

**Effects of Family Configuration
on Cognitive Functions and Health
Across the Adult Life Span**

Sara Holmgren

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ABSTRACT

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This thesis examines whether childhood family configuration influences performance on cognitive functions and health in adulthood and old age. All studies examined participants in the Betula Prospective Cohort Study aged 35 to 85 years (Nilsson et al., 1997). Study I established whether there are reliable effects of sibship size and birth order in a large sample of participants in adulthood and old age. The results showed that the effects previously demonstrated in children and adolescents (e.g., Belmont & Marolla, 1973; Mercy & Steelman, 1982) have a long-lasting effect and can be demonstrated in an adult sample. These studies concluded that intelligence and executive functioning decreased as the sibship size increased. Birth order, in contrast, had only influenced executive functions and working memory: earlier born siblings performed at a higher level than later born siblings. Study II examined whether the effects of sibship size and birth order can be replicated and extended to episodic memory and whether the effects of family configuration are stable over a five-year interval. The results showed that early born siblings and siblings belonging to a smaller sibship size performed at a higher level and that these effects on both recall and recognition were stable over a five-year interval. Study III explored whether childhood family configuration influences chronic adult diseases (myocardial infarction and circulatory disorders, stroke, and hypertension). The overall results showed that being born in a large sibship is a risk factor for stroke, myocardial infarction /circulatory disorders, and hypertension in old age. The results also suggest that being born early in a sibship is a predictor of stroke.

Key words: sibship size, birth order, intelligence, executive functioning, episodic memory, health, diseases, adulthood, old age.

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"The three main terms for happiness in life are: something to accomplish, something to love, something to hope for." (Chalmers, 1956, p.113).

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Umeå, December, 2007

Sara Holmgren

LIST OF PAPERS

The present doctoral dissertation is based on following three articles, which will be referred to in the text by their Roman numerals:

- I Holmgren, S., Molander, B., & Nilsson, L.-G (2006). Intelligence and executive functioning in adult age: Effects of sibship size and birth order. *European Journal of Cognitive Psychology*, 18, 1, 138-158.
- II Holmgren, S., Molander, B., & Nilsson, L.-G (in press). Episodic Memory in Adult Age and Effects of Sibship size and Birth Order: Longitudinal data. *Journal of Adult Development*.
- III Nilsson, L.-G., Holmgren, S., Nilsson, E., Bergman, L.R., & Molander, B. (2007). Sibship size and birth order as predictors of heart-related diseases. Manuscript submitted for publication.

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INTRODUCTION

The way children are raised has been of interest for social and behavioural scientists for several years. Most scientists agree that environmental factors may be important for children's cognitive development (e.g., Bronfenbrenner, 1989; Bussey & Bandura, 1999; Erikson, 1963; Fischer & Bidell, 1998; Gibson & Pick, 2000; Siegler, 1998; Vygotsky, 1986).

Several scholars (e.g., Anastasi, 1956; Berbaum & Moreland, 1985; Brackbill & Nichols, 1982; Grotevant, Scarr, & Weinberg, 1977; Marjoribanks, 1978; Retherford & Sewell, 1991; Zajonc, 1975, 1976, 1986; Zajonc & Bargh, 1980; Zajonc & Markus, 1975) have been involved in exploring the relationship between the configuration of siblings (i.e., sibship size, birth order position, and spacing between children) and performance on various measures of intelligence. Findings indicate that younger siblings with many older siblings are generally impaired on tests of intelligence (e.g., Zajonc, 1986, 2001; Zajonc & Markus, 1975).

Some researchers state rather provocatively that the most consistent predictors of educational outcomes are due to sibship size (e.g., Blake, 1981, 1985, 1989; Downey, 1995; Powell & Steelman, 1993; Steelman 1985; Steelman & Powell, 1989). According to various measurements of intellectual skills and educational achievements, subjects with few siblings outperform subjects with many siblings (e.g., Blake, 1981, 1985, 1989; Downey, 1995; Powell & Steelman, 1993; Steelman 1985; Steelman & Powell, 1989).

Empirical support for the effect of sibship size and birth order has been obtained in a number of studies (e.g., Blau & Duncan, 1967; Downey, 2001; Kuo & Hauser, 1997; Markus & Zajonc, 1977; Mercy & Steelman, 1982; Zajonc, 2001; Zajonc & Markus, 1975). However, there are also several studies that have failed to reproduce this pattern (e.g., Guo & Van Wey, 1999; Retherford & Sewell, 1991; Steelman, 1985; Teachman, 1995; Wichman, Rodgers, & MacCallum, 2006). This inconsistency has led to a long-standing debate (e.g., Blake, 1981; Downey, 1995; Rodgers, 1984; Steelman, 1985; Zajonc, 2001) about the validity of earlier findings and about proper methods for approaching the study of effects of family size. At present, there are contradicting studies about family configuration. An overview of methods and findings of earlier conducted studies on family configuration will be presented in Table 1. These earlier studies will occur in the text as references as well.

This thesis examines whether the effects of childhood family configuration (sibship size and birth order) are true and remain to influence cognitive functions (intelligence, executive functions, and episodic memory) throughout the adult life span.

Several theories have been proposed to account for the effect of family configuration on intellectual development. The most cited studies are The Confluence Model, The Resource Dilution Theory, The Economic Resource Hypothesis, The Social Contact Hypothesis, and Genetic Legacy. The confluence model and the resource dilution theory have gained more momentum and received more attention by scientists. Therefore, the confluence model and the resource dilution theory will be described in more detail. Alternative theories will be mentioned more briefly. The content of these various theories will be described in Chapter “Theories of family configuration”.

In addition, this thesis explores the relationship between childhood family configuration and chronic adult diseases (myocardial infarction and circulatory disorders, stroke, and hypertension). The diseases and potential risk factors will be presented in Chapter “Family configuration and health”.

RESEARCH OBJECTIVES

The objectives of each study will be presented below. From now on, in order to simplify the presentation of the objectives, the first paper will be referred to as I, the second as II, and the third paper as III. The objectives within each paper will be listed as a, b, c, etc.

- Ia. There are no studies that systematically have examined whether sibling size and birth order (sibship size is defined as the total number of siblings, including adopted children in the same family. Birth order is defined as a child's birth position among the children in the family) influence intelligence, memory, and other cognitive functions across the adult life span; that is, studies have not examined these issues from young adult groups through elderly groups. The first study establishes whether there are reliable effects of sibship size and birth order in a large sample of participants in adulthood and old age. Results from such a study should be of potential interest for increased understanding of the influence of childhood factors on the cognitive life of adults and elderly persons.
- Ib. Previous research (e.g., Anastasi, 1956; Berbaum & Moreland, 1985; Brackbill & Nichols, 1982; Davis, Cahan, & Bashi, 1977; Grotevant, Scarr, & Weinberg, 1977; Guo & VanWey, 1999; Markus & Zajonc, 1977; Mercy & Steelman, 1982; Pfouts, 1980; Rodgers, 1984; Zajonc, Markus, & Markus, 1979) on family configuration has been based on intelligence tests or achievement tests; we will follow this tradition and use assessments of intelligence to measure family configuration. We use standardised tests assessing visuo-spatial (The Block Design Test of Wechsler Adult Intelligence Scale, WAIS; Wechsler, 1981) and verbal components (Word Comprehension Test, WAIS: Kaufman, Reynolds, & McLean, 1989; Wechsler, 1981) of intelligence.
- Ic. Another objective is to extend knowledge beyond mere intelligence. Executive functioning reflects general intellectual ability (Obonsawin et al., 2002) and is strongly involved in intellectual functioning. However, there is a call for knowledge about the relationship between executive functions and general intellectual ability and the concept of executive functions since it is under scrutiny (e.g., Bryan & Luszcz, 2001). In the present study, working memory and word fluency reflect executive functions. The present study may contribute with further understanding about the concept of executive functions.

- Id. In the present study, we attempt to control for possible confounding variables such as socioeconomic status (e.g., Blake, 1981; Downey, 2001) and health (e.g., Bäckman et al., 2004; Nilsson & Söderlund, 2001), and to control for possible interactions with the sex (e.g., Herlitz, Nilsson, & Bäckman, 1997) and age variables (e.g., Cornoldi, 2006).
- IIa. The second paper examines whether the effects of sibship size and birth order previously observed in assessments of intelligence and executive functions (e.g., Holmgren et al., 2006) can be replicated and extended to episodic memory. The objective is to explore whether sibship size and birth order will affect performance in recall and recognition in general, and, in particular, this study explores the stability of these measures across age groups (middle-age, young-old, and old-old).
- IIb. A longitudinal examination of effects of family configuration is performed and presented in the second paper. Longitudinal designs are unusual in sibship size and birth order studies, and they are not previously performed in such studies that examine life-span development. Other reasons for a longitudinal approach are to observe the intraindividual stability of family configuration and the advantage of less age-related impairment in contrast to a cross-sectional design (e.g., Rönnlund, Nyberg, Bäckman, & Nilsson, 2005).
- IIc. In the present study, we are interested in examining whether the age of the parents at the time of birth of the participants is a factor that must be considered in studies of family configuration, since it has been reported that the age of the parents at the time of the birth of their children have an effect on children's intelligence score (e.g., Malaspina et al., 2005).
- IIIa. In the third paper, the issue is whether family configuration influences the health variable. The objective is to establish the role of sibship size and birth order on chronic adult diseases (myocardial infarction and circulatory disorders, stroke, and hypertension). These kind of studies are largely lacking with the exception of previous studies examining other diseases such as asthma (e.g., Karmaus & Botezan, 2002).

BACKGROUND

Theories of family configuration

The confluence model

Several scientists (e.g., Belmont & Marolla, 1973; Markus & Zajonc, 1977; Zajonc, 1976, 2001; Zajonc & Marcus, 1975) found that earlier born children and children in smaller sibling groups outperformed children who were born later or who came from larger sibling groups. The only child performs only slightly better in comparison with the last child in a three-child family. The results also view a sharp drop for the last child within each family size. Zajonc and Markus (1975) initiated the confluence model to illustrate the negative correlation between family size and performance on various intelligence measures, the birth order effect, and birth intervals on these scores. This tendency was revealed by a large set of Dutch data (i.e., Belmont & Marolla, 1973). Belmont and Marolla (1973) observed that there was a relationship between birth order and intelligence scores, but they did not suggest underlying factors or processes to explain their results. The confluence model offers such an explanation and has been applied to other data sets (e.g., Berbaum & Moreland, 1980, 1985; Galbraith, 1982; Grotevant, Scarr, & Weinberg, 1977; Retherford & Sewell, 1991; Rodgers, 1984) to explain birth order patterns as well.

Most research about family configuration (i.e., sibship size, birth order, and child spacing) and cognitive performance has been guided by the confluence model. One explanation is the cleverness of the theory, its widespread appeal, and the praise the model has received (Galbraith, 1983; Steelman, 1985).

The confluence model is a theory that both explains underlying behavioural processes and offers a mathematical operationalization (Rodgers, 1984). Because the confluence model is based on a first-order difference equation, the model shows that each sibling is born into a weaker intellectual environment.

The intellectual environment varies with number of newborn children in the family. Each family member contributes to the average intelligence in the family, and therefore, the average intelligence is changing over time. Change may be due to the addition of a newborn or a family member moving out. The average intelligence depends on the number of children and the intervals between births (Markus & Zajonc, 1977; Zajonc, 2001; Zajonc & Markus, 1975). Zajonc (1986) suggests the following explanation:

The only child is surrounded mainly by adults, whereas the third of seven children is surrounded by intellectually

immature individuals, is exposed to a less extensive pool of words, and witnesses primarily how toddlers confront their world. (p.862).

Several scientists (e.g., Breland, 1974; Mascie-Taylor, 1980; Nisbet, 1953, 1953; Nisbet & Entwistle, 1967; Scott & Nisbet, 1955) note that verbal tests, in comparison with nonverbal tests, are more sensitive to the effects of family configuration. Reduction in parental attention due to the birth of more children may negatively influence verbal development (Mercy & Steelman, 1982). Zajonc (1975) even advised parents to have no more than two children if they were concerned with the intellectual growth of their children.

Research (e.g., Baydar, Greek, & Brooks-Gunn, 1997) has also shown that the arrivals of newborns have an effect on home environment. First-born children have been reported receiving more attention and verbal stimulation from their parents during infancy and throughout upbringing in comparison to later-born children. It is reasonable to believe that this interaction with adults may explain why the first-born is reported to learn to walk, talk, and read at an earlier age (Pfouts, 1980). Further research on family interaction (e.g., Irish, 1964) revealed that older siblings often informally teach their younger siblings.

The effect of time spent with friends has also been examined, and the results give further support for the confluence model. The data revealed that time spent with friends was negatively related to children's performance on intelligence tests (Mercy and Steelman, 1982). Other scientists (e.g., Allen & Feldman, 1973; Gartner, Kohler, & Riessman, 1971) have observed peer tutoring among children and concluded that the teaching process can benefit the tutor as well as the learner.

The teaching function is another important factor that must be considered in the confluence model. In addition to sibship size, birth order has been reported to have a positive effect on the development of intelligence. Most of the time first-born children score at a higher level on intellectual tests than later-born children; for this reason, we can talk about a birth-order factor. Older siblings can assume a "tutorial function" by answering questions and helping their younger siblings to solve problems. By doing so (i.e., learning by teaching and rehearsal) this activity will provide the older sibling with an intellectual advantage in form of verbal fluency and set the stage for a birth-order effect. The birth order is a critical factor because neither the youngest sibling nor the only child will have the opportunity to teach their siblings (Markus & Zajonc, 1977; Zajonc, 1976, 2001; Zajonc and Markus, 1975; Zajonc, Markus, and Markus, 1979). With this in mind, the confluence model expects a handicap for last born and only child with regards to the teaching function.

“A few years after the birth of his or her younger sibling, the first-born acquires a teaching function, and thus his or her rate of growth accelerates and eventually surpasses the rate of growth of the only child. At maturity, the first of two will have a higher intellectual level than the only child” (Zajonc, Markus, & Markus, 1979, p. 1333).

It is hypothesized that increasing family size decreases the average intellectual environment, whereas increasing age spacing between children increases the average intellectual environment. Birth order is mediated completely by the age spacing between siblings. A negative effect of birth order is expected with small spacing between children, whereas a positive effect is likely with large spacing between children (Galbraith, 1982). The confluence model assumes that longer birth intervals provide the older siblings with more time to mature, which leads to higher average intellectual performance (Markus & Zajonc, 1977).

