of Two Girls	# Second Born of Three Girls	# Third Born of Three Girls	Total Number Participants
5-6	1	-	-	1	-	3	5
6-7	1	-	-	2	-	1	4
7-8	1	1	-	3	3	2	10
8-9	3	-	-	2	-	0	5
9-10	-	2	2	-	-	1	5
10-11	-	2	-	4	1	1	8
11-12	2	1	1	-	2	2	8
12-13	2	1	-	1	-	-	4
13-14	1	2	1	-	3	-	7
14-15	-	1	2	-	1	1	5
15-16	-	1	2	1	1	-	5
16-17	1	1	1	-	-	-	3
17-18	-	2	2	-	-	-	4
Total	12	14	11	14	11	11	73
Mean Age	10 years, 6 months	12 years, 9 months	13 years, 9 months	9 years, 7 months	11 years, 3 months	8 years, 5 months	10 years, 9 months

Although a majority of the participants attended Kingsmead, St. Mary's and Roedean (47 participants or 64% of the participant total), other participants attend schools of a similar socioeconomic stature, the majority of which are in the proximity of the above three. Ninety-two percent of participants lived five to ten kilometers away from their children's school which means that most participating families live in similar areas. The exceptions are Heronbridge Primary, situated in Pretoria; Fairways Primary, located in Fourways and Leicester Road Primary, Redham House and Holy Rosary, situated in the Eastern suburbs of Johannesburg. These five schools are both geographically distant from the others and the only public schools in the sample. However, at least three of the five mentioned schools have reputable record of high standard of schooling. Thirteen participants attended these schools. Table 5 summarizes the names and the number of participants attending the thirteen schools represented in this sample.

Table 2: Name of represented school and number of participants per school

Name of School	Total Participants from School
Fairways Primary School	1
Heronbridge Primary School	2
Holy Rosary School	1
Kingsmead College	13
Laerskool Jan Cilliers	9
Leicester Road Primary School	2
National School of the Arts	1
Redham House	4
Roedean School (Primary and Secondary)	12
St Katharine's College	2
St Mary's School (Primary and Secondary)	22
St Stithians College	2
St. Teresa's Mercy College	2
TOTAL	**73**

Ninety-two percent of families (34 families) owned or had permanent access to the following appliances or services: television, refrigerator, music or HI-FI system, DVD player, internet, home security system and digital satellite television. Another five percent (2 families) had all of the above appliances without having a home security system. The remaining family owned the mentioned applications, except for the home security system and internet connectivity. Eighty-nine percent (33 families) of the represented families owned the following items: cell phone, desktop computer, laptop computer and motor vehicle. Four families reported that they owned the listed items, except for a laptop computer.

When consulted about household help either on full time or part time basis, two families responded that they employ a domestic worker, a gardener *and* a driver; thirty families indicated that they have the help of both a domestic worker and a gardener and five families employed only a domestic worker. Therefore, every participating family had at least one domestic worker with four families having two and one family having an au pair as well as a domestic worker.

The participants of this study were from well educated families. The following table highlights the professions of both parents and the number of parents that fell within that category.

Table 3: The count of parents per profession

Father's Profession	# of Fathers	Mother's Profession	# of Mothers
Advocate/Attorney	2	Accountant	4
Banker	2	Teacher	7
Construction	1	Makeup Specialist	1
Director	5	Manager	5
Doctor	3	Doctor	4
Editor	1	Lawyer	1
Engineer	3	Occupational Therapist	2
IT Professional	2	Secretary	2
Lab Technician	1	Self-employed	3
Manager	3	Freelance Journalist	1
Not indicated	4	Housewife	4
Physicist	1	Not Indicated	3
Policeman	1	**TOTAL**	**37**
Programmer	1		
Research Analyst	1		
Self-employed	4		
University Professor	2		
TOTAL	**37**		

The five fathers that comprise the 'Director' category include positions such as a Chief Executive Officer and Executive Director and fathers who own and direct their own companies. Another two fathers that work as private consultants are recorded in the 'Self-employed' category. The seven mothers that are teachers consist of five primary and secondary educators, one music teacher and a university lecturer. The four mothers who are doctors include an anesthetist, two nurses and a general practitioner, while the 3 fathers who fell within the general category of 'doctor' include a general practitioner, a radiologist and a surgeon.

Thirty-two families spoke English as their home language and five families were first language Afrikaans speakers.

Instruments

Raven's Standard and Coloured Progressive Matrices

Raven's Progressive Matrices (RPM) were developed to assess what Raven termed 'eductive ability' in response to Spearman's observation of correlations between test scores of one individual (Raven, Raven & Court, 1998a). The RPM manual defines eductive ability as "making meaning out of confusion; developing new insight, going beyond the given to perceive that which is not immediately obvious; forming (largely non verbal) constructs which facilitate the handling of complex problems involving many mutually dependant variables" (Raven et. al., 1998a, pg. 3). RPM was developed in order to study the genetic and environmental origins of this ability. Raven has distinguished five distinct qualitative developments in children's intellectual capacities, which are related to age. The RPM Manual describes which abilities should be visible in a child at a particular age (referred to as the 'maturation of eductive ability'), which has led to the development of age appropriate tests, namely the Standard Progressive Matrices (SPM) and Coloured Progressive Matrices (CPM), used in this study, and the Advanced Progressive Matrices.

In general, each problem in the Matrices reflects a "system of thought" while the order in which the problems are presented provides training in the method of the test (Raven et. al., 1998). The SPM is divided into five Sets (A-E) of twelve problems where each item contains a figure with a missing piece. Given are either six or eight alternate pieces to complete the figure, depending on the Set, where each Set involves a different principle for obtaining the missing piece. Each Set starts with a problem and the Set develops the theme in which the problems build on the argument that has gone before and thus become progressively more difficult. The SPM was designed for children between the ages of six to adult although most normed tables provided for the marking and grading of the test are limited between ages of six and seventeen.

The CPM comprises of three sets of twelve questions each. An additional set of problems has been interpolated between Sets A and B, which also appear as the first two sets in the SPM. These sets have been designed to assess, the gradual intellectual capability of younger children, the mentally retarded and the elderly with greater precision (Raven et al, 1998b). The coloured backgrounds were introduced to the test in order to heighten attention and interest and also to obviate the need for too much verbal instruction. Set A depends on the person's ability to complete continuous

patterns which towards the end of the set changes first in one and then in two directions at the same time. Set Ab requires the person to perceive and mentally rotate and manipulate discrete figures that form part of a spatially related whole. Set B involves the use of analogies to a certain extent, tapping to the abstract reasoning and more independent ways of thinking. The last few sets in this set are equal in difficulty to the matrices in Sets C, D and E of the SPM (Raven et. al, 1998a).

Reliability of the SPM and the CPM

Internal consistency of the SPM was measured according to the Item Response Scale rather than factor analytic theory. In the United States' standardization, the correlations between the item difficulties were established separately for different ethnic groups (Black, Anglo, Hispanic, Asian and Navajo) ranged from .97 to 1.00 (Raven et. al., 1998a). According to the research done in 1992 in South Africa, the test has the same psychometric properties among all ethnic groups in South Africa: "it scales in a similar way, has similar reliability, correlates in almost the same way with other tests, and factor analysis yields a similar factorial structure" (Raven et. al., 1998a, pg. 22). The majority of split-half internal consistency coefficients reported in the literature exceed .90 (Raven, et. al., 1998a). In the original work with the SPM, test-retest reliabilities ranged from .83 to .93, with higher values being associated with younger respondents and shorter intervals (Raven et. al., 1998a).

High split-half reliability estimates for the CPM have been based on scores of respondents of various ages and countries, ranging from .90 in America for the White, Black and Hispanic populations, to .82 for a young participant sample from Singapore. Studies emerging from Australia have reported the split-half reliability starting at .80 for the younger age groups and peaking at .93 at age 11 and six months (Raven, et. al. 1998b). This researcher also reported a high reliability for non English speaking origin children. The test-retest reliability studies have shows that the CPM is stable in various cultures and particularly so when the retest interval is short. For example, one study cited in Raven et. al. (1998b) retested 100 children from Shanghai after three weeks of the original test and reported a value of .86. Another study carried out in Nigeria, though, showed a test-retest reliability of .59 after a six month rest period (Raven et. al., 1998b).

Validity of the SPM and CPM

Spearman considered SPM to be the best and purest measure of **g** or general intellectual functioning (Raven et. al., 1998a). When SPM was evaluated by factor analytic methods with other cognitive measures in Western cultures, loadings higher than .75 on a general factor have been reported. Concurrent validity coefficients between the SPM and the Stanford – Binet and Wechsler scales range between .54 and .86 (Raven et. al., 1998a). Correlations between the SPM and performance on achievement tests and scholastic aptitude tests are generally lower than correlations with intelligence tests (Raven et. al., 1998a).

The CPM scales congruently in many cultures and countries. In a Spanish speaking context, the CPM was examined against the WAIS and the Culture Fair Test designed by Cattell and the correlations between the CPM and the others were .63 and .68 respectively. Another study with groups of Anglo and Mexican American children tested in Arizona found no bias against the minority groups and a good validity coefficient for both groups when predicting academic performance. Other cultural contexts such as Africa, India and Asia have yielded validity data around .60 and .70. Work in Canada concluded the CPM to have **g** loading of .77 to .84 depending on age (Raven, et. al, 1998b).

South African Application

The SPM has been used several times in recent years in the South African context mainly occurring on engineering students of various races studying at the University of the Witwatersrand and Rand Afrikaans University (now University of Johannesburg). A study conducted in 2000, found that the White college students in these universities averaged between one and two standard deviations higher than the African students on the RPM (Rushton & Skye, 2000). Another study was undertaken in 2002 with the same participant profile on the RPM (Rushton, Gewer & Khunou, 2002). One of the earliest studies conducted with this participant pool occurred in 1992 studying Black / White, Colored / White and Indian / White test score differences in order to confirm or refute the Flynn Effect in South Africa (Raven et. al., 1998a). Other studies show that RPM can be transferred from British and American norms into the South African context (Rushton, Skye & Fridjhon, 2002; Owen, 1992).

The CPM has been used in South Africa to a lesser extent although there are attempts to scale and norm the scores of South Africans on this version of the RPM ahead of the more utilized SPM (Lindstrom, 2002). One study examined the effects of stunting on the South African population under the age of nine and found that one in every five children is affected by it especially so in the Limpopo province (Richter, 2006). The U.K. norm tables were used in this study.

Family Background Questionnaire

The Family Background Questionnaire was developed to screen for family type and participant suitability. The purpose of this questionnaire was to elicit information from the parents regarding the family as a unit and its individual members due to the fact that several important restrictions were put in place on the participant profile. The Family Background Questionnaire asked for the following information to be completed by a parent of a participating family: the names of both parents and their daughters including the children's birthdates and the school which they attended; the mother's and father's professions (to control for socioeconomic status); whether both parents are the biological parents of all the children (to ascertain whether it was a nuclear family); whether the family has lived as a unit since the birth of the first child without a member of the extended family (such as an uncle, aunt or grand parent) living with them for more than 2 years; and how far away the family lives from the child's school (referring to the child through whom they received the researcher's forms). This form was distributed to the parents of learners at the abovementioned three schools, as an attachment to the Cover Letter or handed to the parents to be filled in at the time of testing. An Additional Questionnaire (Refer to Appendix F) was designed to act as a supplement to the Family Background Questionnaire to obtain information on the economic status of the families. This added sheet collected information on whether the family owned or rented certain household appliances and had access to specific services; how many of specific electronic items the family owned and if and how many household staff were employed in the house according to specified categories.