By examining the interaction between a child and the younger sibling, Marjoribanks (1978) found that age spacing might influence how often the interaction occurs. Smaller age spacing between child and adjacent sibling benefits interaction in a teaching situation. However, the amount of teaching is associated only to the intelligence scores and to the verbal environment that is provided in the home.

Zajonc and collaborators (Markus & Zajonc, 1977; Zajonc, Markus, & Markus, 1979) did some modification of the confluence model by including the age of the participant at the test occasion. The child's age at the test occasion is an important variable concerning the family structure effect and may help explain why some data reveal a positive relationship between birth order and performance; however, other data reveal a negative effect or null effect. This is one possible reason for the discrepancy between various data sets (Zajonc, 2001). The confluence model supplies a solution to this birth order puzzle, which alternative explanation (e.g., SES, and cohort effects) cannot offer (Zajonc, Markus, & Markus, 1979). The age factor has to do with the positive effect of the teaching function. However, this effect is not viewed at birth because it grows at first less rapidly than the negative effect of increasing sibship. Zajonc expects a negative effect, or no influence of birth order at all for children younger than 11 ± 2 years, and a positive effect of birth order for older children. It is suggested that the quality of the environment is a vital factor in cognitive development, especially during the early stages of development in comparison with adolescence (Zajonc, 2001).

Steelman (1985) reviewed previously conducted studies in an attempt to investigate the intellectual consequences of sibship size and birth order. There is some evidence in this research literature against the predictions of the confluence model. Steelman suggests that scientists should use the confluence model as springboard and develop new models that might

explain the existing relationship better than the original one does. There are two choices when it comes to the confluence model; the first one is to reject the model as a consequence of evidence against it. The second choice is to accept the theory because no one has been able to make an appropriate test of the model. Zajonc (1983) strongly feels that longitudinal data on intact families is necessary in order to test the confluence model in a correct way. As a consequence, according to Steelman (1985), the confluence model is probably not testable because the data that are required are impractical and impossible to collect.

It is suggested by critics of the confluence model that the negative effect of birth order and family size on intelligence are, in fact, the tendency for parents with lower SES to have more children (Rodgers, 1988).

Zajonc and Marcus (1975) point out that the confluence model illustrates the importance of the environment on intellectual development of individuals. The authors acknowledge other factors not included in the model that contribute to the intellectual development as well, such as genetic background and other environmental processes (e.g., child rearing practices and unique experience). However, the authors consider birth order as a strictly environmental factor.

In sum, the core of the confluence model is that the intellectual level within the family provided by adults and children is crucial for the intellectual development of each child.

Resource dilution theory

The second theory is the resource dilution theory, which offers a simple resource explanation for declines in educational outcomes and in intellectual assessments. Most or all of the relationship found can be explained from the assumption that when the number of children in the family increases, the parents' resources decrease.

It is important to differentiate between basic parental resources that are important for survival (e.g., food, clothes, minimal supervision, and, of course, a place to live) and resources that enhance children's opportunities (e.g., one-to-one reading, hiring a math tutor, buying computers, and saving money for education) and therefore not essential for children's survival. However, surplus resources enhance children's opportunities (Downey, 2001). With regards to surplus resources it has been reported that children with many siblings, in contrast to children with few siblings, are not engaged in activities that enhance intelligence and they spend less time together with their parents (Steelman & Powell, 1989).

Dilution theorists also believe that some resources play a larger role than others, depending on periods in children's life. One such resource is parental attention—the most important resource when the children are

young—whereas money saved for education is more important when children are older (Downey, 2001).

Blake (1981) concluded that encouragement, attention, and interaction by parents are the most important factors. Parents cannot successfully eliminate the negative outcome sibsize has on treatments by offering their children cultural and physical advantages (settings). It has also been pointed out that close spacing of siblings leads to more competition between the siblings for similar parental resources (Downey, 2001).

Some authors (e.g., Ernst & Angst, 1983) believe that the inverse association between sibship size and educational achievement is an artefact and is in fact a function of socioeconomic status. Children from large families are disproportionately from groups with lower socioeconomic status. However, although sibship size is negatively related to social class, the effect of number of siblings remains strong even when socioeconomic status is controlled for (Downey, 1995).

The effect of number of siblings may vary across contexts because different societies play different roles in supporting the family. Studies that have reported a weak link between educational achievement and sibship size have often been conducted in communities with norms that support large families (Downey, 2001). The negative effect of sibship size may be counterbalanced if other adults (e.g., neighbours, coaches, teachers, and relatives) have a significant role in children's life.

Pong (1997) argued that the effect of siblings is weak in the case where the state supplements education in comparison to states that plays a minor role. In the latter case, the family will play a large role, and, as a consequence, sibship size will have a stronger effect on educational outcomes.

Of importance is that European and American systems of higher education differ regarding contribution from the family. In the American system, parental financial contributions for college expenses are expected, although the parental support is voluntary (Steelman & Powell, 1989).

A suggested functional form between sibship size and educational outcome is

$$\text{target child } (y) = 1/\text{number of children in the family } (x).$$

This relationship is believed to occur only between sibship size and strictly economic parental resources. Economic resources in comparison with interpersonal resources may be less readily explained. One explanation is that the parents can decide over their spare time and choose to quit exercising or reading when the second child is born (Downey, 2001).

A comparison between the confluence model and the resource dilution theory show that the two theories have in common the assumption that large families tend to bring about low-IQ children (Rodgers et al. 2000).

The resource dilution theory predicts a negative effect of sibship size as does the confluence model (Guo & VanWey, 1999); however, the confluence model does not propose an explanation regarding effects of sibship size on educational achievement merits separately from intellectual skills. However, the resource dilution model offers such an explanation: some parental resources affect intellectual skills, while other parental resources, such as money saved for college, influence educational achievement directly (Downey, 2001).

Because early born children receive more parental attention than later born children, the resource dilution model and the confluence model predict that early born children do not have to share parental resources until new siblings arrive (Downey, 2001). In contrast to the confluence model, the resource dilution model does not include a sib-socialization component. In other words, only children and last-borns are not handicapped by lack of siblings; they do not suffer from a teaching deficit. The parental dilution model implies nothing about possible birth order effects (Blake, 1981). The dilution theory concludes that children still continue to compete for parental attention (e.g., gifts, loans and inheritances) even after they moved out of the home (Downey, 2001).

According to Steelman and Powell (1989), the resource dilution theory has been used as an ad hoc explanation for the educational outcomes due to sibship size. Therefore, the theory is seldom tested directly. However, several studies note a negative effect of sibship size on financial arrangements (e.g., Steelman & Powell, 1989), intellectual performance (e.g., Blake, 1981; Marjoribanks, 1990), parental treatments and attention (e.g., Blake, 1981; Downey, 1995), and material resources (e.g., Downey, 1995). Blake (1981) reported that the only child performs equally well or slightly better in comparison with those from two-child families. The performance drops off starting with three-child family and beyond.

Clearly, the core of the resource dilution theory is that the availability of resources of parents decreases as sibship size increases.

Economic resources hypothesis

The economic resources hypothesis is a resource theory similar to resource dilution theory, but with an economic approach. The economic resources hypothesis is a theoretical explanation of the influence of family size on the per capita material resources that are distributed by the parents. The pattern observed is the decline in resources as the family increases in size (Steelman, 1985).

Found patterns of previous studies support the economic resources hypothesis since it has been reported that the negative influence of sibship size is either reduced or eliminated when the socioeconomic status of the family increases. Moreover, the curvilinear association between sibship size

and educational achievement reported by Olneck and Bills (1979) is further support for the hypothesis of economic resources. As the impact of family size diminishes, an economic explanation over a psychological one is suggested. It is also suggested that additional siblings generate less of a relative strain on the resources of larger families in contrast to smaller families. Additional siblings should not require the same amount of investment regarding items (e.g., toys, books), since younger siblings can inherit from older siblings (Steelman, 1985).

The theory agrees with data that shows that birth order has no effects, as the general tendency is that most families receive higher economic status by the time the youngest children are born. This tendency may counteract possible effect of initial advantage for first-born children. If resources were expected to be invariant over time, we would expect the early born child to have an intellectual advantage (Steelman, 1985).

Social contact hypothesis

The Social Contact Hypothesis is a resource theory similar to resource dilution theory, but with a different approach. The theory states that the size of the family determines the extent to which parents have the ability to interact with their own children and how much undivided attention they can give to their children (Steelman, 1985). Support for the social contact hypothesis is the fact that performance on verbal tests of intelligence is more affected by family size compared to non-verbal tests. There is some support that this effect may persist into adult life (Scott & Nisbet, 1955). This may not come as a surprise as the development of verbal skills occurs in a social context (Steelman, 1985). Several studies (Nisbet, 1953, 1953; Scott & Nisbet, 1955) were conducted to examine the role of parental contact regarding family size and intelligence. The authors concluded that some of the negative effect family size has on intelligence may be explained with the effect sibship size has on verbal development. According to Scott and Nisbet (1955), children are less stimulated to develop the use of words in large families. If this theory is accurate, a birth order effect is expected, as the first-born child and early born children will spend some uninterrupted time with their parents. However, because birth order effect is not found, the theory is undermined, unless one could argue that older siblings are as stimulating as adults when it comes to verbal interactions (Steelman, 1985).

The spokesmen for the social contact hypothesis argue that the curvilinear relationship found between sibship size and intelligence is evidence for this theory. The decline found in children's received attention and encouragement is related to sibship size according to a curvilinear function. One can explain this phenomenon by stating that one child receives all the attention and encouragement, two children split the attention, and each of three children receives one-third of the attention and

so on (Nisbet & Entwistle, 1967). However, Steelman (1985) points to the fact that two theories (social contact hypothesis and economic resources hypothesis) can use the same curvilinear pattern as support and argues for the need of alternative explanations.

Genetic legacy

Some scientists (e.g., Grotevant, Scarr, and Weinberg, 1977) suggest that the effect of sibship size depends on genetic legacy. The proposed explanation is that parents that have many children represent those less genetically fit regarding intelligence; therefore, these parents pass their weakness on to their children. Support for this theory is that adopted children are not influenced significantly, while biological children are influenced significantly by confluence factors (Steelman, 1985).

The theory behind all genetic models is the combination of the genetic contribution from the parent's pool of genes. According to Belmont and Marolla (1973), a genetic explanation of the birth order effect is unlikely. Another suggested explanation is biological where mothers may be less effective reproducers with increasing numbers of births. The prenatal environment theory (i.e., gestation effect) has been tested indirectly by Belmont, Stein, and Susser (1975); it received no support.

Table 1
Methods and Findings of Earlier Conducted Studies on Family Configuration

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Anastasi (1956)	Literature review.		Family size.	Intelligence Tests.	Observed association between family size and intelligence.
Bellmont & Marolla (1973)	386,114 men from the Netherlands participated. Age 19-year-olds.	Mean Raven class scores by family size and birth order.	Birth order, family size, and social class.	Raven scores.	Observed independent effects of birth order; family size on intellectual performance. Birth order effects consistent across social class. Family size effects not present in all classes.
Berglund, Eriksson, & Westerlund (2005)	524 boys and 495 girls' were selected from 37 healthcare centres in Uppsala. Age 18-month-olds.	One-way ANOVA, and stepwise regression.	Gender, birth order, SES, and child care.	Swedish Communicative Screening at 18 months (SCS18). Includes gestures, vocabulary comprehension and production.	Girls performed at a higher level than boys on vocabulary comprehension and vocabulary production, as well as first-born children in comparison with later-born children.
Berbaum & Moreland (1980)	Archival data set was used (Outhit, 1933). The data set included 51 families from USA and Canada. Median age 11 years.	Simulation techniques along with iterative nonlinear least-squares BMDP program.	The confluence model.	Observed mental ages. Army Alpha examination (12-year-olds and above), and the Stanford-Binet (children under 12-years).	The results viewed that the confluence model performs well and can be applied on individual level. The model explained 51% of the variance. <i>(Continues)</i>

Table 1
Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Berbaum & Moreland (1985)	Within-family data included 176 adopted children and 145 biological children. 4-year-olds to 22-year-olds (see Scarr & Weinberg, 1976). The median age was 7 years.	Nonlinear least –squares estimation procedures.	All children, biological children, adopted children, early adopted children and later adopted children.	Stanford-Binet IQ Scale (age four to seven), Wechsler IQ Scale (8-year-olds to 15-year-olds), and Wechsler adult IQ Scale (16-year-olds and above). Transformed IQ scores to mental age.	Strong evidence for the confluence model. Data from both biological and adopted children fit the model. A better fit for early-adopted children than for later adopted. Evidence for environmental influences of intellectual development.
Bjerkedal, Kristensen, Skjeret, & Brevik (2007)	252,799 Norwegian males, 18-19 years of age. Medical Births Registry of Norway and national registers.	Between- and within-family comparison (N = 63,951 adjacent sibling pairs). Linear regression analyses.	Mother's age, education, and marital status, spacing of births, father's income, region of residence, birth weight, and height at conscription.	Score of intellectual performance (i.e., military board examination).	The authors reported a negative effect of increasing birth order on measures of intelligence, regardless of between-family analysis or within-family analysis.
Blake (1981)	The University of Michigan study of 10 th -grade boys, <i>Youth in Transition</i> .	Schematic path diagram, Correlation matrix.	Predetermined variables are parent's education, sibsize, settings, parent's treatments, and child ability.	Sibsize, settings, parent's treatments, child ability, and grades. Examining effects on college plans.	Treatments have the most direct effect on college plans followed by ability. Sibsize has a negative effect on every variable in the model. <i>(Continues)</i>

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Brackbill & Nichols (1982)	Longitudinal data from the NINCDs Collaborative Perinatal Project (NCPPI). 53,000 4-year-olds and 7-year-olds participated.	Biserial correlations and multiple regression equations.	Examined father-absent, "single" twins, birth interval, only children, extra adult. Controlled for socioeconomic status (SES).	Assesses for ability: Stanford-Binet Intelligence Scale (4-year-olds) and the Wechsler Intelligence Scale (7-year-olds). Assess for achievement (i.e., reading, spelling, and arithmetic) was Wide Range Achievement Test (WRAT).	Ability: None of the examined hypothesis of the confluence model was confirmed. Achievement: Only children performed at a lower level than other firstborns. Effects of parity were less pronounced in children if there where long pregnancy intervals. This effect was not found in all groups.
Davis, Cahan & Bashi (1977)	Two groups of Israeli students participated: Students of Asian-African origin (N = 109304), and European-American origin (N = 82689). 14-year-olds.	The averages are plotted as a function of birth order and family size.	Birth order and family size. Examined the intellectual environment at birth by varying the values of parents' intellectual levels.	Standard achievement test (i.e., arithmetic computation and mathematical problem solving).	Achievement decreases as an effect of birth order when there are few family members, and increases with many family members due to external factors such as schooling. The findings cannot be explained with differences in size of birth intervals or developmental rate.