Measures

The measure in this study was Grade generated from the raw scores obtained on either the SPM or CPM, depending on which version of the RPM the participant completed. Participants from age six to seventeen completed the SPM and participants aged below six years of age completed the CPM.

Obtaining a SPM measure

The SPM is comprised of five sets or, as structured visually, five columns of twelve questions. The correct number of answers in each of the 5 columns was notated at the bottom of each column and those scores were summated to obtain a cumulative total. Participant raw scores were scrutinized against a standardized scores norm table of relative performance of children in the United Kingdom of the same age. No South African norms are available for either the SPM or CPM and previous studies which have used the RPM have utilized the United Kingdom standardized tables (Rushton & Skye, 2000). This exercise yielded a percentile assignment for each participant's raw score. For example, a seven year old that attained a raw score of 28 achieved above the 50^{th} percentile but below the 75^{th} percentile. Based on this measurement, each participant's percentile was assigned with a Grade between 1 and 5 according to Table 4. The Grades differentiate the different percentile intervals. The 'Grade Score' column was added to indicate the notation of the Grade in SPSS for analysis purposes. A lower Grade indicates better performance on the SPM or CPM.

Table 4: Scoring percentiles, Grade Designation and Grade Scoring

Percentages	Grade Designation	Description	Grade Score
95%-100%	1	Intellectually superior	1
90%-94%	2+	Above average in intellectual capacity	1.5
75%-89%	2	Above average in intellectual capacity	2
51%-74%	3+	Intellectually average	2.5
50%	3	Intellectually average	3
26%-50%	3-	Intellectually average	3.5
11%-25%	4	Below average	4
6%-10%	4-	Below average	4.5
0%-5%	5	Intellectually impaired	5

Obtaining a CPM measure

The CPM is a test of three columns of twelve questions each, giving a maximum raw score of 36. The correct number of answers per column was noted below each column and these figures were tallied together to get an overall CPM score. A conversion table was consulted to transform the CPM raw score into an equivalent SPM raw score (Raven et.al., 1998b). This table, however, was not age specific. For example, a raw score of 28 is equivalent to a raw score of 32 on the SPM.

Once the conversions were obtained for the five participants that wrote the CPM, the same procedure of ranking the score according to a percentile achieved and converting the percentile into a Grade, as described in the previous section, was followed. The Grades were adjusted to reflect the equivalent grade score notations according to the 'Grade Score' column of Table 4.

Categorizing percentiles into Grades Scores removed the age reference related to participants' SPM or CPM raw scores allowing the Grade Scores to be compared. The analyses were therefore, run on the generated Grade Scores.

Statistical Analysis

Analysis for birth-order effects on g

Repeated measures analysis of variance was used to test for significant differences in RPM scores between individuals born in differing birth orders. The unit of analysis was a family; the children of the family were considered to be the different occasions of measurement where the comparative analysis was carried out on scores of every daughter within one family.

Analysis for family-size effects on g

One – way analysis of variance was conducted on scores of all first and second born children born in different sized families in order to determine whether there were differences in **g** levels between individuals born in families of either single, two or three daughters.

Additionally, a one-sample t-test was performed on the mean of each individual first borns variant against the overall mean score of *all* first borns in order to determine family size effects. The mean of all first born participants was analyzed against each individual variation of the first born, individually. Similarly, the mean of *all* second borns tested in this study was analyzed against each variant of the second born, individually.

Ethics

Permission for participation was obtained from the participants' parents through a Consent Form once the parameters of testing were explained. All participants were explained the extent of their involvement, made aware that no emotional, mental or physical harm was anticipated nor that

anyone would be advantaged or disadvantaged because of their participation or lack of participation in the research study. The participants were also made aware that they had the option of discontinuing their participation at any time should they wished to have done so.

Consent from daughters over the age of 8, was obtained via signing of an Assent Form. Children younger than 8 were not required to sign the form but were verbally explained and asked whether they understood and agreed with the conditions explained to them. Parents were asked to be present at the time of explanations and clarifications regarding participation in order to lessen the risk of intimidation which particularly the younger children might have felt by the presence of an unknown person. The parents of children aged 6 and 7 from the Afrikaans families were encouraged to reiterate what was stated in their home language or allowed to reword what was said in English to support the explanation by the researcher. Confidentiality was adhered to at every point of the research study: at testing, data capture, data analysis stages and in reporting. Anonymity of the participants, their families and any identifying information was guaranteed by giving each family and participant a letter-number combination. No person other than the researcher, was aware of any identities linked to test scores.

Since an analysis of SPM performance had to be considered in relation to a participant's sibling or another family, anonymity of the participant by the researcher was not possible. Only the researcher and the school psychologist who observed the testing at the school knew who participated in the study but only the researcher had access to both a participant's identity and score. The school psychologists only knew of the participants that partook in the school testing session; the other families of Kingsmead, St. Mary's and Roedean obtained via word-of-mouth and tested at home were unknown to the school psychologists. The identifier combination of a letter and number unique to each participant allowed the researcher to remove the names and any other identifying information allowing the participants to stay anonymous to any observers. Participant scores were recorded on a spreadsheet according to individual identifiers; at this point, individual participants could not be identified other than referring back to the answer sheets.

Once the analyses were complete, the general results of the study were disseminated to the parents, participants and school authorities via a letter. The feedback letter – Research Study Results (Refer

to Appendix G) – was distributed to the eldest child attending the abovementioned schools or sent to parents' email addresses provided on the Additional Questionnaire form. The reported results were those obtained with respect to the research questions. Individual results did not appear anywhere in the report, nor did any other identifying information of individuals that took part in the study. At the time of testing, a number of parents requested individual feedback of results within their family with respect to normed scores. This information was provided to parents that requested the information, via telephone. However, as the researcher was not authorized to discuss the meaning of scores, interpretation of scores was not provided. However, the school psychologists agreed to interpret scores if this request was made by the families and in such case, the test scores were disclosed to the school psychologist only. The performance or particulars of any other participant were not given to third parties in the individual feedback sessions.

RESULTS

Table 5 summarizes the total number of participants, their means and standard deviations per group according to rank of the mean. The second borns of two-girl families, therefore, achieved the highest mean and the second born of three girls achieved the lowest mean.

Table 5: Summary table of means and standard deviations per rank

Participant Group	Number Participants	Mean Grade	Std. Deviation
2nd Born of 2 Girls	14	1.71	.80
3rd Born of 3 girls	11	1.73	.56
1st and Only Girl	12	1.88	.96
1st Born of 2 Girls	14	1.93	.92
1st Born of 3 Girls	11	2.27	.96
2nd Born of 3 girls	11	2.50	.97

The following bar graph represents the number of participants, irrespective of birth order or family size that achieved a specific percentage thereby achieving a particular grade.

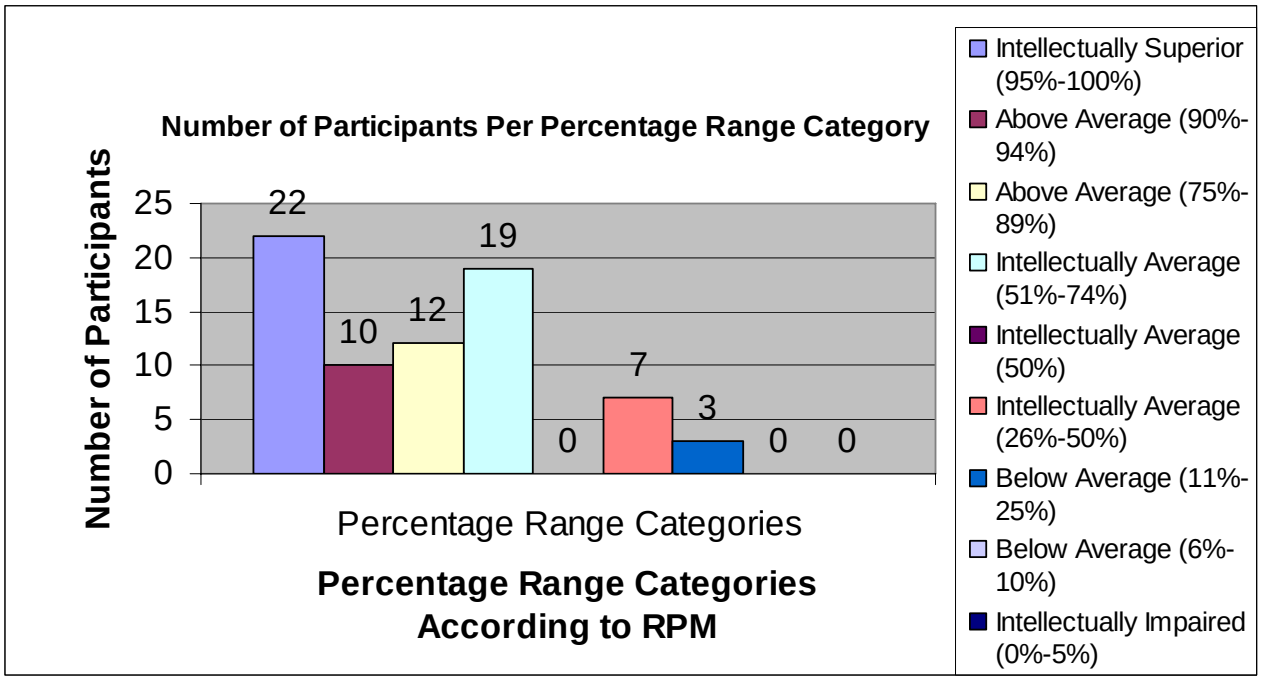


Figure 1: Number of Participants per Percentile Range Category

Analysis for Birth-order effects on g

Result A)

The scores of 11 families of three daughters were used in this analysis. The scores of 11 first borns, 11 second borns and 11 third born children from the same family were analysed against one another. The following table summarizes the mean Grade Scores and standard deviations of scores.

Table 6: Means and standard deviations of first, second and third borns in a 3 girl family

Participant Group	Number Participants	Mean Grade	Std. Deviation
1st Born of 3 girls	11	2.27	.96
2nd Born of 3 girls	11	2.50	.97
3rd Born of 3 girls	11	1.73	.56

Figure 2 plots the means and standard deviations of the three daughter groups.

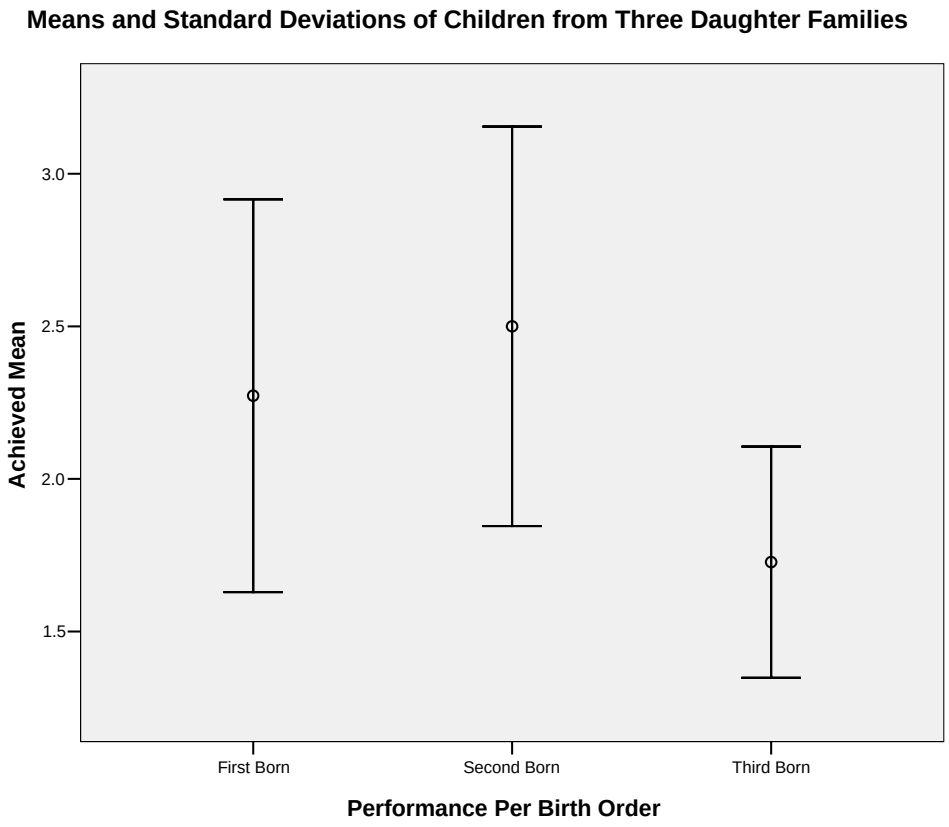


Figure 2: Means and Standard Deviations of Scores of Children from 3 Girl Families

According to the percentile range descriptions, the overall mean of the first born daughters of three-girl families (2.27) achieved an intellectually average description fairing in the upper range of the 51%-74% group. The standard deviation of the mean for the first born of three girls group varied from 1.32 (intellectually above average) to 3.25 (intellectually average). The mean dispersion within the second born of three girls group ranged from 1.53 (intellectually above average) to 3.47 (bottom range of the intellectually average group bordering on the below average cluster). The mean for the second born of three girls group of 2.5 translates into an intellectually average performance albeit in the upper ranges of this interpretation (mean score fell in the 51% - 74% range). The mean performance of third borns of three girls group obtained an above average rating, the average scores falling within the 90%-94% percentile range. The scores of participants within this group were more closely grouped together than the other two groups. The standard deviation of the scores fell between the ranges of intellectually superior to the lower ranges of the above average group.

The following table collates the number of participants that scored within a particular percentile range, recorded according to the three categories of birth order.

Table 7: Collated number of participants from 3 daughter families scoring per percentile range

Frequency: 1st Born of 3 Girls	Frequency: 2nd Born of 3 Girls	Frequency: 3rd Born of 3 Girls	Achieved Percentile Range	Range Achievement Description
2	1	3	95%-100%	Intellectually superior
2	1	2	90%-94%	Above average in intellectual capacity
0	4	4	75%-89%	Above average in intellectual capacity
5	1	2	51%-74%	Intellectually average
0	0	0	50%	Intellectually average
1	3	0	26%-50%	Intellectually average
1	1	0	11%-25%	Below average
0	0	0	6%-10%	Below average
0	0	0	0%-5%	Intellectually impaired

The repeated measures ANOVA for birth-order effects on **g** levels within a three-girl family was not significant: $F(2)= 2.77$; $p=.09$.

Result B)

A total of 14 first born daughters and 14 second born daughters' scores of the same family contributed to the repeated measures analysis of variance used to test for birth order effects, focusing only on families of two daughters. The following table captures the mean Grade Scores and standard deviations of scores per group.

Table 8: Mean and standard deviations of first and second borns of 2 girl families

Participant Group	Number Participants	Mean Grade Scores	Std. Deviation
1st Born of 2 Girls	14	1.93	.92
2nd Born of 2 Girls	14	1.71	.80

Figure 3 illustrates the means and standard deviations of the mean achieved by the both children of the two-girl family.

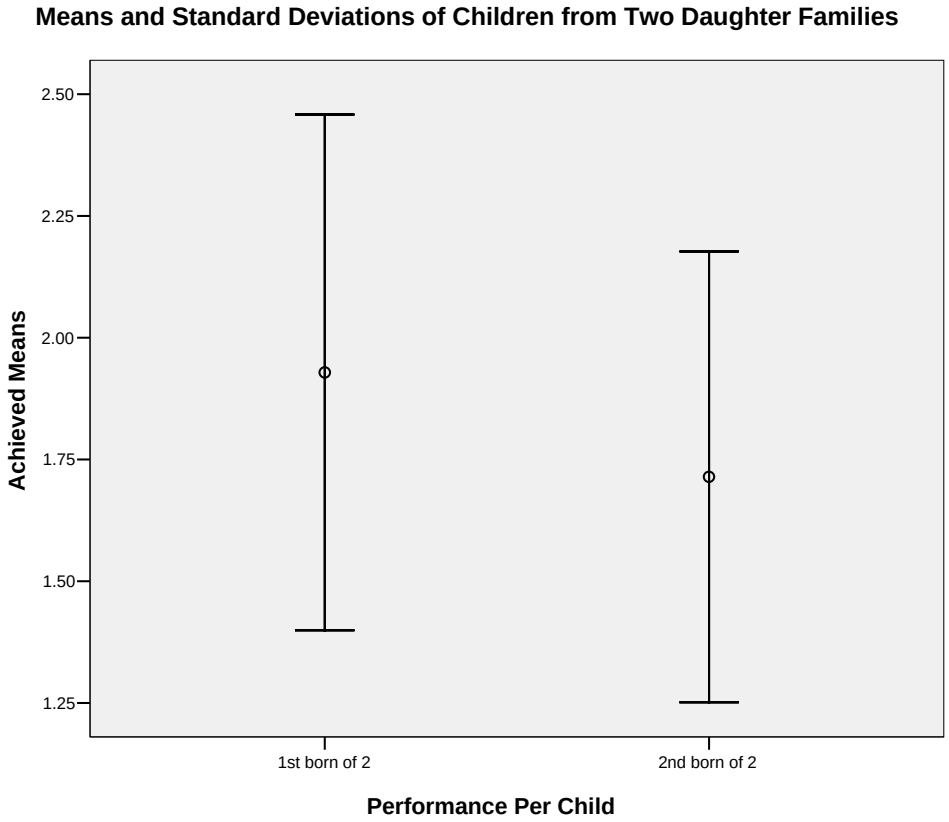


Figure 3: Means and Standard Deviations of Scores of Children from 2 Girl Families

The first borns of two girls achieved the rating of above average in intellectual capacity with a mean score of 1.93. This performance equates to achieving in the lower part of 75%-89% range. This is much the same scenario with the second borns of two girls as that group's mean was slightly higher although fell within the same percentage range. The large standard deviations around the means of both groups indicate that performances ranged from intellectually superior to intellectually average.

Table 9 collates the number of participants that scored within a particular percentile range, recorded according to the oldest and youngest child in a family of two.

Table 9: Collated number of participants from 2 daughter families scoring per percentile range

Frequency: 1st Born of 2 Girls	Frequency: 2nd Born of 2 Girls	Achieved Percentile Range	Range Achievement Description
5	6	95%-100%	Intellectually superior
2	2	90%-94%	Above average in intellectual capacity
1	2	75%-89%	Above average in intellectual capacity
4	3	51%-74%	Intellectually average
0	0	50%	Intellectually average
2	1	26%-50%	Intellectually average
0	0	11%-25%	Below average
0	0	6%-10%	Below average
0	0	0%-5%	Intellectually impaired

The repeated measures ANOVA for birth-order effects on **g** levels within a two-girl family was not significant: $F(1)=.63$, $p=.44$.

Analysis of Family-size effects on g

Result C)

A total of 37 first borns' scores were utilized in the analysis of family-size effects of which 12 were single children, 14 were the first borns of two girls and 11 participants were the eldest of three daughters. Table 10 summarizes the groups' descriptive statistics.

Table 10: Mean grades and standard deviations of all first borns

Participant Group	Number Participants	Mean Grade	Std. Deviation
1st and Only Girl	12	1.88	.96
1st Born of 2 Girls	14	1.93	.92
1st Born of 3 Girls	11	2.27	.96
Total	37	2.01	.93

The following graph illustrates the means and standard deviations of the first born group.

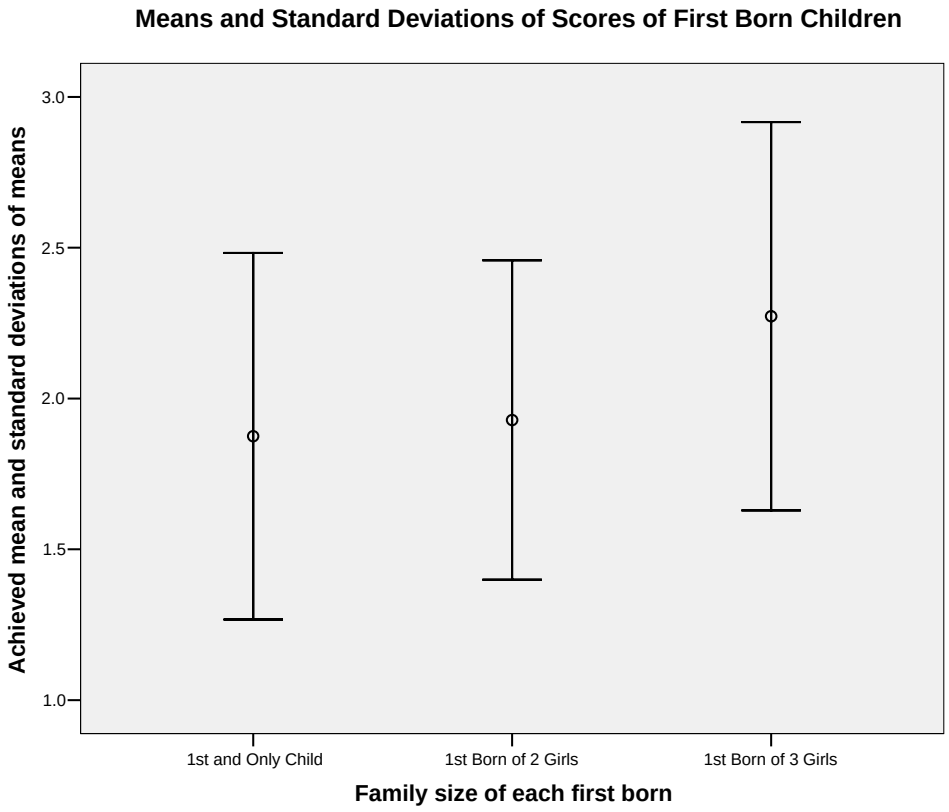


Figure 4: Means and Standard Deviations of Scores of First Born Children

Both the only girl and first born of two girls group performed better in terms of surpassing the overall mean of the first born group (2.01). The respective means, 1.88 and 1.93, for the only child and first born of two girls, falls within the above average in intellectual capacity range with the standard deviations ranging the scores from intellectually superior to intellectually average. The performance of first borns of three girls was both intellectually average, a level below the one

achieved by the other two groups of first borns, but also dipped into the lowest range of intellectual performance as the standard deviation around the mean was almost identical as the other two groups but with a lesser scoring mean.