(Continues)

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Galbraith (1982)	10,298 students at Brigham Young University. Including complete data on 1200 sibling pairs.	Multiple regression analysis on individual scores (i.e., between-family) and regression analysis of sibling score differences (i.e., within-family).	Individual scores: Father's occupation and education, mother's education, birth year of child, family size, birth order position, and <i>M</i> spacing. Siblings: In addition to the above, younger sib's birth year, younger sib's birth order, child spacing, older sib's ACT score, and number of intervening sibs.	The American College Testing Program Examination (ACT). The differences between younger sib ACT and older sib ACT was the dependent variable in the within-family analysis.	Between-family: Significant but rather weak effect of family size, birth order position, and <i>M</i> spacing on ACT scores. Within-family: No effect of family size or child spacing on ACT scores. Increase in mother's education and/or improving occupation of fathers seems to reduce sibling differences. Longitudinal data reduce the effects of aggregated data. The explained variance of birth order and family size drops from 67% to 1%.
Grotevant, Scarr, & Weinberg (1977)	319 children and their parents participated.	Regression analysis.	The confluence model.	IQ scores.	The confluence model explained 2% of the variance. The results showed that the confluence model is inappropriate for individual data but is useful for population trends.
Guo & Van Wey (1999)	1702 youth from the National Longitudinal Survey of Youth (NLSY). Test occasions, year 1986 and 1992. 14-year-olds to 21-year-olds.	Conventional regression analyses, change models or fixed effect models (i.e., sibling analyses and repeated measures of the same individuals).	Sibship size. Change models control family effects (i.e., family SES, family genetic makeup, and intellectual environment.	Peabody Picture Vocabulary Test-Revised (PPVT), Reading Recognition Assessment of the Peabody Individual Achievement Test (PIAT-R), and the mathematics assessment of the Peabody Individual Achievement Test (PIAT-M).	Regression: A negative sibship size effect. Sibling analyses and repeated measures failed to reproduce such an effect. Conclusion: after controlling for additional family/environmental effects, genetic effect, child-specific effects, and the interactions between child and family effects, the effect of sibship size vanished.

(Continues)

Table 1
Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Kennett (1973)	144 Grade Nine students.	Analysis of variance.	Socio-economic status groups. Family size.	Henmon-Nelson Test.	The negative association found between family size and intelligence, may be influenced by SES, as the correlation vary from social class to social class.
Markus & Zajonc (1977)	Data from the Netherlands (1963-1966), and a data set from Scotland collected in 1947.	Average transformed score for simulated data based on the confluence model and actual data.	Birth order and family size.	Raven score (the Dutch data), and Stanford-Binet score (S.C.R.E).	The simulation of the confluence model achieves a close fit with national aggregate patterns on performance of intelligence measures. The model may function as an underlying model for other aggregate profiles.
Marjoribanks (1978)	500 Anglo- Australians (i.e., 260 boys and 240 girls). 11-year-olds and 12-year- olds.	Zero-order correlations and regression surfaces.	Birth order, sibsize, and age spacing. Social status was controlled for (i.e., calculated from father's occupation, father's education, and mother's education).	Raven Progressive Matrices Test assed intellectual ability. Class Achievement Tests included mathematics achievement, word knowledge and word comprehension. Other tests; parents' expectations for their children, and language environment of the home.	Significant birth order association with mathematics and word knowledge. Sibship size was not related to any measures. Age spacing at various birth-order positions is none significant. Birth order has a negative effect on intelligence, when age-spacing is less than seven years, after that it is reversed.

(Continues)

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Marjoribanks (1990)	900 Australian children (i.e., 450 boys and 450 girls) and their parents. The children were 11-year-olds.	Hierarchical regression models.	Number of children, birth order, children's intellectual ability (i.e., Raven's Progressive Matrices), and social status (i.e., parents' occupations and education).	Family educational resources: Parents' aspirational references and parents' press for achievement, individualism, independence, and interaction with their children.	Some of the analysis indicated tentative support for the resource dilution theory, although the overall results showed the possible complexity of the link between sibling variable and family educational resources.
Mercy & Steelman (1982)	7119 American children from Cycle II of the National Health Examination Survey. Sample: Children from unbroken homes, who have no experience of death of a sibling, or have had any addition of other adults than their parents in the household. 6-year-olds to 11-year-olds.	LISREL IV techniques.	Family income, parents' education, number of older siblings, number of younger siblings, preschool education, time spent variables (i.e., reading, time with friends, time alone) and number of activities.	Wechsler Vocabulary Subtest and Wechsler Block Design Subtest.	Number of older siblings has a negative significant effect on the vocabulary subtest, but is not significant linked to block design. The number of younger siblings was found to have an inversely effect on both subtests. The negative effect of number of siblings remained in the presence of socioeconomic controls. The number of younger siblings has the stronger impact on ability in comparison with number of older sibling.

(Continues)

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Retherford & Sewell (1991)	Wisconsin Longitudinal Survey data 1975 provided aggregate data, between-family data (N = 1015), and within-family data (N = 507 sibling pairs). Most participants were 16-year-olds.	Examined the mathematical form of the confluence theory with nonlinear least squares regression.	Family size and birth order. By using sibling pairs (i.e., have the same parents and grew up in the same home) genetic and environmental factors are controlled for.	Henmon-Nelson Test of Mental Ability and the Raven Test Scores.	None of the tests conducted to examine the confluence model confirms the very same model. An alternative analysis based on sibling pairs indexed by birth order reveals no birth order effects on intelligence.
Rodgers (1984)	906 children. Fels Research Institute, in Ohio. 7-year-olds to 13-year-olds. Longitudinal data.		Within-family mental age scores.	IQ Tests. The forms are equated into the metric of the Stanford-Binet.	A significant correlation between the scores and the prediction of the model was reported. However, it rejects the confluence model in favour of a simpler model that consistently fits the data better.
Rodgers (1988)	Comment on Zajonc's findings.				Birth order may be alias for SES. Zajonc's findings may be an effect of a relationship between SAT and SES. Within-family longitudinal data are recommended to test within-family processes.
Rodgers, Cleveland, van den Oord, & Rowe (2000)	NSLY data consisted of 1311 families with 1255 sibling pairs.	Between-family analysis and within-family analysis.			Between-family analysis revealed a negative link between birth order and performance. The within-family analysis viewed no sibling differences.

(Continues)

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Smith (1984)	4918 students. 6th-grade, 8th-grade, 10th-grade, and 12th-grade (see Smith, 1981).		Marital disruption, parental formal education and spacing of the adjacent younger siblings.	Self Reported School Grades.	The confluence model needs some revision. It's more adequate for white people than for black people. Grades have a negative relationship with numbers of siblings, although this is not true for black people.
Steelman (1985)	Literature review.		Reviewed studies.	The Confluence model.	The confluence model generally fails to explain differences in IQ- development. Recent studies do not support the predictions. Use the model as a point of departure and look at alternative explanations of the effect of siblings.
Teachman (1995)	505 senior - sophomore sibling pairs were selected from High School and Beyond (HSB). Critical file for this study was National Centre for Educational Statistics (NCES) 1982	A latent- variable structural equation model was conducted on within- family data.	Parental education and income, educational resources, sibship size, and parent- child interaction. Control of various sibling pairs.	Intellectual skills: Vocabulary test, Reading test, and Mathematics test.	Little variance was found for sibling pairs by sex and ordinal position (i.e., older brother-younger brother, older brother-younger sister etc.). Conclusion: Ordinal position of sibling is not linked to siblings' mental ability.
Velandia, Grandon, & Page (1978)	36,000 18-year-olds Columbians.		Family configuration variables (i.e., family size & birth order).	College Entrance Exam Scores included verbal aptitude, mathematical aptitude, and abstract reasoning.	Aggregated means: Family configuration variables explained 90% of the variation. Individual scores: The explained variance dropped to less than 1 percent, when the model was applied on individual scores.

(Continues)

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Wichman, Rodgers, & MacCallum (2006)	National Longitudinal Survey of Youth. 7-year-olds to 8- year-olds (N = 1902), and 13-year-olds to 14-year-olds (N = 1769).	Multilevel models and Nested data were used on within-family data.	First model included birth order, second model included cohorts (i.e., examined if birth order is consistent across age cohorts), and in the third model maternal age at birth was added.	Subtests (i.e., mathematics, reading recognition, and reading comprehension) of Peabody Individual Achievement Test (PIAT) assessed intelligence.	Significant birth order effect was received on all PIAT assess. Cohorts did not alter the significance. When added maternal age birth order became no significant. Conclusion: Birth order has no effect on intelligence. The birth order effect was confounded by factors that vary between families.
Zajonc (1976)	Dutch (19-year- olds), American (17-year-olds), French (6 to 14-year-olds), and Scottish (11-year- olds) samples were used.	Mean scores and S.D. units. Partial correlations.	Family size and birth order.	Raven (Dutch), National Merit Scholarship Qualification Test (American), I.Q. Gille (France), and Stanford-Binet (Scotland).	All samples: Decline in intellectual performance with increasing family size. Dutch and American samples: A decline in intelligence for later siblings. French sample: Performance increased for later siblings. Scottish sample: Viewed inconsistent birth order results. Conclusion: The inconsistent results may depend on child spacing.
Zajonc & Bargh (1980a)	12,597 SAT participants, selected from cohorts 1970-1971, 1973-1974, and 1976-1977.	Multiple regression analyses.	Birth order and family size.	Scholastic Aptitude Test (SAT scores) included verbal ability, quantitative ability, and combined.	Birth order and family size explained approximately 3% of the variance. The SAT scores viewed little variation with family configuration.

(Continues)

Table 1

Methods and Findings of Earlier Conducted Studies on Family Configuration (continued)

Author	Data	Statistics	Independent/ control variables	Dependent variables	Major findings
Zajonc & Bargh (1980b)	Six national data sets (i.e., Dutch, French, Scottish, American, Western Israeli, & Oriental Israeli survey). The total N was 1.5 million.	Re-parameterized model was used to simulate the mental patterns. Correlation coefficient and multiple regression analyses.	Predicted values of the confluence model. Factors of birth order and family size.	Mental scores such as Raven Progressive Matrices or National Merit Scholarship Qualification Test (NMSQT).	Birth order and family size explained 92 % of the variance (i.e., average $r^2 = .92$). All surveys linked intellectual performance to family configuration. The confluence model was able to accurate prediction.
Zajonc & Markus (1975)	The Belmont-Marolla results are reproduced.	A linear transformation.	Birth order, birth order squared, family size, and lastborns. SES was ruled out by Belmont & Marolla.	Raven Scores.	The confluence model explains the findings by Belmont & Marolla (i.e., large families are linked with lower intellectual performance, and intellectual performance decreases with birth order). The confluence model explained 97% of the variance.
Zajonc, Markus, & Markus (1979)	Literature review.		Birth order and family size.	Various measurements of intelligence (e.g., Raven, Stanford-Binet, Gille IQ), and abilities test (e.g., Primary Abilities Test).	The results of family size are consistent, showing a decline in scores with size. The pattern of results in the literature review concerning birth order are expected on the basis of the confluence model.

Methodological considerations

Previously reported conclusions about the link between family configurations and performance in various cognitive tasks are heavily debated, and different research designs have produced different results. With this in mind, a presentation of methodological problems and potential confounding variables within this domain will be discussed later.

Flaws in past studies

Several studies have examined the effects of birth order on cognitive performance (e.g., educational attainment, scores on educational achievement tests, and intelligence tests), but according to reviewers (e.g., Adams, 1972; Schooler, 1972; Steelman, 1985) previous studies are flawed, conceptually or methodologically. The major faults of earlier research are non-probability sampling (i.e., samples that are not representative of the population), selection bias, inadequate measurement of key variables, and lack of control of socioeconomic background or family structure (Retherford & Sewell, 1991).

Methodological debate

Some authors (e.g., Rodgers, Cleveland, Oord, & Rowe, 2000) question the relationship between birth order and intelligence and claim that the relationship is a methodological illusion due to the use of between-family data containing potential selection bias. For example, depending on the design, the selection bias may be related to socioeconomic conditions, race, region of the country, or family structure (i.e., sibship size, and birth order).

Studies that have used between-family data (e.g., Anastasi, 1956; Bellmont & Marolla, 1973; Berglund, Eriksson, & Westerlund, 2005; Blake, 1981; Zajonc, 1976; Zajonc & Bargh, 1980) have reported an association between sibship size, birth order, and behavioural outcomes, while studies using within-family data (e.g., Galbraith, 1982; Records et al., 1969; Retherford & Sewell, 1991; Rodgers et al., 2000; Wichman, Rodgers, & MacCallum, 2006) have found only a weak association or no association at all, with some exceptions (e.g., Berbaum & Moreland, 1985; Bjerkedal, Kristensen, Skjeret, & Brevik, 2007). This discrepancy has led to a debate that is still not settled although it has been discussed intensely (e.g., Armor, 2001; Downey, 2001; Rodgers, 2001; Rodgers, Cleveland, van den Oord, & Rowe, 2001; Zajonc, 2001; Rodgers, 2001).

According to Steelman and Powell (1989), intra-familial data offer a more rigorous test for examining birth order effects than interfamilial data. However, some authors (e.g., Zajonc, 2001) disagree with spokesmen for

within-family data with the argument that if the families are compared at the same time, birth order will be confounded with age effects. An advantage of using between-family data is that aggregated effects are easier revealed than in within-family data. If a within-family analysis is to be conducted, a longitudinal approach with control for time period effects is necessary. One advantage of using within-family designs is that variations in social class, sibship size, and parental personality will be reduced. However, although this design provides methodological advantages, it may not be more proper to use than a between-family design (Michalski & Shackelford, 2001). The argument behind this statement is that additional confounds (i.e., within-family changes over time may be social status) may occur in within-family designs as well. As stated by Wichman, Rodgers, and MacCallum (2006), there are many potential threats to studies of siblings, such as within-family influences (e.g., birth order, and SES over time) and between-family influences (e.g., mother's intelligence, parental disciplinary style, and quality of schools).