Table 11 illustrates the number of first born participants per family size, whose scores fell within the respective percentile ranges.

Table 11: Collated number of first born participants scoring per percentile range

Frequency: 1st & Only Girls	Frequency: 1st Born of 2 Girls	Frequency: 1st Born of 3 Girls	Achieved Percentile Range	Range Achievement Description
5	5	2	95%-100%	Intellectually superior
1	2	2	90%-94%	Above average in intellectual capacity
1	1	0	75%-89%	Above average in intellectual capacity
4	4	5	51%-74%	Intellectually average
0	0	0	50%	Intellectually average
0	2	1	26%-50%	Intellectually average
1	0	1	11%-25%	Below average
0	0	0	6%-10%	Below average
0	0	0	0%-5%	Intellectually impaired

The one way analysis of variance did not yield any significant results for family size effect on **g** levels between the characterized groups: $F(2,34)=.60$, $p=.55$. There were no significant differences between the scores of only children, first borns of two girls and first borns of three daughters.

Result E)

Additionally, the three individual one-sample t-tests revealed no significant difference in scores between any group of first borns against the overall mean of the entire first born group regardless of family size from which the first born emanates. Therefore, the mean of all first borns, 2.01, was not statistically significant different to any individual group of first borns: $t(11)= - .49$, $p=.63$ for the only child group; $t(13)= -.33$, $p=.75$ for the first born of two girls group and $t(10)=.91$, $p=.39$ for the first born of three daughters group.

Result D)

A total of 25 second borns' scores were employed for this aspect of the family-size effects on **g** research question. There were a total of 14 last borns from the two girl families and 11 second borns from the three girl families. Table 12 depicts the descriptive statistics for these two groups.

Table 12: Mean and standard deviations for both variants of the 2nd borns

Participant Group	Number Participants	Mean Grade Score	Std. Deviation
2nd Born of 2 Girls	14	1.71	.80
2nd Born of 3 Girls	11	2.50	.97
Total	25	2.06	.95

Figure 5 illustrates how the means and standard deviations of the mean plot against each other when considering each second born group.

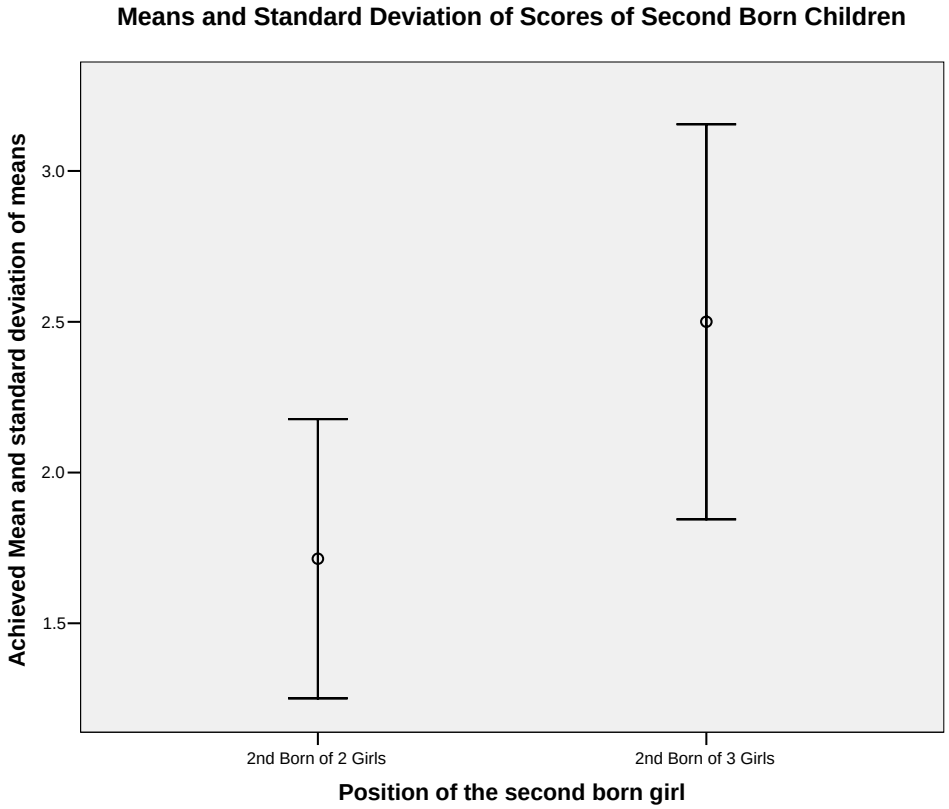


Figure 5: Means and Standard Deviations of Scores of Second Born Children

The second born of two girls group achieved a higher mean grade score (1.71) when compared to the second born of three girls (2.50). The standard deviation of scores of the former group was also smaller (0.80) than that of its counterpart in this analysis (0.97). This indicated that second borns of two girls performed intellectually above average and that this group's scores ranged from intellectually superior to intellectually above average. The second borns of three girls scored intellectually average and the standard deviation indicates that the scores ranged in the region of above average to intellectually average.

The following table collates the number of second born participants within different family sizes whose grade scores fell within the stipulated percentile ranges.

Table 13: Collated number of second born participants scoring per percentile range

Frequency: 2nd Born of 2 Girls	Frequency: 2nd Born of 3 Girls	Achieved Percentile Range	Range Achievement Description
6	1	95%-100%	Intellectually superior
2	1	90%-94%	Above average in intellectual capacity
2	4	75%-89%	Above average in intellectual capacity
3	1	51%-74%	Intellectually average
0	0	50%	Intellectually average
1	3	26%-50%	Intellectually average
0	1	11%-25%	Below average
0	0	6%-10%	Below average
0	0	0%-5%	Intellectually impaired

The results of this one way ANOVA showed that there was a significant difference in **g** levels of participants born second in a two-girl family versus those born second in a three-girl family size: $F(1,23)=4.90$, $p=.04$.

Result F)

The additional one sample t-test analysis of comparing the mean of *all* second borns (which was 2.06) to each individual means of each second born group, namely the second born of two girls and the second born of three girls, yielded no differences between any group and the overall mean: $t(13)= -1.61$, $p=.13$ for the last born of two girls group and $t(10)=1.50$, $p= .17$ for the second born

of three girls group. Neither the second borns of two girls nor the second borns of three girls apparently performed better than the overall performance of all second borns when considering all second borns in this study.

Additional Analysis for Birth Order Effects

The significant one way analysis of variance finding between the second born of two girls and second born of three girls group prompted an independent samples t-test of scores by the two last born groups available: the second born of two girls and the third borns of three girls. This analysis was run to test for the birth-order effects of being a *last born* in a family of either two or three girls instead of matching birth orders in different sized families (such as last born of two girls versus the second born of three girls). The questions which emerged from the above is whether there is a difference between being born last in a two-girl family and last in a three-girl family. The only girl participants' scores' were excluded from this analysis as they are both first and last borns.

The following are descriptive statistics of the two groups:

Table 14: Mean and standard deviations of the two last born groups

Participant Group	Number Participants	Mean Grade	Std. Deviation
2nd Born of 2 Girls	14	1.71	.80
3rd Born of 3 Girls	11	1.73	.56

Figure 6 represents the means and standard deviations of the mean for both last born groups.

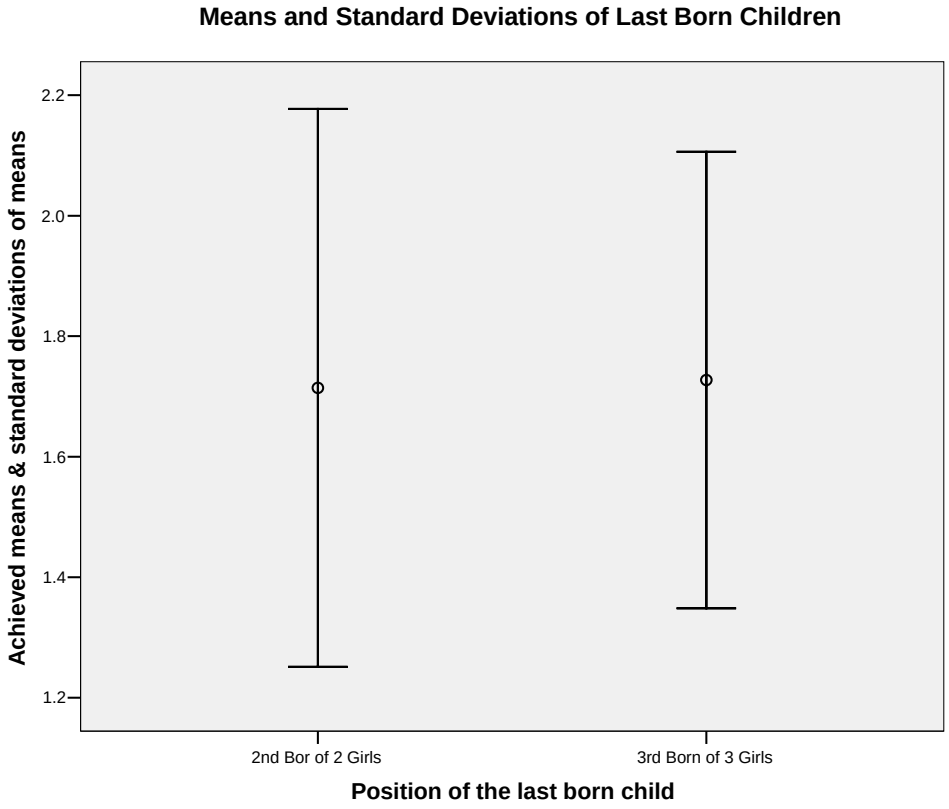


Figure 6: Means and Standard Deviations of Scores of Last Born Children

The independent sample indicated no significant differences between scores of second borns of two girls and third borns of three girls: t(23)=-0.47; p=.96.

DISCUSSION

Birth-order effects on g

The repeated measures analysis of variance for both result A) and result B) showed no significant birth-order effects in the sample of this study. There were no significance differences in RPM scores between the first born, second born and the third born daughters within a three-girl family. Similarly, there were no birth order differences in relation to **g** levels between the older and younger daughters within a two-girl family arrangement. This finding is consistent with findings from studies by Dolph (1966) and Wolf (1967).