Guo and VanWey (1999) note that siblings do share family economic resources and are exposed to a similar intellectual climate in the family, but siblings also share neighbourhoods and similar schools. Guo and VanWey controlled for parental genetic effects instead of controlling for genetic effects shared among siblings, because they believed that it is the former type of effects that correlate with family size.

Confounded variables in between-family data

In this chapter, I have focused only on potential between-family confounders as the present thesis is based on such data (see Chapter "The Betula Prospective Cohort Study").

Family size

If birth order was calculated across families of all sizes, then family size is a possible confounder. In other words, "the mean for second-born children was based on second borns of families having two or more children, the mean for third-born children was based on families with three or more children, and so on" (Berbaum, Markus, & Zajonc, 1982, p. 178). This type of confounding variable may be the reason why the patterns of sibling differences are stronger in the between-family data as compared to within-family data reported in earlier conducted studies (e.g., Record, McKeown, & Edwards, 1969).

Some researchers (e.g., Rodgers, Cleveland, Oord, & Rowe, 2000) consider birth order as a within-family measure. If birth order is examined with cross-sectional samples, it operates as a proxy for between-family variables (e.g., SES, educational level, nutritional quality, maternal age) and

relationships between birth order and IQ. Family size, on the contrary, is considered as a between-family measure.

Socioeconomic status and health

There are several other authors (e.g., Blake, 1981, 1989; Downey, 2001; Rodgers, 1988; Zajonc, 1976) who have pointed out the existing link between lower socioeconomic status and families with many children, but socioeconomic status has also been connected with health. It is known that health and medical conditions (e.g., dementia, heart infarction, circulation disorders, stroke, hypertension, and diabetes) is related to life style and socioeconomic status, but it also influences cognitive performance (e.g., Bäckman et al., 2003, 2004; Lee et al., 2003; Nilsson & Söderlund, 2001; Stachran et al., 1997).

Parental age at the time of childbirth and birth weight

Another factor of interest to control for is parental age at time of birth of children. Malaspina et al. (2005) reported an independent effect of parental age on children's intelligence scores. They observed an inverted U-shaped relationship. Other scholars, such as Record, McKeown, and Edwards (1969), found a positive relationship between maternal age and children's intellectual progress, explaining this finding by stating that older women are more prepared emotionally, more educated, or more intelligent compared to younger mothers. Similarly, Wichman, Rodgers, and MacCallum (2006) believe it is important to control for mother's age at birth because it can influence sibship size and the conditions in the home. Therefore, maternal age can capture many between-family environmental factors that may influence children's intelligence. Paternal age is also associated with low birth weight. Risk factors for low birth weight (< 2500 grams) are first childbirth and teenage fathers (Lu, Sung, & Li, 2003). James (1969) reported that birth weight increases with birth order. In other words, a first-born child weighs less than second, and the second child weighs less than the third. This tendency disappears after the birth of the fifth child.

Children with low birth weights endure increased risk of developing diseases (e.g., type 2 diabetes, coronary heart disease, and osteoporosis) in adult life (Barker, 1998). Shenkin, Starr, and Deary (2004) reviewed literature on the association between normal birth weight (>2500 grams), over 2500 grams, and childhood intelligence. They found a small positive relationship between birth weight and intelligence even after controlling for confounders.

Women in the age of 30 are more likely to give birth to premature babies or give birth to children with low birth weight due to a decline in the condition of the eggs. It is even calculated that 90% of a woman's eggs are abnormal by the time women reach age 42 (Cnattingius, Berendes, & Forman, 1993; Gibbs, 2002).

Other environmental processes

Cognitive performance of children is also influenced by parents' expectations on their children and the language environment in the home (Marjoribanks, 1978). Variables predicting performance on American College Testing Program Examination (ACT) are father's occupation and education and mother's education. These variables produce a positive effect on performance, independent of sibship size and spacing between siblings (Galbraith, 1982). Education seems to provide the individual with tools (e.g., strategies and verbal skills) that leads to a direct influence on cognitive performance (Ceci, 1991).

THE BETULA PROSPECTIVE COHORT STUDY

In this thesis, the participants are from the Betula prospective cohort study. In 1988 Lars-Göran Nilsson, Department of Psychology, Umeå University, began the Betula project. The university town of Umeå, the centre of the study, is situated on the coast in northern Sweden. The town has 110.000 people and is known for its many birch trees. Because Betula means birch tree in Latin, this name was chosen for the project.

The Betula project studies health and memory in adulthood and old age (e.g., Nilsson, 1996). Other objectives are determining preclinical cognitive signs of dementia (e.g., Nilsson, 1999; Nilsson, Winblad, Adolfsson, Bucht, & Bäckman, 1992) and finding out risk factors for dementia (e.g., Nilsson et al., 2004). The final objective is to assess premorbid memory function in those cases where brain injuries occur during the course of the project (Nilsson et al. 1997).

Three test occasions of data collection (T1 = 1988-90, T2 = 1993-95, T3 = 1998-2000) were initially planned (Nilsson et al. (1997); however, an additional test occasion (T4) was completed between the 2003 and 2005. Currently, there are plans for another test occasion (T5) between 2008 and 2010.

Design

The Betula study increases the possibility to separate the effects of age, cohort, and time on cognitive functions. The design of the study allows for several types of analyses: cross-sequential, cohort-sequential, time-sequential, cross-sectional, and longitudinal. More importantly, the design allows for testing the reliability of data of independent samples.

The design used in the Betula study follows a model that has been developed by Schaie (1965, 1977).

An overview of the design is presented in Table 2, where information on age of participants at test occasion is provided, as well as birth-year of

participants, number of participants in each sample, and time of test occasion.

The design was initially planned to contain three independent samples (S1, S2, and S3) each containing 1000 participants. Each sample included 10 age cohorts that ranged from 35-40 year-olds to 80-85 year-olds, with 100 participants in each cohort (Nilsson et al., 1997).

In test wave three (T3), a fourth sample (S4) was added to the design. In (S4) two additional age cohorts (85 and 90) were included in the design. For these age groups, there were only 50 participants in each cohort due to various reasons (unwillingness to participate or failure to reach the criteria that was set for participation). Consequently, S4 consisted of 1100 participants. Due to the problems of recruiting older participants, the designed number of participants in sample five (S5) consisted of 50 participants in each of the age groups. Also, one 95 year-old group was added, making a total of 13 age groups in the S5 sample.

As shown in Table 2, the samples differ systematically regarding the age of the participants. The design makes it possible to compare age groups using cross-sectional analysis and to exclude potential cohort effects. The age of the participants in S1 and S2 at first test occasion ranged from 35 year-olds to 80 year-olds, and 40 year-olds to 85 year-olds, respectively. Participants in S3, S4, and S5 were at the same age as the participants in S1 when they were tested for the first time.

This design makes allows for longitudinal analyses with proper control for training effects. The participants in S1 have been tested four times (T1, T2, T3, and T4), while the participants of S2 have been tested twice (T2, and T3). Participants of S3 have participated on three occasions (T2, T3, and T4). The participants of S4 and S5 have only been engaged in the project once (T3 and T4, respectively). As shown in Table 2, there was a five-year interval between the test occasions for each participant. (See Nilsson et al. (1992) for a more complete description of how to compare different samples to achieve control of various factors).

Participants

The participants were 35 to 95 year-old men and women from Umeå and the surrounding community who were randomly selected from the population registry. Individuals with health-related problems—such as dementia, mental retardation, or sensory handicap—were removed from the study. Individuals who did not accept to participate, could not be reached, or missed the appointment were also excluded. A crucial factor for participation was the native language of the participants. Non-native speakers of Swedish speaking were also excluded from the study (Nilsson et al., 1997).

The generality of the samples was tested by comparing participants with the overall population. This was achieved by using information about the Swedish population characteristics (Statistiska centralbyrån, 1985). The demographic variables were gender, marital status, employment, education, income, and number of persons living in the household. Nilsson et al. (1997) reported that the analysis revealed no major differences between participants and the Swedish population in general. However, there were small differences regarding employment and income. Participants in the Betula study of age 40, 55, 65, and 70, were employed to a greater extent. It was also reported that the participants of age 70, 75, and 80 had a higher income compared to the overall population. The participants in the Betula study reported a higher level of formal education and a higher income as compared to the overall population; these differences may be because Umeå is a university town. A presentation of the characteristics of the participants (S1T1, S2T2, and S3T2) on which this thesis is based on is presented in Table 3.

Procedure of collecting health and memory measures

The participants were introduced to the Betula study by a posted letter and told that the main purpose of the project was to examine memory and health. Furthermore, the participants were told that by participating they would help increase knowledge about why some people perform at lower memory level with increasing age and how aspects of health, environment, and heritage affect memory functions.

The participants were later contacted over the phone to settle the first appointment with a nurse. The 1.5- to 2-hour meeting with the nurse included filling in questionnaires, health examination, and cognitive testing. An overview of the tests assessed by nurses is presented in Table 4.

Participants in the project received a questionnaire to complete before the meeting with the nurse. Included were questions about daily living activities, socioeconomic background, living, childhood (e.g., child diseases, type of place, paternal age at birth of participant, birth order of the participant, and number of siblings), medical treatments, history of family diseases, and memory difficulties

The next interview and recording addressed health condition and active daily status and a health examination (i.e., height, weight, vision, hearing, blood pressure, heart rate, blood and urinal samples) of the participant. Nurses also carried out some of the cognitive tests: Mini-Mental State Examination, a source memory test, and a word comprehension test.

At the end of the health examination session, the nurse left questionnaires for the participants to complete before the memory test session, which took place approximately one week later. Among these

questionnaires was Critical Life Events, which included questions that addressed status of work environment, economic status, family status, death in the family or severe diseases in the family, and status of friends the past five years.

During the memory test session, a wide range of processes and memory systems were tested (Table 5). The tests included short-term memory and long-term memory processing, semantic memory, episodic memory, priming, and attention. It was important that the tasks were embedded in extant theories of memory. The tasks should also be able to dissociate different memory functions in relation to age and be sensitive to memory deficit in old age. The test battery was deliberately biased toward episodic memory because in such tasks the magnitude of age-related deficits is typically most pronounced. The memory test session lasted 1.5-2 hours. For a more detailed description of the measurement of medical, social, and cognitive variables, see Nilsson et al. (1992) and Nilsson et al. (1997).

Table 2
Overview of the Design of the Betula Prospective Cohort Study

Time of test occasion	Sample	Age of participant at test occasion										Total n of participants
1988-1990 = T1	S1	35 ^{c3}	40 ^{c4}	45 ^{c5}	50 ^{c6}	55 ^{c7}	60 ^{c8}	65 ^{c9}	70 ^{c10}	75 ^{c11}	80 ^{c12}	1000
1993-1995 = T2	S1	40 ^{c3}	45 ^{c4}	50 ^{c5}	55 ^{c6}	60 ^{c7}	65 ^{c8}	70 ^{c9}	75 ^{c10}	80 ^{c11}	85 ^{c12}	1000
	S2	40 ^{c3}	45 ^{c4}	50 ^{c5}	55 ^{c6}	60 ^{c7}	65 ^{c8}	70 ^{c9}	75 ^{c10}	80 ^{c11}	85 ^{c12}	1000
	S3	35 ^{c2}	40 ^{c3}	45 ^{c4}	50 ^{c5}	55 ^{c6}	60 ^{c8}	65 ^{c9}	70 ^{c10}	75 ^{c11}	80 ^{c12}	1000
1998-2000 = T3	S1	45 ^{c3}	50 ^{c4}	55 ^{c5}	60 ^{c6}	65 ^{c7}	70 ^{c8}	75 ^{c9}	80 ^{c10}	85 ^{c11}	90 ^{c12}	1000
	S2	45 ^{c3}	50 ^{c4}	55 ^{c5}	60 ^{c6}	65 ^{c7}	70 ^{c8}	75 ^{c9}	80 ^{c10}	85 ^{c11}	90 ^{c12}	1000
	S3	40 ^{c2}	45 ^{c3}	50 ^{c4}	55 ^{c5}	60 ^{c6}	65 ^{c7}	70 ^{c8}	75 ^{c9}	80 ^{c10}	85 ^{c11}	1000
	S4	35 ^{c1}	40 ^{c2}	45 ^{c3}	50 ^{c4}	55 ^{c5}	60 ^{c6}	65 ^{c7}	70 ^{c8}	75 ^{c9}	80 ^{c10} 85 ^{c11} 90 ^{c12}	1100
2003-2005 = T4	S1	35 ^{c0}	40 ^{c1}	45 ^{c2}	50 ^{c3}	55 ^{c4}	60 ^{c5}	65 ^{c6}	70 ^{c7}	75 ^{c8}	80 ^{c9}	610
	S3	40 ^{c1}	45 ^{c2}	50 ^{c3}	55 ^{c4}	60 ^{c5}	65 ^{c6}	70 ^{c7}	75 ^{c8}	80 ^{c9}	85 ^{c10}	706
	S5	35 ^{c0}	40 ^{c1}	45 ^{c2}	50 ^{c3}	55 ^{c4}	60 ^{c5}	65 ^{c6}	70 ^{c7}	75 ^{c8}	80 ^{c9} 85 ^{c10} 90 ^{c11} 95 ^{c12}	613

Note. Year of birth: c0 = 1969, c1 = 1964, c2 = 1959, c3 = 1954, c4 = 1949, c5 = 1944, c6 = 1939, c7 = 1934, c8 = 1929, c9 = 1924, c10 = 1919, c11 = 1914, c12 = 1909. This table is a modified version based on Nilsson et al. (1997).

Table 3
Characteristics of Participants in Sample S1, S2, and S3

	S1			S2			S3		
	35-45	50-60	65-85	35-45	50-60	65-85	35-45	50-60	65-85
Age group									
<i>N</i>	299	296	393	285	285	376	194	280	436
% female	52	53.3	53.5	50	53.7	59.4	51	52	61.8
Age (years)									
<i>M</i>	40	55	72.5	40	55	72.5	42.5	55	74.3
<i>SD</i>	(4.01)	(4.01)	(5.60)	(4.09)	(4.09)	(5.59)	(2.51)	(4.09)	(6.83)
Education (years)									
<i>M</i>	13.4	9.4	7.8	13.2	10.7	7.8	13.6	10.7	7.6
<i>SD</i>	(3.53)	(3.47)	(3.03)	(3.01)	(3.85)	(3.41)	(3.09)	(3.76)	(4.73)
Sibship size									
<i>M</i>	3.4	4.6	5.7	3.4	4.1	5.7	3.4	4.2	5.7
<i>SD</i>	(1.87)	(2.65)	(3.24)	(1.83)	(2.57)	(6.41)	(1.58)	(2.59)	(3.11)
Birth order									
<i>M</i>	2.3	2.8	3.3	2.3	2.7	3.3	2.3	2.9	3.3
<i>SD</i>	(1.59)	(2.24)	(2.56)	(1.54)	(2.33)	(2.50)	(1.40)	(3.07)	(2.51)

Table 4

Overview of Tests Assessed by Nurses at T1, T2, and T3

	Test occasion 1	Test occasion 2	Test occasion 3
1	Form 1 "Social anamneses" (study I, II, III)	Form 1 "Social anamneses" (study I, II, III)	Form 1 "Social anamneses" (study I, II, III)
2	Form 2 "Social anamneses" (study III)	Form 2 "Social anamneses" (study III)	Word fragment completion 1
3	Mini-Mental-State	Mini-Mental-State	Form 2 "Social anamneses" (study III)
4	SRB: 1 (study I)	SRB: 1 (study I)	Mini-Mental-State
5	Katz ADL status	Katz ADL status	SRB:1 (study I)
6	Word fragment completion	Word fragment completion	Katz ADL status
7	Source recall of facts	Source recall of facts	Word fragment completion 2
8	Health examination	Form "Critical life events"	Hearing test "FMHT" *
9	Form "Critical life events"	Form "SPAQ" *	Odour test *
10	-	Health examination	CES-D scale *
11	-	-	Form "RTQ" smoking *
12	-	-	Health examination
13	-	-	Forms "women" *, "critical life events", and "TCI" *

Note. * A new test is included in the test battery since the last test occasion. Study refers to the studies in the present thesis.

Table 5
Overview of Cognitive Tests

Test order illustrated by figures		Test occasion	Study
1	Initiation of a later prospective memory test	T1-T4	-
2	Encoding of faces for a later recognition test	T1-T4	Study II
3	Encoding of names for a later recognition test	T1-T4	Study II
4	Encoding of sentences, first list (enacted/non-enacted)*	T1-T4	Study II
5	Immediate free recall of list of sentences presented in 4	T1-T4	Study II
6	Encoding of sentences, second list (enacted/non-enacted)*	T1-T4	Study II
7	Immediate free recall of list of sentences presented in 6	T1-T4	Study II
8	Cued recall of nouns in sentences with and without enactment, presented in 4 and 6	T1-T4	Study II
9	Stem completion of surnames presented in 3	T1-T4	-
10	Word fluency, letter A	T1-T4	Study I
11	Word fluency, letter M, five-letter words	T1-T4	-
12	Word fluency, letter B, professions	T1-T4	-
13	Word fluency, letter S, five-letter names of animals	T1-T4	-
14	Free-choice recognition (i.e., yes/no) of faces presented in 2	T1-T4	Study II
15	Forced-choice recognition (i.e., multiple-choice) of names that was presented in 3	T1-T4	Study II
16	Block design test	T1-T4	Study I
17	Free-choice recognition (i.e., yes/no) of nouns, presented in 4 and 6, with or without enactment	T1-T4	Study II
18	Cued recall (categories) of nouns in sentences presented in 4 and 6	T1-T4	Study II
19	Source recall of sentences (i.e., recall if it was an enactment or no enactment) presented in 4 and 6	T1-T4	-
20	Study of word-list (presented in 20-27). First condition: Full attention during encoding phase and retrieval phase (free recall of nouns)*	T1-T4	Study II

(Continues)

Table 5
Overview of Cognitive Tests (continued)

	Test order illustrated by figures	Test occasion	Study
21	Free recall of word-list presented in 20	T1-T4	Study II
22	Study of word-list. Second condition: Full attention during encoding phase, concurrent task during retrieval phase *	T1-T4	-
23	Free recall of word-list presented in 22	T1-T4	-
24	Study of word-list. Third condition: Concurrent task during encoding phase, full attention during retrieval phase *	T1-T4	Study I
25	Free recall of word-list presented in 24	T1-T4	Study I
26	Study of word-list. Fourth condition: Concurrent task during encoding phase and during retrieval phase *	T1-T4	-
27	Free recall of word-list presented in 26	T1-T4	-
28	Tower of Hanoi	T2-T3	-
29	Letter digit substitution test	T3-T4	-
30	Free recall of activities in whole session (i.e., task 1-30)	T1-T4	Study II
31	Prospective memory test, presented in 1	T1-T4	-
32	Extra memory test (S1T2; S1, S2, S3T3;S1S3,S5T4)	T2-T4	-

Note. * = Random assignment of list order. Study refers to the studies in the present thesis. T₁ = 1988-1990, T₂ = 1993-1995, T₃ = 1998-2000, T₄ = 2003-2005.

COGNITIVE FUNCTIONS

Memory

Declarative and non-declarative memory

When it comes to the mechanism of memory, studies of amnesia patients reveal strong evidence for a distinction between short-term memory (i.e., capacity-limited) and long-term memory (Squire, 1986). In this thesis I will emphasize long-term memory.

Declarative and non-declarative memories are two forms of long term memory. Declarative memory refers to a conscious act and includes factual knowledge and personal episodes. Non-declarative memory, on the other hand, refers to knowledge that does not require a conscious mind and that includes skills and habits, priming, classical condition, and non-associative learning. Declarative memory contains memory for words, scenes, faces, and stories. This kind of memory is tested in terms of recall and recognition (Squire, 1992). Declarative memory and non-declarative memory operate in different ways and depend on separate brain systems. Declarative memory depends on the hippocampus and related structures, whereas non-declarative is not (Squire, 1993).

In an attempt to learn more of the structure of memory, patients with different types of brain damage have been studied. Cohen and Squire (1980), Brooks and Baddely (1976), and Squire (1994) studied patients that suffered from severe damage on the medial temporal lobes. These studies revealed that patients performed at a normal level compared to healthy people regarding non-declarative memory, but they exhibited severe deficits concerning declarative memory. Amnesic patients are able to learn at a normal rate when it comes to motor skills, perceptuomotor skills, perceptual skills and cognitive skills, but they fail in tasks such as recall and recognition that depend on declarative memory (Squire, 1992). These studies give evidence of the existence of two forms of long-term memory, namely declarative memory and non-declarative memory. These two memory structures require different forms of knowledge.

Memory systems

There is a consensus among memory researchers (e.g., Tulving, 1985; Nyberg & Tulving, 1997) of the existence of multiple memory systems.

In 1985, Tulving argued that memory is composed of procedural memory, episodic memory, and semantic memory. Tulving's (1993) more recent classification of the multiple memory system is procedural memory,

perceptual representation system, semantic memory, primary memory, and episodic memory.

Episodic memory can be defined as a system that stores information of episodes or events; in contrast to semantic memory, it even stores the temporal and spatial relationship of that event (Tulving, 1985). This system can be tested in a laboratory setting by conducting miniature events, such as the appearance of words, word pairs, or items (Tulving, 1983). Other traditional tasks applied to the measurement of episodic memory are recall and recognition of sentences and faces (Lewin, Wolgers, & Herlitz, 2001).

By using language and organizing knowledge of the world, a person applies the semantic memory system. *Semantic memory* is knowledge of words, verbal symbols and their meanings, rules, and algorithms. The organisation of knowledge is timeless and can be classified as conceptual (Tulving, 1985).

The memory systems have different diagnostic features regarding information, organisation, operations, and even applications (Tulving, 1984). Hence these systems depend on each other and do not operate completely independent. Episodic memory depends on both procedural and semantic memory to operate, but semantic memory has the ability to function independently of episodic memory, although not of procedural memory (Tulving, 1985).

Episodic and semantic memory differs regarding operations. Episodic memory registers immediate experience and the temporal order of the occurrence of personal events. Retrieval of episodic memory concerns questions regarding events at a specific time and place. Semantic memory registers knowledge about objects, situations, and characteristics. This memory asks “what is”. Semantic memory is associated with the subject’s knowledge of its world. There is also a difference with respect to formal education where the aim is acquisition, retention of skills, and knowledge of the world. This aim is irrelevant for episodic memory. Semantic memory has a central position in human intelligence, while the episodic memory is unrelated (Tulving, 1985). The systems also differ from each other regarding different types of consciousness. Episodic memory is associated with self-knowing, which allows an individual to be aware of his or her own identity in time that extends from the past to the present and into the future.

Neurologically differentiation

Various correlative studies show that there is a neurologically differentiation between the episodic and semantic system (Nyberg et al., 2003). Activation of the right prefrontal cortex is linked with the episodic memory, in contrast to retrieval of semantic information, which is associated with higher activity in the left prefrontal cortex (Nyberg et al., 1996). However, it is suggested that the structures of medial temporal lobe (MTL) connect the components

of episodic and semantic memories. The specific components are represented in diverse neocortical sites (Squire, 1992). To be more specific, the hippocampus is especially associated with the episodic memory (Cabeza and Nyberg, 2000); while other studies (Dalla Barba et al., 1998) report that the left lateral temporal lobe is associated with the semantic memory system.

Using positron emission tomography (PET), researchers have found a relation between frontal lobes and episodic memory. The found patterns have been reviewed by Nyberg, Cabeza, & Tulving (1996). Regarding encoding of episodic information, the left prefrontal cortex is activated (Nyberg et al. 1996). Other scientists—Tulving, Kapur, Craik, Moscovitch, and Houle (1994)—have associated the left prefrontal cortex with encoding of episodic information and the right prefrontal cortex with retrieval of episodic memory. Much research regarding frontal lobes and episodic memory derive from cognitive neuropsychology, neuroimaging, developmental psychology, and clinical literature.

Other brain areas that are associated with memory are medial temporal (hippocampal) and diencephalic regions (Markowitch, 1995; Markowitch & Pritzel, 1985; Squire, 1987). Wheeler, Stuss, and Tulving (1997) point out that it is not known how these regions are connected to episodic memory processes. More knowledge about what extent the activity of medial temporal and diencephalic structures are involved in episodic memory (autonoetic awareness) is needed. However, it seems like the medial temporal lobes are crucial for the capacity to become noetically aware. Studies of patients with medial temporal damage show that they are grossly impaired regarding attempts to recall recent life episodes or learn new semantic facts.

However, Kramer et al. (2005) note that both the hippocampus and the frontal lobes contribute to episodic memory, although the contributions can be dissociated, where the hippocampus is of more importance for memory accuracy in recall and recognition and frontal structures are more important for the strategic processing and decision-making aspects of recall and recognition. It is worth noting that episodic memory resembles behaviours that require a higher level of control such as complex problem solving. Problem solving is often classified as supervisory or executive functions and requires adaptation to situational demands (Wheeler, Stuss, & Tulving, 1997).

Memory systems and gender

According to Nilsson (2003), the episodic memory system is unique in the sense that it is the only memory system where women perform at a higher level than men throughout the adult life span (e.g., Herlitz, Airaksinen, &

Nordström, 1999; Herlitz, Nilsson, & Bäckman, 1997; Maitland et al., 2004; Nilsson et al., 2004).

Herlitz, Airaksinen, and Nordström (1999) reported that women outperform men on most verbal episodic memory tasks. This cannot fully be explained by women's performance on verbal production tasks. Women outperform men on some episodic memory tasks with visuospatial components. Some authors (e.g., Berenbaum, Baxter, Seidenberg, & Hermann, 1997; Herlitz, Nilsson, & Bäckman, 1997; Schaie, & Willis, 1993) have reported that women outperform men on word recall. There are also reports of advantages for women regarding word recognition, recall of words (focused and divided attention), story recall, face and name recall and recognition, recall of subject performed tasks and real-life activities, spatial recall, picture recall, and odour recognition (for a review, see Herlitz, Airaksinen, & Nordström, 1999).

The study by Herlitz, Airaksinen, and Nordström (1999) found that women performed at a higher level than men in face recognition, recall of activities, and recall of newly acquired facts. According to this study memory performance is consistent across different materials as well as for encoding and retrieval conditions. The authors did not find any differences between men and women regarding tasks assessing semantic memory, primary memory, or priming.

Memory systems and aging

The separate memory systems function differently in normal aging. Mitchell (1989) points out that studies that reveal that the memory systems are affected differently by aging are support by the theory of separate memory systems. According to several authors (e.g., Mitchell, 1989; Naveh-Benjamin, Hussain, Guez, & Bar-on, 2003; Nilsson, 2003; Nyberg et al., 2003; Rönnlund, Nyberg, Bäckman, & Nilsson, 2003), episodic memory is unique for its sensitivity to aging (see also Craik & Jennings, 1992; Light, 1991).

Data show that there are clear age deficits in the episodic memory system that is not to be found in the semantic memory system. The age-related deficit is generally observed in older adults (Kausler, 1994; Smith, 1996). The results of Nyberg et al. (2003) showed that the age deficit was more pronounced for recall (highly sensitive for aging) than for recognition (less sensitive for aging). Other literature (Schonfield & Roberson, 1966) supports the finding that recognition memory remains relatively stable. The results of Nyberg et al. (2003) also showed that episodic memory is more sensitive to aging as compared to semantic memory. Studies of brain damage (e.g., Hirst, Johnson, Kim, Phelps, & Volpe, 1986) and brain imaging studies (Cabeza et al., 1997) support the division of recall and recognition. More importantly, the authors (Nyberg et al., 2003) found an

age deficit for the episodic memory that was more pronounced for recall than for recognition.

Several studies (e.g., Naveh-Benjamin, Hussain, Guez, & Bar-on, 2003; Naveh-Benjamin, Guez, Kilb & Reedy, 2004) support the associative-deficit hypothesis (ADH) developed by Naveh-Benjamin (2000). This theory states that poorer episodic memory in older adults depends on deficiency in making and retrieving links between units of information. Older adults perform better when connections already exist in memory between the components of the episodes that are used.

Cabeza, McIntosh, Tulving, Nyberg, and Grady (1997) studied age-related differences in encoding and recall; they found a lateralized pattern in young participants. However, activation and path analysis showed that this pattern does not hold in old age. One hypothesis is that the involvement of the left prefrontal area in old adults (during recall) may be a sign of functional reorganization.

Hertzog, Dixon, Hulstsch, and MacDonald (2003) reported that changes that occur in episodic memory were correlated with changes in speed and working memory. This result agrees with the processing resource theory that claims that age changes in complex cognitive performance are due to age changes in basic information processing capacities and other mechanisms that are of importance for executing complex cognitive operations (Salthouse, 1991). The results of Hertzog, Dixon, Hulstsch, and MacDonald (2003) support the processing resource theory.