Findings with Regard to the Confluence Model

Although no significant effects were uncovered, the last born daughters in both analyses, that is the third born daughter of three girls and the second born daughter of two daughters performed better than their older sisters when only considering these groups' means. The fact that standard deviations of the third born of three girls (.56) and second born of two girls (.80) were the smallest obtained with respect to all other groups indicates that the scores were more densely situated around the means. This indicates that the participants scored within a close range of each other illustrating a more consistent performance than any other group. This points to the possibility of a common underlying influence acting on both these groups although differences were not sufficient to be statistically significant in this study. The high means and smallest standard deviations give weight to the possibility of a true effect that was possibly not uncovered due to research design limitation such as an inadequate sample size. One of the initial studies performed on birth order by Roberts (1947) also found that the second borns achieved a slightly higher IQ score, although this was statistically non-significant.

The displayed pattern of the youngest siblings achieving a better RPM score to their older sisters in this study is one contradictory to what the Confluence Model indicates should happen between siblings of a family. According to the Confluence Model, the first born's immediate advantage when it is still the only child switches over to the second born when the second child is born and then reverses back to the first born when the teaching function supersedes the environmental disadvantages imposed on it by the entry of another child. Although it could not be statistically concluded that a difference between the first and second born daughters of a two-girl family exists,

this is not what occurred in the families sampled in this study according to the group's individual means. The third borns' mean surpassed the means of both elder siblings and the second born daughters emerging from the two-child family did better than their older sisters although not statistically different.

The average ages of the third born of three girls and the second born of two girls groups were 9 years and 7 months and 8 years and 5 months, respectively. These two groups were the only two to have an average age lower than the pivotal age of +/- 11 years; the remaining groups were all older, on average, than the critical age. The next closest group in terms of age closeness was the single girl group with an average age of 10 years and 6 months. Both the first born of three girls and the first born of two girls were above the pivotal age with average ages of 13 years and 9 months and 12 years and 9 months, respectively. The teaching function mentioned in this model should have already come into effect for the eldest born of the first born of three daughters and the first born of two daughters although this is not what was observed in the comparison of means. If we were to assume the means as indicative of a difference between the children of different birth orders, it appears that the age advantage was either never present or that it did not revert back to the first born and was always at the advantage of the last born child.

When considering the three-girl family, the configuration is that there are more of the younger children than older children and because that is so, the overall mental environment would cater to the majority of the family (i.e. the younger siblings). As shared resources such as time and attention become more stretched, as suggested by the Resource Dilution model, the lexical surround might cater to the younger children of which there are more in the family. The older siblings are subjected to this, scaling their development back to the age level appropriate to the younger sibling. One cannot exclude that parents talk differently and more maturely to the older siblings, independently; however, the model states that this would only happen if the oldest child is older than its immediate sibling by more than one year. This difference in age classifies the oldest child into another 'group' within the family, a group with its own communication patterns and displayed behaviours by the parents towards that child. In both instances of first borns in this study however, the age gap between the first born and the second born, was over two years, above the one year threshold. This means that the oldest sisters should have been exposed to different

learning intensities than their younger sisters and should have scored better than their siblings. Likewise, the fewer children in a family, the more time there is available for the parents to opportune the older children with language, conversation, and engagement; the more children in a family the less chance there is of a parent actually engaging with the older sibling or siblings despite the fact that they might be 'older' and requiring of their own engagement. If this were indeed occurring, the first borns of two girls, provided that the first born is older than her sibling by more than year, would perform better than the first born of a three-girl family provided she, too, was older than her two siblings by more than a year. The age gaps, as stated, were observable in this sample and indeed, the first born of two-girl families achieved a higher mean than the first born of three girls although this was not statistically significant.

Judging by the achieved means, the effect of the teaching might affect the youngsters more than the teaching does the oldest. It may be that the teaching elevates the younger children's level of learning by accelerating the pace at which they learn and propelling them beyond the norm for that child's age despite the older children apparently having the chance to amalgamate and verbalize information thereby formulating their own ideas and systems of thought. Therefore, when comparisons are made with an older child that performs 'normally' – falling within a normal distribution for her age – it appear that the younger children are relatively brighter. The mean grade of the second born of two girls and third born of three girls achieved an *above average* intellectual capacity score which means the described 'elevating' of performance for the age norm could be occurring with the youngest siblings of a two or three-girl family. This also shows that the effect of learning might have more impact than originally thought.

The third borns of three girls performed above the average normal for their age, with the second highest achieving a mean of 1.73. The third born children have three potential sources of knowledge more developed than its own: each of the two older sisters and the parents. This aspect could diversify their level of understanding. On the other hand though, although the youngest child can be a stimulus, the implication is that the ability to provoke learning for the older children is not existent considering that the older children have gone through the stage which their younger siblings are experiencing. The possible benefit of being a bystander to the more complex interaction between the eldest children and the parents needs to be explored.

By expounding this idea, the second born child of the three-girl family should score higher than the first born and on par with or better than the third born sibling depending on which effect (teaching or the effect of teaching) scales more influence. Considering the possibility of this effect, the second born would score higher than its first born sibling as the second born has the benefit of: 1) the effect of teaching; 2) the teaching function, and 3) the 'bystander' effect from the first born's interaction with the parents more so than the interaction of the parents with the third born. The first born only has the benefit of the teaching function; the effect of teaching and the bystander effects are presumed to be of little influence as it is catering to an intellectual level lower than its own. The third born child has the benefit of the effect of teaching and the bystander effect; the teaching effect is presumed to be non existent as the youngest is not considered to be teaching the older children. Studies show that the more diversified quality influences available to a child, the more opportunity is availed to the child to both learn more and at a faster rate (Fischbein, 1980; Schooler in Neisser, 1998).

Although not statistically different, the mean of the only middle child group in the sample of this study did not illustrate this. The second born of three girls achieved the lowest mean score in comparison to their first and third born counterparts within a family of three. Considering that there were no differences between mean scores, it is possible that something about one of the three components, individually, or of the three, simultaneously, might be canceling out the positive effects of the teaching function. The non significant birth order results challenge the teaching function and postulate that other effects such as the two mentioned above are working to negate the teaching function benefit rendered to the first born.

Considering that both the second borns of two girls and the third borns of three girls gained the highest mean of all the groups could be said to support the notion of the effect of teaching (or indicate that there are other factors not incorporated in the Confluence Model). It is plausible that the last borns' positioning makes this group of children more open to asking questions. The third born can also be inquiring and posing questions to the second born that in effect makes the second born a 'teacher' in the sibling configuration and therefore not so much the 'tutee' to the first born. The Confluence model does acknowledge the benefit of being a tutee although places more

emphasis on the actual teaching done by the tutor (Zajonc, 2001). The process of formulating questions could be as beneficial as formulating answers. The age proximity of the second and third born in this study (just less than three years average age difference) might serve as a deterrent and incentive for the third born to ask questions of the second born. It works as a deterrent in that the second borns are not the main 'source' of knowledge; the age difference between the first and third born of 5 years indicates that to be the first born in this sample. However, the age proximity might be an incentive, on the other hand, for the third borns to ask questions of the second born by the virtue of following in the footsteps of the second borns through school and other learning environments. Literature indicates that children of similar ages bond together more than siblings of bigger age gaps because of the similarity in experience (Powell & Steelman, 1993). The average three year gap between the second and third born children from the same family supports this bond. This interaction might have provided the interferences to the benefit of the teaching function which resulted in no significant results in this study.

The nature of the second borns positioning within a three-girl family (two years younger from its elder sibling and three years older than its younger sibling) suggests that this group could be portraying a little of both the first and third born group without having much constant influences acting on them as a group as those which are acting on the other two. Studies have shown that middle born children tend to portray characteristics of the 'other' children whether younger or older (Herrera, Zajonc, Wieczorkowska & Cichomski, 2003). The largest standard deviation by this group in comparison to all others (0.97) denotes scores characteristics of both the first born and third born group. This illustrates the 'oscillating' characteristic of second borns emerging from three-girl families, because as a group, the factors which are present and acting on this group are inconsistent. Some second borns perform as first borns and some perform as third borns. In summary though, these results do not support the Confluence Model.

Findings with Regard to the Resource Dilution Model

The non significant findings refute the principles of the Resource Dilution Model which states that each child after the first has fewer individual, household and financial resources assigned and available to it which should negatively impact the child's cognitive ability. The first should perform better than the second who in turn would have a better result than the third. This study

found no significant differences between the children born in different birth orders nor were the mean results reflective of this notion. On this basis, the findings contest whether more children diffuse the number of resources; simultaneously, the lack of *significant* results challenges that resource availability alone is adequate to infer advantage to some children of others. Therefore, it is important to examine why later born children did not achieved a lower score, as postulated by the model.

It is evident that if a family of three children owned only one book that no child would have sole exclusivity to that book. This, however, does not signify that the third born child will not get to read the book because she is the last in the 'chain'. She will have to, in the worst case scenario, wait for the book to become available. In fact, it is plausible that what larger families experience more than smaller families with respect to intellectual and household resources, is greater rotation of a resource; this need not automatically imply a shortcoming or disadvantage to the larger family. This pattern follows for other intellectual property or cultural possessions of a household: computer, musical instruments, radio programs, television programs, books, etc. Judging by the relative similarity in mean trends between the sisters of a three girl family or a two girl family, the sharing aspect does not imply disadvantage merely a need for adjustment or compromise, which is something that children from larger families inevitably learn to do better than single child families (Ernst & Angst, 1983). Also, all families had domestic assistance which may have to be factored in the confluence or resource dilution hypotheses.

Similarly, a parent's time with individual children is observably stretched in a larger family (Blake, 1981). Due to this, parents have had to become increasingly versatile to incorporate all children in the activities which they plan which might again suggest that both the earlier and later born siblings are considered as one. If anything, the advantage should then go to the younger children and not to the older ones as the model states because parents have been shown to either use language appropriate for or play to the capability level of the younger siblings (Blake, 1989). This is essentially comparable to spending more time with the younger siblings and the quality of the time spent together might not always be proportionate in quality to cater for the older children's age level. Individual time spent with children is important for teaching done by the parents; here is where the younger siblings might lose out in bigger families as the younger ones

inevitably need more personal attention and are considered to need "more help" whereas a certain level of independent work is expected of the older children. So even though last borns might receive proportionately more time with the parents than the first born, it might be inadequate still because the younger children require *more* time.

The absence of an intellectual resource does not mean a deficit for a child; it might indicate an opportunity to engage with another intellectual, individual or household resource. Birth order in this sense, might impact the order of availability for the children starting with the first borns having foremost preference. However, one is inclined to think that this is highly dependent on the resource in question and the parents' discretion of order of use. The use of the computer might be given more to the older child because they would be more competent to use it and make use of it whereas toys would be reserved for the younger siblings. Similarly, the younger children have the capacity to 'inherit' individual resources from their older siblings; that might span over many individual resources such as clothes and books, which impact both personality and intellectual development of the later born children (Retherford & Sewell, 1991). However, considering that all families emanate from middle to upper class socioeconomic status, all children would most likely have been bought new and/or additional individual resources; the likelihood of younger children being bought resources is quite high. In certain aspects, the younger children might have *more* individual resources than their older siblings because they are both accumulating and receiving new resources from parents; this notion does not currently feature or fit in the model. By the same token, the later born children would experience more household resources because as the number of children increases, the greater number of resource would be accumulated for the house.

The third segment of the model – financial resources – is most applicable across families of differing socioeconomic statuses and cannot be used to describe which child from the participating families would benefit most due to their relatively similar statuses. The schools which the participants attended are either private or reputable public schools where the educator – learner ratios are relatively small and where learning is enhanced by various teaching aids. Likewise, families which participated can afford to continue to provide this educational benefit to their children throughout their schooling careers.

A criticism of the two theories converges at the notion that the presence of another child is a barrier in the attainment to both the resources and the overall higher intellectual environment. However, the results do not show this trend and question whether it is the youngest or the oldest who receives the greatest diversity of stimuli and therefore advantage. With particular focus on the Resource Dilution Model, the older children, if they indeed had more resources available to them at one point in time, presumably when they were the only child, have internalized the benefit of having those resources and may relay that knowledge second hand to the younger siblings. The younger children do not necessarily *not* benefit from not being present at the time of the first born; the learnings and knowledge which emerged as a result thereof may be passed down to the second born in an osmotic and indirect way by the older sibling (Retherford & Sewell, 1991). The third born children have an additional asset and diversity as they have two older siblings that can impart this 'indirect effect'. This is certainly something that can influence the non-shared environment or add to the environmental complexity which is deemed to impart the significant edge for some and not other children in a family (Schooler in Neisser, 1998). It is also possible that both models might be in operation, but that their individual benefits cancel each other out, hence no significant birth order effects. The attained results of this study lend themselves to the possibility of genetic effects.

Family-size effects on g

The significant effect for family size came in the form of the second born daughters of a two-girl family performing statistically better than the second born daughters of a three-girl family. No first born variant, either the only child, first born of two girls or first born of three girls yielded a significant result although the mean trend of these groups are interesting to note in that they mimic the pattern described in the two models. The lack of a statistical finding amongst the first born groups suggests that the statistical finding amongst the second born groups could have been due to chance. This is supported by the fact that all one sample t-tests yielded non-significant results, showing no differences between the average scores of a birth order against any individual group's score for that birth order. Therefore, there are findings and lack of findings in other cases that both support certain aspects of the models as well as refute it.

Findings with Regard to the Confluence Model

According to the Confluence Model, the larger families have a more diluted intellectual family environment making the respective members therein intellectually less capable when compared to people born in the same order but in a smaller family size. The average ages of the first borns to the two groups from which the significant results emerged – 12 years and nine months and 13 years and three nine, respectively for the first born of two girls and firsts born of three girl families – indicate that the teaching function benefit should already have been imparted on them and resultantly the family. Although the Confluence Model focuses more on how this benefit balances the negative impact of new siblings entering the family configuration for the first born, this principle also speaks to what occurs to the family environment as a whole. Any 'personal' benefit imparted on the first borns should also act as a benefit to the whole, making its environment more mature. However, in consideration of the finding, the 'lexical surround' appears to be more mature in smaller families for certain reasons. It is possible that the second born children of two girl families are 'clumped' into one homogenous group with their older siblings thereby taking on the identity and treatment of the first borns. The fact that the lexical surround might be more developed in a smaller family is a direct function of the time which parents have to engage with their children and the children with each other. The result is that the younger daughter has the opportunity to learn at a faster rate than its counterpart from a three girl family and might therefore be more mature for her age; a configuration which inevitably aids the older daughter in her progress and learning as well. The resulting effect is that the family environment is more stimulating for all members of the sibship effectively compounding the positive effect of a smaller family size (Moltz, 2001).

The three daughter family might also experience this pattern although at a slower rate as there are more siblings in the family and less proportional time for the parent with each one, or amongst the siblings themselves. This, then, negatively impacts the maturation level of the entire family environment when compared to the two daughter family and how each child benefits from it. Therefore, the learning curve might be less significant for the second born of a three girl family than it is for the second born of a two girl family. The family environments are tailored more to the younger or youngest children within larger family contexts due to the fact that the younger siblings make up the predominant part of the sibship. The second and third born daughters of a three girl

families are closer in age than the first and second born daughters of the same family size meaning that the two youngest daughters naturally 'gravitate' towards each other making the environment 'younger'. Therefore, the older children in the three girl families are subjected to the surrounding which are not beneficial to their developments as due to time pressures it is presumed that activities are tailored to the younger children. Therefore, the second borns of the three girl family do not stay on pace with their counterparts from the smaller families that are engaging with their family environment on a level appropriate for their age. In fact, the non-shared environment is hampered by the influx of too many inputs; diversity might be watering down the lexical surround. This is supported by the statistically significant difference between the second borns in two and three girl families.

However, if this was the exclusive difference for all siblings between the two and three girl families, the one way ANOVAs performed on the scores of the first born groups would have also yielded significant results. This signifies that there is something specific acting on the second born children. The only difference offered by the model between the two groups is that the second born of three girls is able to be a tutor to the youngest sibling whereas the second born of two daughters never gets that chance. The Confluence Model states that the first born of two daughters should outperform the single child because of the teaching function (Zajonc, 2001) yet this did not occur. There were no differences in the scores of the first born children regardless of family size; the means of the two first born groups under discussion were nearly the same: 1.88 and 1.93 for the only child and first born of two girls group. It appears that the teaching function is not as influential in imparting advantage as is the maturity of the family environment and in this, that the state of the family environment is most beneficial to the last born children in any family size although this difference was not statistically different. The third born daughters did not have a comparative measure and were not utilized in determining family size effect however; it is noteworthy that this group performed equivalently to the best performing group in the study.

Findings with Regard to the Resource Dilution Model

Any findings pertaining to family-size effects are perhaps best explained by the elements of the Resource Dilution Model as it is intuitive to believe that the more children there are per family, the less likely each one is to spend with and therefore benefit from the resource. However, when

considering that all participating families could afford to buy each child in the family the same amount of resources, this explanation no longer seems feasible. It is possible that something within the quality of the interaction with resources in a two girl family is different to a three girl family, however, in that case both research questions (pertaining to between family first born and second born comparisons) should have yielded a significant result. The one significant result could lead us to speculate that if the two family size types have the same amount of resources that the smaller families interaction with the resources is proportionally longer and therefore more beneficial which would herald the result that this study uncovered. By the same token, if families of both types could afford to purchase the same number of resources for each child, the resulting number of individual and household resources in a three girl family would be larger than in the two girl family. The quality of interaction with resources could differ somehow due to this result.

Limitations & Suggestions for Future Research

The inability of this study to uncover any birth order or family-size effects or significant differences in terms of **g** levels could possibly lie more in the study's mechanics than its substance. There were several technical limitations or inadequacies in the design or administration.

Principally, for a within-family birth-order effects study, the soundest approach of detecting any difference in **g** levels would be to test each family member at a specified age which would require a longitudinal design. In a family of two girls, for example, a five and an eight year old, the five year old daughter should be tested at age eight, if that is when the first born daughter was tested. The time limit on this research prevented a longitudinal study from occurring although its current design was second best in comparison to testing unrelated first, second borns and third born children without a common genetic background.

Post analysis of data, a further literature review revealed that general intelligence ability is heritable in varying proportions throughout a person's life and therefore evident in varying degrees at different ages, such as adulthood and childhood. Although empirical evidence was not abundant in order to support this claim, several studies build their arguments on the notion that heritability for IQ levels starts at 20% in infants, rises in various degrees through early adolescence and middle adulthood and peaks to as much as 80% in adulthood where shared environmental effects on IQ

virtually disappear (Jensen, 1998; Petrill, & Deater-Deckard, 2004). If this claim is empirically correct, this essentially means that the earlier we measure IQ, the more of a chance there is of measuring influences other than that which you are trying to measure; general inheritable intelligence. This suggests that the age of the participants in this study might not have been ideal in uncovering birth order and family-size effects and that the present study might not have been valid in its attempt. The Raven's SPM manual, however, has age adjusted **g** scores, which attempts to address the concern of different development curves of eductive ability at different ages. The problem with this rationalization as a viable response to the above concern is that the age adjusted scores were assigned per age group based on a bell curve principle where the mean score obtained for all 7 year olds on the SPM, for example, made up the 75% percentile and the remaining scores were graded into percentiles according to this assignment. However reliable this method was in designing the age adjusted tables, it does not address the weighted heritability at different ages – it only responds to the maturation of the eductive ability or **g** or essentially illustrates the norm of the displayed **g** per particular age. The age adjusted tables do not address that at a certain age, **g** is only responsible, for example, 5% of the actual contribution to an answer where the remaining 95% might be due to specific ability or **s.** A lack of a finding might actually be a lack of opportunity for an effect to manifest itself.

Similarly, the scores in age adjusted tables are indiscriminant of gender when there is evidence that girls and boys develop differently and hold different abilities at similar ages (van der Sluis, Posthuma, Dolan, de Geus, Colom & Boomsma, 2006). Boys tend to be more visio-spatially orientated than girls of the same age, which might assist in perceiving the Raven's matrices differently. Girls have been reported to outperform males of the same age on perceptual speed and verbal ability. The nature of **g,** however, suggests that a problem can be unraveled using various talents: mathematical, artistic or otherwise, which minimizes advantage of having one talent over another. Studies show that no difference in **g** levels exist between the different sexes although one study indicates that the growth of girls accelerates at around nine years of age and remains in advance of boys until around 14 to 15 years of age after which the boys development accelerates (Colom & Lynn, 2004). This does not refute the possibility that testing only boys might have yielded different end results.

On a similar note, the researcher made use of scores normed for children stemming from the United Kingdom as there were no tables of normed scores for children of South Africa. This might have skewed the reading of the raw scores into percentiles and assignment of an incorrect and equivalent grade for the respective performances by South African children on the RPM. Similarly, the researcher encountered a problem of assigning Grades for children above the age of 16 as the United Kingdom age normed table spanned from age six to sixteen although the manual stated that the SPM is appropriate for use by research subjects up until age 17. For each of the four participants over the age of 17, the researcher extrapolated the Grade based on the trend of score assignment to each Grade for the 16 year olds. A certain amount of error could have been introduced into the study with this practice; however, removing these participants from the study would have represented a loss of four families and ten participants or 7% of the total sample (two 17 year olds came from two-girl families and the other two 17 year olds were daughters of three-girl families).

The RPM scoring scale was not conducive in highlighting subtle differences in participant scores as the ranges were too large to be truly meaningful with the type of research questions posed in this study. For example, the entire 'Intellectually Average' category spanned from 26% to 74% with three individual subgroups contributing to this group: Grade 2.5, 3 and 3.5. For a participant aged eight years and two months, a 25% achievement mark is equivalent to a raw score of 17 to 25. This means that if one participant of that age scored a 17 and another one of the same age scored a 24 – comprising a seven point difference – that they would receive the same grade. Seven raw score points translates into 12% of the test and resultantly a considerable difference that is not detected by the RPM grading scale. In this instance, however, the grading might have contributed in covering any real effects.