Moreover, the results of Hertzog et al. (2003) agree with previous cross-sectional data because it was found that there was a correlate of changes in working memory with changes in episodic memory stronger than with changes in perceptual speed. Although these findings even suggest a stronger connection between processing of speed and memory changes than had been reported before, the authors point out that change in speed and working memory are not sufficient to account for episodic memory changes in aging. It is also suggested that there is a third resource that has a potential affect on age-related changes in memory, namely executive functions, including inhibition (Rönnlund, 2003).

Rodgers, Hertzog, and Fisk (2000), on the other hand, argued for an association between working memory and fluid intelligence. However, Hertzog et al. (2003) reported that working memory and fluid intelligence are differently affected by age-related changes (i.e., after age 55) and this result supports the theory of a distinction between working memory and fluid intelligence. The theory proposes that episodic memory changes are not affected by changes in fluid intelligence. Instead the theory emphasizes the importance of age changes in retrieval mechanisms for driving episodic memory changes. The debate about the relationship between working memory and fluid intelligence is further commented below in connection with the summary of Study I.

Working memory

According to Baddeley and Hitch (1974), working memory is not the same as short-term memory. Working memory as a concept replaced the traditional short-term memory. An important difference between these two is that short-term memory is viewed as a passive form of memory in contradiction to working memory that is viewed as an active form of memory. Working memory calculates and manipulates information. In short-term memory, the information can be either encoded into long-term memory or be forgotten (WAIS-III – WMS-III-technical manual, 1997).

One test of executive function in study I emanates from a series of tests to assess working memory. Working memory should be included because of the current debate about the relationship between working memory and intelligence (Ackerman, Beier, & Boyle, 2005; Beier & Ackerman, 2005; Kane, Hambrick, & Conway, 2005; Oberauer, Schulze, Wilhelm, & Süß, 2005). According to several authors (Borella, Carretti, & Mammarella, 2006; de Ribaupierre & Lecert, 2006; Wilhelm & Oberauer, 2006), working memory and intelligence are different but related concepts. Working memory is considered by some authors (Kyllonen & Christal, 1990) to be a critical component of intelligence because of the ability to store and manipulate information.

INTELLIGENCE

Traditional theories

Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings-“catching on,” “making sense” of things, or “figuring out” what to do. (Gottfredson, 1997, p. 13)

There are many alternative definitions and there are many alternative theories of intelligence (e.g., Binet & Simon, 1916; Carroll, 1993; Catell, 1971, 1987; Gardner, 1983, 1999, 2000; Spearman, 1927; Sternberg, 1985; Thurstone, 1938). Only the most influential theories and models will be mentioned in the following.

Early studies of intelligence have focused on identification of a single general factor, which is suggested to underlie performance on tests of mental abilities. Because various subtests of IQ test batteries were found to correlate positively, the view of a single factor theory was enhanced.

Spearman (1927), for example, suggested that intelligence can be explained by postulating a single general intelligence factor (g) and a set of specific factors.

Spearman reasoned that if the existence of a unitary cognitive ability (general intelligence or g) gives the individuals the ability to reason and solve problems, it would be possible to construct various problems to measure this ability. If the hypothesis is true, all correlations should be positive. Thus if an individual performs at a high level on one type of cognitive test, the individual should perform well on other types of tests. Later, Spearman found evidence for the existence of several specific factors such as verbal ability, visuo-spatial ability, and numerical ability.

Thurstone (1938), on the other hand, argued that intelligence cannot be explained with one single factor. Instead, Thurstone suggested that intelligence consists of seven factors: verbal comprehension, verbal fluency, inductive reasoning, spatial visualization, number, memory, and perceptual speed. Spearman and Thurstone both used factor analysis to examine which factors underlie intelligence.

Catell (1971) used a hierarchical model to determine a number of factors of intelligence. The author proposed that general intelligence consists of the sub-factors fluid ability and crystallized ability. Fluid ability is defined as accuracy of abstract reasoning and speed regarding novel problems, whereas crystallized ability measure knowledge and vocabulary. At first, the fluid-crystallized theory was used as an argument against the theory of general intelligence.

The most widely accepted psychometric model today is a hierarchy model comprising three strata and is developed by Carroll (1993). Stratum I includes specific abilities, such as spelling and speed of reasoning, while stratum II includes broad abilities, such as fluid intelligence and crystallized intelligence. In addition, there are learning and memory processes, visual perception, auditory perception, facile production of ideas, verbal fluency, and speed. Stratum III is equal to Spearman's " g ", just a single general intelligence.

Contrary to the theorists mentioned so far, Ackerman (1988, 2005) argues for an integrative approach that includes various models of cognitive functioning. These models are combined and they function as the basis for intelligence. Breadth of declarative knowledge, breadth of procedural skills, capacity of working memory, and speed of processing are sources that can explain individual differences. The assessments of intelligence most frequently used in schools today are based on the assumption of a unitary mental ability (a single factor) (Lubinski, 2004).

Fluid and crystallized intelligence

Fluid cognitive functioning (gf) is defined as a cognitive process that maintains information (i.e., verbal and visual-spatial) in working memory to plan and execute goal-directed behaviour (Baddely, 1986)

Fluid ability is measured by tests that have little scholastic or cultural content, because prior experience and knowledge are of little use for solving novel problems (Johnson & Gottesman, 2006). Tasks used to measure fluid intelligence is most often verbal tasks (e.g., Johnson & Gottesman, 2006) or tasks like Raven's Progressive Matrices, Number of Series, or Word Analogies (e.g., Garlick & Sejnowski, 2006).

Salthouse and Davis (2006) included WASI Matrix Reasoning Test and the WASI Block Design Test to assess fluid intelligence. However, according to Woodcock (1990), fluid skills are underrepresented in many widely used intelligence tests.

Fluid functioning is distinguishable from crystallized intelligence, although fluid functioning is important for encoding and retrieving crystallized knowledge. Crystallized intelligence (gc) is acquired knowledge available from the long-term memory store (Blair, 2006). It is referred to as combined knowledge that people obtain by education, culture, and experience (Johnson & Gottesman, 2006).

According to Henry and Phillips (2006), the Mill Hill Vocabulary Test (MHVT) is suitable to assess crystallized intelligence. The task requires that the participants identify synonymous word (i.e., choose between sex words closest in meaning to the target word) for each 30-target words. Another routinely used measurement to assess fluid intelligence is the Raven's Progressive Matrices (RPM). The participants are asked to solve 40 visually presented problems. The task was to choose between several possible solutions the correct solution to complete the pattern. Other measurements that can be used to assess crystallized intelligence are WASI Vocabulary Test, WASI Similarities Test (Salthouse & Davis, 2006), and WAIS (Ashton et al. 2001).

Aging and intelligence

According to the literature (Raven, 1948; Thurstone & Ackerson, 1929; Wohlwill, 1970; Anderson, 2005), the growth curve of mental performance always improves each year. In other words, intelligence develops with age. The growth curve is faster in childhood in comparison with adolescence where the growth curve slows down. However, it does not seem like this increase of improvement continues throughout the life span.

In cognitive aging, the distinction of fluid cognition and crystallized intelligence has been established due to the evidence that fluid cognition is affected by aging. One possible explanation is an alteration in the

neurobiology of the prefrontal cortex (PFC). In addition, the processing of information in the PFC may be less efficient. Crystallized intelligence shows greater stability compared to fluid cognition (Schaie, 1994).

Bugg, Zook, DeLosh, Davalos, and Davis (2006) observed age-related declines in fluid intelligence (i.e., block design, and matrix reasoning), speed of processing (i.e., simple reaction time tasks), and frontal function (i.e., Wisconsin Card Sorting Test). The authors concluded that the decline in fluid intelligence depends on general slowing and frontal decline. The authors speculate with support from the literature (e.g., Salthouse, 1991) that a decline in working memory ability may also contribute to the age effect on fluid intelligence. Losses of working memory capacity and speed influence problem solving (Diehl, Willis, & Schaie, 1995).

Several other scientists (e.g., Raven et al., 1987; Salthouse, 1991) have reported that fluid intelligence is affected by aging, with a decline in performance as a consequence. There is no consensus among scientists about the specific age of the decline, but it is suggested that there may be a slow decrease after age 40 (Salthouse, 1992, 1996, 2005). However, when crystallized intelligence is measured, as for example vocabulary, a significant age advantage is often found (e.g., Verhaeghen, 2003). It seems as if crystallized cognitive abilities increase all through the life span (Salthouse, 1992, 1996, 2005).

Gender and intelligence

According to Colom and García-López (2002), there is contradictory evidence regarding whether there is differences between the sexes in general intelligence. The authors define fluid intelligence as the core of intelligent behaviour and concluded there is no sex difference in fluid intelligence, although their results showed that females outperform males in the PMA reasoning test and that males performed at a higher level than females in the Raven test. Their conclusion was based on the fact that the data revealed no systematic difference, and, more importantly, that the Culture-Fair Test, according to the authors the finest available representation of fluid intelligence, did not reveal sex differences.

The results demonstrated that reasoning performance can be affected by the information content, where the use of a single verbal content, such as a series of letters, gives females an advantage over males. However, using a single figural content such as Raven gives males an advantage over females.

Genetic or environmental effects?

It has been a standing debate among scientists whether genetics (i.e., inherited DNA differences among individuals) or environmental factors are the major influence on intelligence. The nature-nurture pendulum has

swung back and forth among various influential scientists (e.g., William James and Francis Galton), the rediscovery of Mendel's laws, the emergence of behaviourism, and animal research (Plomin & Petrill, 1997), along with studies that examine the association between the genetic link between individuals and general intelligence (e.g., McGue et al., 1993; Rowe, 1999). These latter studies reported greater association genetics and IQ (e.g., McGue et al., 1993; Rowe, 1999). Bouchard and McGue (1981) reported a correlation between genetics and two individual IQ scores. Identical twins reared together received the highest correlation followed by identical twins reared apart. Both variables had a median correlation above 0.7. These kinds of studies support the view that genetics plays a crucial role in intelligence.

With this in mind, several authors argue that general intelligence is inherited rather than significantly affected by environmental factors (e.g., Bouchard, 1998; Plomin & Petrill, 1997; Plomin, DeFries, McClearn, & McGuffin, 2001). Some researchers believe environmental factors—such as parents' education and income and child-rearing style—have a minor effect on intelligence (Gottfredsson, 2004).

Twin and adoption studies (e.g., Bailey, Kirk, Zhu, Dunne, & Martin, 2000; Bouchard & McGue, 1981; Bouchard & Pedersen, 1999; Loehlin, 1989; Pedersen et al., 1992) have examined whether genetics significantly influences intelligence. Many researchers have concluded that genetics significantly influences intelligence. Model-fitting analyses that attempt concurrent analyses of all twin and adoption studies reveal that heredity (i.e., describes the proportion of observed differences that can be attributed to genetics) accounts for 50% of the variance. Since it is rare for the behavioural science to explain 5% of the variance, this is a major discovery.

Since heritability is suggested to explain 50% of the intelligence variance, 50% remains to be explained with no genetic influences (e.g., parenting styles, nutrition, and illness). It is suggested that shared environment (i.e., studies of adoptive siblings) accounts for 25% of the variance (Plomin & Petrill, 1997).

Of special interest for this thesis are developmental genetic analyses that show how genetic factors increasingly affect intelligence throughout the life span. It seems that the influence of genetics increases with age. Plomin and Petrill (1997) compiled the explained variance of heritability reported in several studies (McGué, Bouchard, Iacono, & Lykken, 1993; Plomin, 1986; Pedersen, Plomin, Nesselroade, & McClearn, 1992). The patterns viewed an increase of heritability: 40% (childhood), 60% (early adulthood), and 80% (in later life—"60 years").

The influence of genetics on intelligence is also reported by McGue et al. (1993) and Brody (1993): they found that identical twins become increasingly similar over the life span. In a study of older adoptive siblings, however, Loehlin, Horn, and Willerman (1989) suggest that shared family

environment has a negligible influence on intelligence after adolescence. These results leave several questions to be answered: What are these shared environmental factors that are important in childhood, and why does their influence disappear by late adolescence? What are the non-shared environmental factors responsible for the long-term influence of the environment on IQ scores? Why are children growing up in the same family so different environmentally? (Plomin & Petrill, 1997, p.64). The effect of family factors (e.g., parents' education and income, and childrearing) disappears almost completely with age (Gottfredson, 2004).

Presently, there is a consensus that both nature and nurture influence intelligence (Plomin & Petrill, 1997; Turkheimer et al., 2003).

EXECUTIVE FUNCTIONS

The executive functions may be related to the frontal lobes. For example, Shallice (1982) thought that the frontal lobes have an important role for planning, organizing, and controlling action. This reasoning is supported by recent neuropsychological findings (e.g., Bryan & Luszcz, 2001; Miyake, Emerson, & Friedman, 2000; Salthouse et al., 2003). The functions may “control processes responsible for planning, assembling, coordinating sequencing, and monitoring cognitive operations” (Salthouse, Atkinson, & Berish, 2003, p 566).

Some authors (e.g., Miyake et al., 2000; Shallice, 1988) argue that the core of mainstream conceptualizations of executive functioning is the capacity for mental flexibility, and the skills to avoid repetitive and perseverative behaviour. Rabbitt (1997) defines executive functions as a broad group of cognitive activities such as handling new tasks, planning and initiating strategies, monitoring performance, using feedback to adjust strategies, and ignoring information that is irrelevant for the task.

Neurologically differentiation

According to Nyberg et al. (2003), previous studies have mostly focused on the role of specific prefrontal cortex (PFC) regions, in specific cognitive domains, and that more recent studies have reported similarities across cognitive domains. Nyberg et al. (2003) examined similarities in brain activities and their results showed that certain processes are common with regard to several different tests, such as working memory, episodic memory, and semantic memory. The data suggested that there were four PFC regions—left frontopolar cortex, left mid-ventrolateral PFC, left mid-dorsolateral PFC, and dorsal anterior cingulate cortex—that contribute to all memory tasks. It is worth noting that the functional accounts of these regions are associated with executive processing/cognitive control.

Therefore, one explanation for similarities across memory tasks is that all of the tasks involved increased demands on executive processing. The results are in line with the view of multiple processing components.