Also, it is important to acknowledge that the grading percentile range, in which the largest number of participants scored, 22 or 30% of the participant group, represented intellectually superior performers or those that achieved between 95%-100% for the test. Figure 1 illustrates the number of participants per percentile range; the skewness to the left is troublesome in that it indicates a potential ceiling effect. The remainder of the grades scored according to a normal distribution; no participant scored in the 50% percentage range. These patterns indicate that the difficulty level of

the RPM is perhaps not as complex as believed or in the very least that Set E, as posited, does not differentiate between the 'normal' intellectual performers to the exceptional intelligent ones as it claims to do. This brings about questions as to whether the RPM test was the correct one to use despite it measuring non-verbal intelligence and being considered one the best measures of **g.** A suggestion for further research is to consider used Cattell's Culture Fair Intelligence Test.

Administration of the test was problematic due to a lack of a uniform testing environment for all participants of the study. In order to gather the data in a timely manner, the researcher administered the test to some participants in their homes and therefore not always under standard conditions despite the heartiest efforts to do so: certain factors were merely outside of the researcher's control. Administering the test in the participants' homes, though, had both unexpected positive and negative influences. The younger participants certainly felt less threatened and more relaxed by the process of answering questions for an unfamiliar person in the familiar surrounding of their own home. Familiar surroundings had a calming and positive effect which allowed the participants to focus on answering the test to the best of their ability without being distracted. In some instances, however, the presence of a parent during the test (i.e. the parent being somewhere around the house and entering the room once in a while) had an adverse effect on the children's true reflection of their own work. For example, one parent noticed that her youngest daughter was struggling to answer a series of questions correctly; the mother interjected with an explanation of the matrix when the intent was for her daughter to gain an understanding and attempt an answer on her own. Some parents tended to enter and exit the testing room and look over their children's shoulders and if on that particular question, the child had answered incorrectly, the parent would say, "take your time" whereupon the child began questioning herself on the correctness of her answers to questions thereafter. This concern became apparent after the first couple of families had been tested; resultantly, the researcher strongly advised the parents to remain away from the testing room for the duration of the test. This occurrence might have swayed the answers to some questions for some participants. The testing times of participants differed throughout the participant pool: some participants were tested on school premises, directly after school hours and others that were tested at home were tested in the late afternoon or early evening. Although the most suitable time was individually arranged with each family in order to avoid fatigue and low motivation levels, this does not eradicate the possibility that some children were

indeed tired, especially younger children. More generally on the time of testing, data collection corresponded with the end of the first school term at all three private schools, immediately prior to a month long holiday. Children might not have been as motivated to perform their best on a test which they had to write during their holidays or at the time when they were thinking about breaking from school. A suggestion for future studies which encompass school going children is to avoid the periods right before school holiday, preferably testing in the middle of the term when the children are in the mindset of test taking. The likelihood of parents volunteering their children to participate is also greater and might have, in this instance, contributed in a larger sample size.

Similarly, more consideration should also have been given to the effects of sibling presence on one another's performance. Certain children were deliberately placed in the same or separate rooms based on the information provided by the parents. For example, one mother said, "the younger daughter gets intimidated when she sees her elder sister finish a project and therefore rushes through her work to catch up". Unfortunately, this information was only obtained if volunteered by the parent otherwise it could not be accommodated for by the researcher at the time of the testing. A suggestion for future research, if it needs to be carried out in the homes of participants, is to standardize the test administration mode.

The testing sample was not large enough to have enough power as although there were 37 families and 73 participants, once the participants were grouped for their respective analyses, their individual sample sizes were smaller than 30. Time was a factor in the end size of the sample as the number of families could have been higher if the researcher had more time to test the additional ten families of two girls that were turned away and to find time and the means to recruit additional single daughter and three daughter families.

Testing families where the extended family members such as aunts, uncles and grandparents do not live in the same household as the nuclear family was presumed to control for additional stimuli available to children over others that do have this benefit. However, eliciting this information via the Family Background Questionnaire and selecting families living independently of extended family members didn't control for this factor despite appearing to be so. Just because someone doesn't live with the family does not mean that they do not spend a substantial amount of time

with them: a first-generation, immigrant family would not have the same interaction with its extended family as a 'born-and-bred' South African family would. The extent of peripheral, non-immediate, family size inadvertently increases the availability of role models, helpers, teachers, play mates of the same age that can act as a sister or brother, certain physical resources such as presents at birthdays and holidays, and time as uncles, aunts and grandparents talk and play with the children. An increased circle of support and resources could distort the effect of birth order, purely on its own. A possible way of controlling for this factor would be to select families which have immigrated into South Africa without their relatives.

The question concerning parental occupation needs further examination in its implication in that some professions require more on the job time than others irrespective of remuneration. This question was asked of the parents to ascertain the level of education attained by the parents and to a lesser extent, the socioeconomic status. Certain professions and/or occupations might impinge on the time available for the children and the family. Perhaps one of the items on the Family Background Questionnaire should have been, "how many hours, on average, do you spend in your home per day?", or even more directly, "how many hours, on average, do you spend with your children?" or "are you frequently away from your home (and for how long, if so)?" A question presently on the Family Background Questionnaire read, "Has any member of your family lived apart from your family for longer than 2 years?" hinted at this concern although the question should have been phrased to elicit how much the amount of daily time the parents spend with their children. Similarly, the question regarding household staff can be used to extrapolate the amount of time that is 'available' for parents to perform parental duties other than cleaning, clearing up and preparing for the family. The analysis of hired help shows that all families had a similar amount of time available for activities directly involving their children; this however, does not guarantee that the time was actually spent with the children. Research on different socioeconomic status families should be conducted as well.

While controlling for the age gap between consecutive siblings to be no greater than five years in order to give the teaching function an opportunity to occur, the possibility of negative consequence of close sibling spacing was not considered. Although a maximum age gap was imposed it was equally important to stipulate a minimum age gap difference between the siblings in order to

eradicate the effects of close spacing. If a child was not more than five years older than their younger sister, this does not mean that the older sister was not just one year older than her sibling. In order to avoid negative effects of close sibling spacing and to sustain the possibility of the teaching function the minimum and maximum age gaps between consecutive children should have been three and five years, respectively. This stipulation would have made sampling that much more challenging, however, the recommendation is that future studies allow adequate time to locate families with children matching these criteria.

Theoretical Implications

Of the two research questions in this study, the results of which were either non-significant, portraying no noteworthy mean trends across the birth orders or significant for family-size effects for the second born children, contribute to the genetic intelligence research and intelligence research in different ways. What the two results considered together imply is also important to consider.

The results of birth order analysis on **g** levels indicated no significant differences between individuals of the same family. The non-shared environment was thought to be differential between children of different birth order but was in fact not significantly different as determined by no differences in **g** levels. This, therefore, simultaneously implies that **g** within a family does not vary significantly and that the influences of non-shared environment even on IQ (which can be extrapolated by assessing the **g** score achieved on the RPM) cannot be effectively illustrated by assessing birth order. This study focused on encapsulating each individual's environment based on different birth orders without honing in on a particular aspect within the non-shared environment, assuming that a child's individual position would render a different experience of this environment. The findings of the study point to further investigation being needed on the interaction of the shared elements of a family and the resulting imparted non-shared influences on the family's members. However, as stated earlier, a study of similar nature should be redone with a larger sample size prior to disregarding birth order effects altogether.

The two models that claim to explain influences on individual family members have been shown to be short-sighted in that results did not follow the exemplified pattern and that only one potential

effect (the teaching function) was represented. The results imply that there are other effects at play that might work in opposition to the teaching function that have not been acknowledged. This research postulates those to be the *effects* of being taught and of being a bystander to the other familial interactions and relationships. There is currently no research which recognizes the possibility of other effects within a family such as these, and particularly not so to isolate or explore these effects when there is evidence (through non-significant results) of the possibility of its impact on the non-shared environment. The findings therefore hold implications for the Confluence and resource Dilution Models. They don't support the models or alternatively suggest that effects cancel each other out.

The one significant result for family size supports both models in principle however. This result indicates that **g** levels may be influenced by a within-family environment created by the effect of the family size. In other words, the non-shared environment within a family is receptive to the size of the family; different sized families might have significantly different non-shared environments available to each of the individuals within the family, so much so that it can influence **g** levels. However, because there was no significant result between the first born groups, this shows that the effect of family size differs for individuals within a family, it being very influential for the second borns, in this case. The possibility of non uniformity of this effect should be examined further.

A consideration of what the two findings imply together might actually lead us in a direction for future research. Since birth order does not create an environment necessary to cause differences in **g** ability (although showing interesting trends) and the size of the family does, perhaps birth-order effects only kick in when the family is of a certain size. This study's largest family unit was five and considering that the significant and most interesting observations occurred for the later borns of larger families, we should direct research of such effects to within larger families rather than small.

CONCLUSION

The study of intelligence is a very complex field with many inter-tangled effects and influencers. The non-significant finding for birth order does not support the Confluence and Resource Dilution Models nor do they support the numerous studies who found significant IQ-birth order effects. More importantly for general cognitive ability understanding, the lack of significant findings suggests a rethink on how we perceive the non-shared environment and how we test for it. The fact that there were both non significant results for birth order and a significant one for family size indicates that certain effects might be canceling each other out at the family level. This finding suggests Jensen to be incorrect in his assumption of the non-shared influence and affirms the possibility that any differences could be largely attributed to genetics.

Significant family size effects in the form of the second born children indicate that it is better to be born second in a smaller rather than larger family. In this context, the Confluence Model is supported but only under certain circumstances. The Resource Dilution Model proved inadequate in explaining advantage imparted in families of middle to upper social standing. The third born daughters had no comparative measure for family size but showed a high mean which, added to the fact that the second born of two girls performed the best, insinuates that last borns, despite family size, might have an advantage in larger families compared to other siblings. This, however, needs more empirical evidence and research attention.

Numerous studies have examined the presence of an underlying factor in IQ tests – **g** – although none have undertaken to examine **g** on its own in relation to another factor that could simultaneously highlight a positive correlation with IQ. In that pursuit, this research report has initiated research on which parts of the environment play an influential factor in positively influencing the general cognitive ability of a person. Several possible avenues for further research emerged from this study which need to be examined in order to further develop the understanding of general intelligence, specifically, and the intelligence research field, in general.

REFERENCES

Bejar, I. I. (1981). Does nutrition cause intelligence? A reanalysis of the Cali experiment. *Intelligence, 5*, 49-68.

Baydar, N., Hyle, P., & Brookes – Gunn, J. (1997). A longitudinal study of the effects of the birth of a sibling during preschool and early grade school years. *Journal of Marriage and the Family, 59*, 957 – 965.

Blair, C., Gamson, D., Thorne, S. & Baker, D. (2005). Rising mean IQ: Cognitive demand of mathematics education for young children, population exposure to formal schooling and the neurobiology of the prefrontal cortex. *Intelligence, 33*, 93-106.

Blake, J. (1981). Family size and the quality of children. *Demography, 18,* 421-442.

Blake, J. (1989). *Family size and achievement*. Los Angeles: University of California Press.

Bronfenbrenner, U., & Ceci, S. J. (1994). Nature-nurture reconceptualized in development perspective: A bioecological model. *Psychological Bulletin, 101*(4), 568-586.

Burt, C.L. (1972). Inheritance of general intelligence. *American Psychologist*, 27, 175-190.