Tasks

Tasks such as card sorting, the stroop-test, word fluency (i.e., in the past classified as semantic measures), and Tower of Hanoi have been used to measure executive functions (Rönnlund, 2003). Many tasks may depend on frontal lobes. Verbal fluency and the Wisconsin Card Sorting Test (WCST) are most consistently shown to be impaired in patients with frontal lobe damage. The verbal fluency task (i.e., generating words that begin with letter “A” for 1 minute) is associated with the frontal lobe. Patients with extensive frontal lobe damage find this task extremely difficult to perform. The task is suggested to be too complicated for the subject to execute because there is no automatic program to be relied on. Instead the patient must choose and run his or her own retrieval strategies and make sure the items are not repeated. The problem is not associated with memory in general, but how to control the retrieval strategy (Baddeley, 1997).

It is important to note that there is a link between executive functions and working memory. More specifically, executive functioning is related to the central executive, a component of the working memory (Baddeley (1997).

The central executive is activated during more demanding working memory tasks. It is the central executive that rules and integrates information and selects and initiates strategies for performance (Baddeley, 1997). The central executive of working memory and the construct of executive function share some attributes because both are thought to control and integrate cognitive activity (Baddeley, 1997; Luszcz & Bryan, 1999). It is difficult to make a clear comparison between executive function and central executive of working memory, although the executive function is generally explained as a broader construct than the central executive.

Notably, performance of executive functions may reflect general intellectual ability (Obonsawin et al., 2002), but little is still known about similarities and differences between these two domains.

Study I tests executive function using a series of tests developed by Baddeley et al. (1984) to assess working memory. In this task, participants are presented with a list of words and are asked to recall as many of these words as possible immediately after presentation. Concurrently with the encoding of these words, participants sort a deck of cards in one black and one red pile. The verbal fluency task requires generation of multiple responses under constrained search conditions. It involves associative exploring and retrieval of words that are either based on phonemic or semantic criteria under time restriction (Henry & Phillips, 2006).

Aging and executive functions

What makes the executive functioning especially interesting in the present context is its relevance for adult age differences in cognitive functioning. Thus executive function is assumed to be related to the frontal lobes and to various age-related cognitive deficits. It is known that both frontal and temporal lobe structures are affected by aging (Raz et al., 2004). Henry and Phillips (2006) have suggested a theory of cognitive aging called fronto-executive theory. The theory predicts that aging is linked to the disproportionate atrophy in the anterior region of the brain. This leads to deficit on tasks that involve executive processes.

Henry and Phillips (2006) detected no age effect for the total output on the semantic fluency. However, their data revealed that older adults generated significantly more responses compared to younger adults on the phonemic measure, although this age benefit was significantly attenuated when crystallized intelligence was entered as a control variable.

In a literature review, Henry and Phillips (2006) noted that age effects are inconsistent. Several studies (e.g., Capitani et al., 1999; Kempler et al., 1998; Phillips, 1999) documented that fluency performance is negatively related to aging and that there is evidence of age-related decline starting at 50 years old. Other studies (e.g., Bolla et al., 1990; Crawford et al., 2000; Miller, 1984), however, have reported no age effect on verbal fluency. It has also been reported (e.g., Parkin & Walter, 1991; Veroff, 1980; Yeudall et al., 1986) that there is a positive link between age and performance in fluency. One possible explanation to the inconsistent results of age effects in phonemic and semantic fluency may due to the contribution of fluid (i.e., generating novel search strategies) and crystallized abilities (i.e., knowledge of vocabulary).

FAMILY CONFIGURATION AND HEALTH

As a result of natural declines and choices of life style, people will gradually change physically (see Burns, 2000; Katz & Marshall, 2003). Most people become aware of these physical changes in the middle adulthood (40-60-years of age). A gain in weight, for example, can often be explained with lifestyle choices, and such a change is often followed by declines in strength. Sixty-year old people tend to have lost, on average, around 10 percent of their strength (see Troll, 1985). Some chronic diseases, such as arthritis, diabetes, and hypertension begin after age 40, between age 50 and 60, and in the middle age, respectively (Smedley & Syme, 2000). However, most people are healthy during middle age, experiencing no chronic diseases. Scientists (e.g., Sterns, Barrett, & Alexander, 1985) have even reported that this age group is less likely, in comparison with younger adults, to suffer

from infections, allergies, respiratory diseases, and digestive problems. This is because people have experienced these diseases in younger adulthood and developed immunity. Several other scientists (e.g., Friedman, Berman, & Hamberger, 1993; Johnson, 2003; McGuinness, 1972) have reported natural physical declines caused by aging. The brain grows in size and weight until it slowly begins to decline after its peak during early adulthood (Johnson, 2003).

In late adulthood the amount of space between the brain and skull increases significantly. The blood flow within the brain will be reduced and the brain uses less oxygen and glucose (see Wickelgren, 1996; Tisserand & Jolles, 2003). The reduced capacity of the heart to pump blood throughout the circulatory system partly causes the reduced flow of blood in the brain (Kart, 1990). The changes in the functioning of various systems of the body are partly connected to life styles. The natural process of aging often occurs earlier in individuals living less healthy life styles (see Mitchell, Haan, & Steinberg, 2003; Hunter, McCarthy, & Bamman, 2004). Common physical disorders in late adulthood are heart disease, cancer, and stroke, along with infectious diseases (Feinberg, 2000).

In late adulthood individuals are more at risk for developing psychological and mental disorders. The most common mental disorder is dementia, which is a broad category of severe memory impairment. Alzheimer's disease is such a brain disorder that causes memory loss and confusion (Morris & Kopelman, 1986).

There is a link between differences in health and social class. Individuals with low SES are more often suffering from illness and death than individuals with high SES (Hummer, Rogers, & Eberstein, 1998). The association between SES and health may vary in strength depending on the extent a country provides health insurance (Adler et al., 1993). There are several explanations to the relationship between SES and health. First, the occupations are generally more dangerous (e.g., mining, construction work) in households with lower SES. Also, inferior health care coverage is inferior, and crime and environmental pollutants are generally more frequent in those neighbourhoods with a higher rate of low-income families (Fingerhut & Makuc, 1992; Dahl & Birkelund, 1997). There is evidence that the link between SES and health is valid through the lifespan, although the strength and nature of this association varies (Lynch, Kaplan, & Salonen, 1997).

With this in mind, we might expect that family configuration may function as a predictor of common chronic adult diseases. Early-life environment (e.g., number of siblings, birth order, mother's age, and residence before age 18 years), however, has an effect on growth and maturation of children and adolescents. As a consequence, early-life environment is associated to many adult chronic diseases, such as heart disease, stroke, hypertension, and diabetes mellitus (Moceri et al., 2000).

Studies have shown a strong association between sibship size and asthma, atopic eczema, hay fever, and allergy markers (Karmaus & Johnson, 2005). There is also evidence that sibship size and birth order strongly influence early-life infection patterns. Since infectious agents have been considered as a component causing prostate cancer, it is possible that there may be a link between family structure and prostate cancer (Nomura & Kolonel, 1991). It is also suggested that diabetes type I may show similar patterns (Karmaus & Johnson, 2005).

Despite these studies, more studies need to examine the association between sibship size and diseases. This thesis explores the role of sibship size and birth order for the following diseases: Infarction of the heart and circulatory disorders, stroke, and hypertension. A short presentation of these diseases follows.

Infarction of the heart and circulatory disorders

In Sweden, 30 000 individuals suffer from infarction of heart (cardiac infarct, coronary artery disease) each year. Mortality of acute cardiac infarct is 15% at the hospital—2.5% for women and 1.2% for men. Outside the hospital these figures are higher. Cardiac infarct is a disease that occurs when the blood supply to the heart is interrupted. This can cause death of the heart tissue (necrosis) in the myocardium. Necrosis can be caused by a blood clot that blocks blood flow to a vessel. Acute cardiac infarct can be diagnosed if at least two of the following three criteria are fulfilled: chest pain with or without radiation characteristics, release of biochemical markers, and change in ECG (Rehnqvist & Lundman, 1999).

Stroke

Stroke is a designation of a group of diseases that depend on changes in blood vessels in the brain, vessels leading to the brain, or changes in the heart. Therefore, stroke is a member of the group of cerebrovascular diseases (CVS), which includes conditions with focal cerebral ischemia. The consequences of ischemia are brain infarct or transient ischemic attack and intracranial bleedings. Most common of all strokes are brain infarct (85%), followed by intracerebral haematoma (10%) and subarachnoid haemorrhages (5%). Well-known risk factors for both brain infarct and haematoma are high systolic and diastolic blood pressure, diabetes, smoking, high S-cholesterol, overweight (i.e., men >65 years), acute alcohol intoxication, and heart diseases.

It has been reported a link between developing CVS and age, where the mean age for CVS is around 70 years. The statistics for CVS show around 200 to 300 cases per 100 000 habitants per year. CVS can cause lasting

disabilities in adults, but it can also lead to death. Heart infarct and cancer, followed by CVS are the most common cause of death among diseases (Nilsson & Norrving, 1999).

Hypertension

In line with WHO's recommendation, the definition of hypertension is repeated blood pressure >140 mm Hg systolic and, or >90 mm Hg diastolic. Hypertension ranges from malign hypertension with complications in the brain, eyes, heart, kidneys, and peripheral vessels to an uncomplicated mild hypertension. Moderate/severe hypertension is therefore defined as repeated blood pressure above 105 mm Hg diastolic, while mild hypertension is defined as lack of hypertension and with a repeated diastolic blood pressure of 90-104 mm Hg.

The characteristics of hypertension are often asymptomatic. In cases of a symptomatic hypertonic, the condition is often severe. The problem with high blood pressure is the severe complications (e.g., cardiovascular diseases such as stroke, coronary disease, and peripheral vascular disease) followed by hypertension. Risk factors for developing complications vary with magnitude of blood pressure, age, gender, effects on organs, other diseases (e.g., cardiac infarct, kidney disease, and diabetes mellitus), and other risk factors for cardiovascular diseases (e.g., smoking and disturbed glucose metabolism). All these factors increase the risk for complications.

Research has not yet been able to explain the mechanisms underlying hypertension. However, both heredity and environmental factors seem to underlie the development of hypertension. There is a weak association between the following factors and hypertension: obesity, stress, and high consumption of salt and alcohol. Suffering from high blood pressure is very common, and especially for individuals above 50 years of age. At age 70 years and above over 50% of the population are suffering from hypertension (Berglund, 1996).

THEORETICAL MODELS OF LIFE SPAN DEVELOPMENT

Focusing on adults and old-old participants, this thesis attempts to establish the effects of childhood family configuration and their influence across the adult life span. Therefore, it is of interest to briefly mention established theoretical perspectives on life span development.

There are several scholars (e.g., Colarusso & Nemiroff, 1981; Eriksson, 1963; Labouvie, 1986, 1990; Perry, 1970, 1981; Schaie, 1977/1978; Schaie et al., 1989; Schaie & Willis, 1993; Sinnott, 1998; Vygotsky, 1986) that examine

the development across a life span from a psychodynamic, cognitive, or evolutionary perspective.

Eriksson (1963), for one, implemented a psychosocial theory, which included these following stages of life development: Trust vs. mistrust (birth to 1.5-year-olds); autonomy vs. shame and doubt (1.5 to 3-year-olds); initiative vs. guilt (3 to 6-year-olds); industry vs. inferiority (6 to 12-year-olds); identity vs. identity confusion (adolescence); intimacy vs. isolation (early adulthood); generativity vs. stagnation (middle adulthood); and ego-integrity vs. despair (late adulthood). Each stage represents a crisis/conflict that must be solved. The concept behind this theory is the existence of developmental changes throughout the life span.

Piaget argued that cognitive development is divided into stages: Sensorimotor stage (birth to 3-year-olds); preoperational stage (3 to 6-year-olds); concrete operational stage (6 to 12-year-olds); and formal operations stage (12 to 20-year-olds) (Masling & Bornstein, 1996). According to this theory, cognitive development develops during these stages and stays stable after formal operation, which is the final stage that occurs during adolescence although people can gather more experience after the final stage is reached. That is, the way of thinking or changes in the acquisition and understanding of new information does not change.

Several scientists (Labouvie-Vief, 1986, 1990; Perry, 1970, 1981; Schaie, 1977/1978; Schaie et al., 1989; Schaie & Willis, 1993) argue that changes should be thought of qualitatively during early adulthood. Schaie (1977/1978), for example, believes that thinking continues to develop during the adult life span. Schaie's focused on how information was used during adulthood. The acquisitive stage (acquire new information) is the first stage of cognitive development and is reached during childhood and adolescence. Young adults are in the achieving stage, which means that they apply their intelligence to specific situations involving attaining long-term goals (e.g., careers, and family). During middle adulthood, people reach the executive stage (involving a broader perspective such as concern about the world) and the responsible stage (focusing on personal situations involving taking care of spouses, families, and careers). The last stage is reached during late adulthood. In the Reintegrative stage, people focus on issues that have personal meaning and on issues that is of interest to them.

According to several scientists (e.g., Labouvie-Vief, 1980, 1986, 1990; Sinnott, 1998; Perry, 1970, 1981), young adults develop post-formal thought, which goes beyond Piaget's formal operations. According to Labouvie-vief, postformal thought assumes that adult predicament can be solved in relativistic terms rather than on purely logical processes. According to Sinnott (1998), post-formal thinkers can take into count real-world considerations when they solve problems and they can acknowledge the existence of several solutions to multiple causes of a situation.

This agrees with Perry's approach (1970, 1981). For Perry, students develop their thinking from a dualistic thinking (i.e., something is right or it is wrong) to a multiple thinking (i.e., knowledge and values are relativistic) during their time in college.

Colarusso and Nemiroff (1981) offered a model of the developmental tasks of adulthood. In adulthood (20-40 years), people face, for example, responsibility for one's own body, deciding whether to have children, having and relating to children, establishing adult relationships with parents, acquiring marketable skills, choosing a career, using money to further development, and assuming a social role. In the middle adulthood (40-60 years), people face new developmental tasks such as dealing with body changes or illness and altered body image, changes in sexuality, living through illness and death of parents, redefining relationship to spouse or partner, consolidating work identity, and transmitting skills and values to the young. In the late adulthood (60- above) people may face adapting to physical infirmities or permanent impairment, losses of partner and friends, reversing role of children and grandchildren, retirement, and companionship vs. isolation. Havighurst (1979) proposed a similar model of developmental tasks that need to be sequentially mastered. The stages range from infancy to old age.