Carroll, J. B. (1993). Human cognitive abilities: A survey of factor analytic studies. Cambridge, U.K.: Cambridge University Press.

Cattell, R.B. (1987). *Intelligence: Its structure, growth and action.* New York: Elsevier Science Publication Company.

Colom, R. & Garcia-Lopez, O. (2003). Secular gains in fluid intelligence: Evidence from the Culture Fair Intelligence Test. *Journal of Biosocial Science, 35,* 33-39.

Colom, R., Juan-Espinosa, M., Abad, F. & Garcia, L. F. (2000). Negligence sex differences in general intelligence. *Intelligence, 28*(1), 57-68.

Colom, R., Juan-Espinosa, & Garcia, L. F. (2001). The secular increase in test scores is a Jensen effect. *Personality and Individual Differences, 30,* 553-559.

Colom, R., Lluis-Font, J. & Andres-Pueyo, A. (2005). The generational intelligence gains are caused by decreasing variance in the lower half of the distribution: Supporting evidence for the nutrition hypothesis. *Intelligence, 33*, 83-91.

Colom, R. & Lynn, R. (2004). Testing the developmental theory of sex differences in intelligence on 12-18 year olds. *Personality and Individual Differences, 36,* 75-82.

Detterman, D. & Daniel, M. H. (1989). Correlations of mental tests with each other and with cognitive variables are highest for low IQ groups. *Intelligence, 13*, 349-359.

Dickens, W. T. & Flynn, J. R. (2001). Heritability estimates versus large environmental effects: The IQ paradox resolved. *Psychological Review, 2,* 346-369.

Dolph, E. A. J. (1966). A comparative study of the ordinal position of the child and his school achievement. Dissertation Abstract.

Downey, D. B. (1995). When bigger is not better: family size, parental resources, and children's educational performance. *American Sociological Review, 60*(5), 746-760.

Downey, D. B. (2001). Number of Siblings and Intellectual Development. *American Psychologist, 56*(6/7), 497 – 504.

Duncan, J., Seitz, R. J., Kolodny, J, & Bor, D. (2000). A neural basis for general intelligence. *Science, 289,* 457-461.

Ernst, C. & Angst, J. (1983). *Birth order: Its influence of personality*. New York:Praeger

Finnie, R., Lascelles, E., Sweetman, A. (2005). Who goes? The direct and indirect effects of family background on access to post secondary education. Retrieved from Statistics Canada; retrieved on 1 February 2006.

Fischbein, S. (1980). IQ and social class. *Intelligence, 4,* 51-63.

Flynn, J, R. (1984). The mean IQ of Americans: Massive gains 1932 to 1978. *Psychological Bulletin, 95,* 29-51.

Flynn, J. R. (1987). Massive IQ gains in 14 nations: What IQ tests really measure. Psychological Bulletin, 101, 171-191.

Flynn, J. R. (1999). Searching for Justice: The Discovery of IQ Gains Over Time. *American Psychologist, 54,* 5 – 20.

Galbraith, R. C. (1982). Sibship spacing and intellectual development: A closer look at the confluence model. *Developmental Psychology, 18,* 151 – 173.

Gardner, H. (1993). *Multiple Intelligences.* New York: BasicBooks

Garlick, D. (2002). Understanding the nature of the general factor of intelligence: the role of individual differences in neural plasticity as an explanatory mechanism. *Psychological Review, 109*(1), 116-136.

Gottfriedson, L. (1998). Jensen, Jensenism and the sociology of intelligence. *Intelligence, 26*(3), 291-299.

Gottfriedson, L. (2001). Environments are "genetic" too. In Sternberg, R. J. & Grigorenko, E. L. (Eds), *Environmental effects on cognitive abilities*. Mahwah, NJ: Erlbaum.

Herrera, N. C., Zajonc, R. B., Wieczorkowska, G., & Cichomski, B. (2003). Beliefs about birth rank and their reflection in reality. *Journal of Personality and Social Psychology, 85*(1), 142-150.

Jensen, A. R. (1981). Raising the IQ: The Ramey and Haskins study. *Intelligence, 5,* 29-40.

Jensen, A. R. (1989). Raising IQ without increasing g? A review of the Milwaukee Project: Preventing mental retardation in children at risk. *Developmental Review, 9,* 234-258.

Jensen, A. R. (1998). *The **g** factor*. London: Praeger.

Johnson, W., Bouchard, T. J., Krueger, R. F., McGue, M. & Gottesman, I. I. (2004). Just one g: consistent results from three test batteries. *Intelligence, 32,* 95-107.

Kane, H. & Oakland, T. D. (2000). Secular declines in Spearman's g: Some evidence from the United States. *The Journal of Genetic Intelligence. 161,* 337-346.

Kline, P. (2000). *A Psychometrics Primer*. London: Free Association Books

Lynn, R. & Hampson, S. L. (1986). The rise of national intelligence: Evidence from Britain, Japan and the United States. *Personality and Individual Differences, 7,* 23-32.

Lynn, R. (1990). The role of nutrition in the secular increases in intelligence. *Personality and Individual Differences, 11*, 273-286.

Lynn, R. (1991). Does Spearman's **g** decline at high IQ levels? Some evidence from Scotland. *The Journal of Genetic Psychology*, *153*(2), 229-230.

Mahlberg, A. (1997). The rise in IQ scores. *American Psychologist, 52*, 71.

Moltz, D. A. (2001). The relationship code: Deciphering genetic and social influences on adolescent development. *Journal of Marital and Family Therapy*, *27*, 137-139.

Neisser, U. (Ed.). (1998). *The Rising Curve: Long term gains in IQ and related measures*. Washington, DC: American Psychological Association.

Nyborg, H. (Ed.). (2003*). The scientific study of general intelligence: Tribute to Arthur R. Jensen*. Oxford: Pergamon.

Owen, K. (1992). The suitability of Raven Standard Progressive Matrices for various groups in South Africa. Personality and Individual Differences, 13, 149-159.

Pedersen, N. L., Plomin, R. & McClearn, G. E. (1994). Is there G beyond **g**? Is there genetic influence on specific cognitive ability independent on of genetic influence on general cognitive ability? *Intelligence, 18,* 133-143.

Petrill, S. A. & Deater-Deckard, K. (2004). The heritability of general cognitive ability: A within family adoption design. *Intelligence, 32,* 402-409.

Plomin, R & Bergman, C. S. (1991). The nature of nurture: Genetic influences on 'environmental' measures. *Behavioural and Brain Sciences, 14,* 373-387.

Powell, B., & Steelman, L. C. (1995). The educational benefits of being spaced out: Sibship density and educational progress. *American Sociological Review, 58,* 367 – 381.

Raven, J., & Raven, J. C., & Court, J. H. (1998a).*Manual for Raven's Progressive Matrices and Vocabulary Scales (Section 1).* Oxford: Oxford Psychologists Press.

Raven, J., & Raven, J. C., & Court, J. H. (1998b).*Manual for Standard Progressive Matrices (Section 3).* Oxford: Oxford Psychologists Press.

Raven, J., & Raven, J. C., & Court, J. H. (2000).*Manual for Coloured Progressive Matrices (Section 2).* Oxford: Oxford Psychologists Press.

Retherford, R. D. & Sewell, W. H. (1991). Birth order and intelligence: Further tests of the Confluence Model. *American Sociological Review, 65,* 141-158.

Richter, L. (2006). *Investment choices for vulnerable children.* Durban: University of Natal, Centre for Social and Development Studies.

Rodgers, J. L. (1988). Birth Order, SAT, and Confluence: Spurious correlations and no causality. *American Psychologist, 43*, 476 – 478.

Rodgers, J. L. (1999). A critique of the Flynn Effect: Massive IQ gains, methodological artifacts or both? *Intelligence 26*(4), 337-356.

Rushton, J. P. (1999). Secular gains in IQ not related to the g factor and inbreeding depression unlike Black-White differences: A reply to Flynn. *Personality and Individual Differences 26,* 381-389.

Rushton, J. P., Gewer, A. & Khunou, D. (2002). Effects of mediated learning experience on Raven's matrices scores of African and non-African university students in South Africa. *Intelligence, 30* (3), 221-230.

Rushton, J. P., & Skye. M. (2000). Performance on Raven's matrices by African and white university students in South Africa. *Intelligence, 28*(4), 251-258.

Rushton, J. P., Skye. M., & Fridjhon, P. (2002). Jensen Effects among African, Indian and White engineering students in South Africa on Raven's Standard Progressive Matrices. *Intelligence, 30* (5), 409 – 418.

Schaie, K. W. (1994). The course of adult intellectual development. *American Psychologist, 49,* 304-313.

Schooler, C. (1998). Environmental complexity and the Flynn Effect. In U. Neisser (Ed). *The Rising Curve: Long term gains in IQ and related measures* (p.67-79). Washington DC: American Psychological Association.

Spearman, C. (1927). *The Abilities of Man*. New York: The Macmillan Company.

Spearman, C., & Jones, W. (1951). *Human Ability*. London: Macmillan & Co. Ltd.

Sternberg, R. J. (1990). *Handbook of Human Intelligence*. New York: Cambridge University Press.

Sternberg, R. J., & Grigorenko, E. L. (1997). Intelligence, heredity and environment. Cambridge: Cambridge University Press.

Sternberg, R. J., & Grigorenko, E. L. (2002). *The general factor of intelligence: how general is it?* New Jersey: Lawrence Erlbaum Associates.

Stoolmiller, M. (1999). Implications of the restricted range of family environments estimates of heritability and non-shared environment in behaviour-genetic adoption studies. *Psychological Bulletin, 125*(4), 392-409.

Taub, G. E., Hayes, B. G. (2000). Identifying g: The current role of intelligence. *The International Journal of Sociology and Social Policy, 20,* 39-51.

Teasdale, T. W. & Owen, D. R. (1989). Continuing secular increases in intelligence and a stable prevalence of high intelligence levels. *Intelligence, 13,* 255-262.

Turkheimer, E., Haley, A., Waldron, M., D'Onofrio, B., & Gottesman, I. I. (2003). Socioeconomic status modifies heritability of IQ in young children. *Psychological Science, 14,* 623 – 641.

van der Sluis, S., Posthuma, D., Dolan, C. V., de Geus, E. J. C., Colom, R., Boomsma, D. I. (2006). Sex difference on the Dutch WAIS-III. *Intelligence, 34*, 273-289.

Vernon, P. A. (1998). From the cognitive to the biological: A sketch of Arthur Jensen's contribution to the study of **g.** *Intelligence, 26*(3), 267-272.

Wicherts, J. M., Dolan, C. V., Hessen, D. J., Oosterveld, P., van Baal, G. C., Boomsma, D. I., & Span, M. M. (2004) *Intelligence, 32*, 509-537.

Wolf, A. (1967). First born and last born: A critique. *Journal of Individual Psychology, 21*,159-165.

Zajonc, R. B, Mullaly, P. R. (1997). Birth order: Reconciling conflicting effects. *American Psychologist, 52*(7), 685-699.

Zajonc, R. B. (2001). The Family Dynamics of Intellectual Development. *American Psychologist*, *56* (6/7), 490 – 496.