In sum, there is a consensus among several scientists (e.g., Eriksson, 1963; Colarusso and Nemiroff, 1981; Havighurst, 1979; Labouvie-Vief, 1980, 1986, 1990; Perry, 1970, 1981; Schaie, 1977/1978; Schaie et al., 1989; Schaie & Willis, 1993; Sinnott, 1998) that developmental growth, as well as change, will continue throughout the life span.

But what about changes regarding socioeconomic status during the life span, which is considered to be linked to education, cognitive outcomes, and health? It has been reported (e.g., Bowen & Bowen, 1999; Prater, 2002) there is an association between educational achievement and socioeconomic status (SES). Students from lower SES homes perform at a lower level on standardized tests of achievement in comparison with students from middle and high SES homes. It has also been observed that the latter complete more school years. It is suggested that the disadvantage of coming from a low SES family may continue to affect school performance from the day they begin school to adolescents since success builds on basic skills learned during the first years of schooling (Phillips, Voran, Kisker, Howes & Whitebook (1994).

SUMMARY OF EMPIRICAL STUDIES

Study I

Holmgren, S., Molander, B., & Nilsson, L.-G. (2006). Intelligence and executive functioning in adult age: Effects of sibship size and birth order. *European Journal of Cognitive Psychology*, 18, 138-158.

It is well known that social and environmental factors influence children's later intellectual functioning in life (e.g., Bussey & Bandura, 1999; Erikson, 1963; Fischer & Bidell, 1998; Gibson & Pick, 2000; Siegler, 1998; Vygotsky, 1986). More specifically, some studies (e.g., Zajonc, 1976; 1986, 2001; Zajonc & Markus, 1975) have reported that children who grow up in large families and are born late in birth order show lower scores on intelligence tests as compared to children that have been brought up in smaller families with few siblings and are born earlier in birth order.

Study I examines whether social factors such as sibship size and birth order have a long lasting effect on intelligence and executive functions: Are 35-year-olds to 85-year-olds affected by the rearing conditions they grew up with even though it was a long time since they moved out of the family home?

In addition, Study I explores whether age and sex would interact with sibship size and birth order. Gender is a factor that may affect cognitive performance, and empirical studies performed by Herlitz, Nilsson, & Bäckman, (1997) and Maitland, Herlitz, Nyberg, Bäckman, & Nilsson, (2004) have revealed, in general, a female superiority in verbal tasks and a male advantage in spatial tasks.

A third aim was to extend the test of measurements to include intelligence tests as well as executive function tests. Intelligence was assessed by two tests, namely block design and word comprehension. Executive function was assessed using working memory and verbal fluency tasks.

The fourth and last aim of the study was to control for variables likely to confound the effect of sibship size and birth order on the cognitive measurements. A factor known to affect cognitive performance is the health status of the participants (e.g., Bäckman et al., 2004; Lee, Kawachi, Berkman, & Grodstein, 2003). Therefore, participants with dementia, heart attack, circulation disorders, stroke, hypertension, and diabetes are excluded from the study. Another factor to control for is socioeconomic status. As reported by Blake (1981, 1989) and Downey (1995, 2001), lower socioeconomic status is associated with larger families (e.g., more children). In an attempt to control for this factor, education was applied as a proxy for socioeconomic status.

With the intention to control for education as well as age, it was necessary to divide the participants into three age groups: middle age (35-45 years), young-old (50-60 years), and old-old (65-85 years). It was also necessary to divide the participants into three groups of sibship size: 1-2 siblings, 3-4 siblings, and 5-16 siblings. The same was done for birth order: born first, born second to third, and born fourth to fifteenth. The data originated from sample S1T1 (i.e., sample 1 at test occasion 1), S2T2 (i.e., sample 2 at test occasion 2), and S3T2 (i.e., sample 3 at test occasion 2). Three samples were selected to receive enough participants and enhance statistical power.

We expected that sibship size and birth order should influence word comprehension rather than block design or any of the executive function measures, since a larger correlation between family configuration and language/verbal tasks than for spatial/reasoning tasks (Marjoribanks, 1976a, 1976b) has been observed. Furthermore, if the data reveal any effects of sibship size and birth order, we anticipated these effects to be found in the younger rather than the older participants. This is based on the assumption that effects of shared family environment on cognitive functions should decrease as chronological age increases (Plomin et al., 2001). Finally, we expected women to outperform men in the working memory and fluency tasks and men to outperform women in the block design task (see Herlitz, Nilsson, & Bäckman, 1997; Halpern & LaMay, 2000; Voyer, Voyer, & Bryden, 1995).

The results exposed a sibship size effect for executive function and for intelligence. Regarding birth order, data revealed effects on executive functions, specifically on working memory, where the participants born earlier performed better than participants that were born later in the birth order range. After controlling for education, a proxy for socioeconomic status, a sibship size effect was demonstrated for executive functions, particularly working memory. Furthermore, earlier-born individuals performed better in tests assessing executive functioning (working memory) than later-born individuals. Regarding the tests assessing intelligence, there were no effects of sibship size or birth order.

Study II

Holmgren, S., Molander, B., & Nilsson, L.-G. (in press). Episodic memory in adult age and effects of sibship size and birth order: Longitudinal data. *Journal of Adult Development*.

In Study I (Holmgren et al., 2006), it was shown that intelligence and executive functions varied as a function of sibship size and birth order. These results agreed with the confluence model (e.g., Zajonc, 1976, 1986, 2001; Zajonc & Markus, 1975), which states that sibship size and birth

order are crucial factors for performance on intelligence tests. Given these findings, it is proposed that the effects of family structure (viz. sibship size and birth order) should be considered in studies of life span development of cognitive function.

Study II examines the range of effects further and whether the effects obtained in Study I hold for episodic memory as well. Because Holmgren et al. (2006) showed that the effects of sibship size on executive functioning was strongest in the age group 65 to 85 years of age, it is of interest to see whether sibship size and birth order interact with age in episodic memory. We also expected recall to be more sensitive to aging as compared to recognition (Nyberg et al., 2003). As pointed out above, women perform at a higher level than men on episodic memory tasks (e.g., Herlitz, Airaksinen, & Nordström, 1999; Maitland et al., 2004; Nilsson et al., 2004) and therefore sex of the participants was included as a factor. More importantly, the results from the Holmgren et al. (2006) suggest that the effects of family structure may be especially strong in interactions with age and sex of the participants.

Another aim of this study was to examine the patterns of longitudinal data regarding effects of family configuration on episodic memory.

We examined the effects of sibship size and birth order by looking at the subsystems of episodic memory, namely recall and recognition (e.g., Cabeza et al., 1997; Gregg, 1976). The data originate from the Betula Prospective Cohort Study where the test battery for recognition included face recognition, name recognition, and recognition of nouns. Measures of recall included free recall of actions, cued recall of nouns, activity recall, and episodic word recall.

Samples selected for this particular study were S1T1, S2T2, and S3T2. The participants of S1T1 were tested between 1988 and 1990. However, the participants of S2T2 and S3T2 were first tested between 1993 and 1995. All participants were tested a second time after an interval of five years. Of interest was to study healthy participants because diseases are known to affect cognitive performance (e.g., Bäckman et al., 2003; Nilsson & Söderlund, 2001). Consequently, participants with dementia, heart attack, circulation disorders, stroke, hypertension, and diabetes were excluded from this study.

SES was controlled for by looking at the number of years of education as a proxy. Furthermore, parental age at the time of birth of their children was controlled for. Effect of parental age on children's intelligence score has been reported (e.g., Malaspina et al., 2005).

The present study concluded that sibship size influences both recall and recognition, showing better memory performance for participants belonging to smaller sibship size groups. Control of education within each age group revealed a stronger influence of sibship size on recall than recognition. An effect of birth order was demonstrated on recall, viewing superiority for

first-born children. After controlling for education within each age group, the strongest effect of birth order was demonstrated on recall in the old-old age group.

Study III

Nilsson, L.-G., Holmgren, S., Nilsson, E., Bergman, L.R., & Molander, B. (2007). Sibship size and birth order as predictors of heart-related diseases. Manuscript submitted for publication.

The main objective in Study III was to explore the role of sibship size and birth order for adult chronic diseases such as myocardial infarction and circulatory disorders, stroke, and hypertension. Studies within this domain are largely lacking, although there are several studies reporting a strong relationship for example between sibship size and allergy (Karmaus & Botezan, 2002).

The data emanates from the Betula Prospective Cohort Study (see Nilsson et al., 1997, 2004) and the information is based on self-reports. The criterion for participating in this study is that the participants either should have consulted a doctor for any of these diseases or have been treated for any of the diseases at a hospital. Data for sibship size were available for 2873 participants in the ages of 35, 40, 45,..., 80 years, conducted on samples S1T1, S2T2, and S3T2.

Logistic regressions were performed with sibship size and birth order as continuous independent variables with proper control for the following variables: age, sex, education (proxy for socioeconomic status), parental age at birth of participants, and lifestyle (alcohol consumption and smoking).

The analyses revealed a significant main overall effect of sibship size ($p < .001$) for all diseases (myocardial/circulatory disorders, stroke, and hypertension) before entering the covariates into the analyses. When controlling for age, sex, education, parental age at time of birth of participant, and life style the effect of sibship size diminished. Birth order showed a different pattern, revealing a significant main overall ($p < .001$) on stroke, but not for cardiovascular disease and hypertension. Only a tendency for the effect of birth order on stroke remained after control of covariates ($p < .10$).

In conclusion, these overall results suggest that being born in a large sibship configuration is a risk factor for developing myocardial infarction and circulatory disorders, stroke, and hypertension. Being born early in a sibship might be a risk factor for stroke.

GENERAL DISCUSSION

Family configuration effects on life-span development

One new and important finding of the present studies is that sibship size is a predictor of cognitive performance in healthy individuals in adulthood and old age. The data show a decreasing performance in tests assessing intelligence and executive functions as sibship size increases. These observed patterns are in line with previous studies of children and adolescents (e.g., Anastasi, 1956; Berglund, Eriksson, & Westerlund, 2005; Belmont & Marolla, 1973; Berbaum & Moreland, 1980, 1985; Bjerkedal, Kristensen, Skjeret, & Brevik, 2007; Blake, 1981; Grotevant, Scarr, & Weinberg, 1977) and with the predictions of the confluence model (e.g., Guo & VanWey, 1999; Markus & Zajonc, 1977; Zajonc, 1976, 2001, Zajonc & Bargh, 1980a, 1980b; Zajonc & Markus, 1975) and the resource dilution theory (e.g., Blake, 1981; Downey, 1995, 2001; Guo & VanWey, 1999; Marjoribanks, 1990). Although these latter models do not make any specific predictions about the effects in adulthood and later part of the life span, the present results replicate and extend the previous findings of children and adolescence and contribute greatly to the knowledge regarding the long-lasting effects of social factors.

Most previous research (e.g., Anastasi, 1956; Berglund, Eriksson, & Westerlund, 2005; Belmont & Marolla, 1973; Berbaum & Moreland, 1980, 1985; Bjerkedal, Kristensen, Skjeret, & Brevik, 2007; Blake, 1981; Grotevant, Scarr, & Weinberg, 1977; Markus & Zajonc, 1977; Zajonc, 1976; Zajonc & Bargh, 1980a, 1980b) assesses intelligence by measuring the effects of family configuration. However, it has been suggested (e.g., Zajonc & Markus, 1975) that the confluence model may function as an underlying mechanism for other processes that develop over time. Therefore, a similar pattern for other cognitive functions may be expected. The results of the thesis agree with this prediction, revealing an overall significant main effect of sibship size on recall and recognition. The effects of sibship size show the same trend for both of these subcomponents of episodic memory; that is, memory performance decreases with sibship size.

Does birth order function as a predictor for adult cognitive abilities? In the examination of intelligence and executive function, sibship size revealed a greater influence on performance than birth order. This agrees with previously conducted surveys, which all show a decline in scores due to family size. Family size has proved to give more stable effects over a large variation of samples and tests in comparison to birth order. This latter factor has shown contradictive results (e.g., Bellmont & Marolla, 1973; Berglund, Eriksson, & Westerlund, 2005; Bjerkedal, Kristensen, Skjeret, & Brevik, 2007; Brackbill & Nichols, 1982; Davis, Cahan, & Bashi, 1977;

Galbraith, 1982; Marjoribanks, 1978; Retherford & Sewell, 1991; Zajonc, 1976), or effects have even been difficult to obtain (e.g., Rodgers, Cleveland, van den Oord, & Rowe, 2000; Steelman, 1985; Wichman, Rodgers, & MacCallum, 2006).

The results in this thesis reveal that birth order influences working memory, which is considered to be a subcomponent of executive function. Thus the first-born child performed at a higher level than later-born children. This finding agrees with the prediction of Zajonc, Markus, and Markus (1979) who conclude that results of studies based on adults never show the second born surpassing the first-born. Altogether, these results show weak effects of birth order, a claim that is consistent with the argument put forward by several authors that birth order has a minor effect on intellectual development (e.g., Retherford & Sewell, 1991; Steelman, 1985).

With this in mind, this question comes into relief: Do birth order patterns occur in episodic memory? Our data revealed that birth order influences episodic memory throughout the life span (middle-age to old-old). In general terms, birth order has a greater influence on episodic memory, especially on recall, in comparison to intelligence and executive functions. The overall analysis revealed a main effect of birth order on recall showing impaired performance with ascending birth order. In other words, later-born siblings perform not as well as first-born siblings. These results agree with the prediction of parental attention in the resource dilution theory and the confluence model: early born children get an advantage over later born children (Downey, 2001). The results also agree with the findings of several authors reporting that first-borns have better school grades and show more outstanding performance than later-born children (e.g., Schachter, 1963; Altus, 1965, 1966). However, there is not much support for the theory of tutorship (e.g., Zajonc, 2001; Zajonc & Markus, 1975). On the contrary, birth-order group “1” showed better recall than birth-order group “2-3”, and performed as well as group “2-3” in recognition. Finally, both groups performed at a higher level than the “4-15” group. The lack of significance between the first two groups could be seen as evidence for the interpretation of weak support for Zajonc’s theory of tutorship.

In Study II, the effects of sibship size and birth order are similar as overall effects are obtained for both factors and the effect size (i.e., η^2); that is, the effects are about the same for both factors. These results call for further examination in order to understand the influence of birth order on different cognitive abilities.

Mechanisms and processes

Studies that have reported a weak link between educational achievements and sibship size have often been conducted in communities with norms that support large families (Downey, 2001). As Pong (1997) argues, the effect of siblings is weak when the state supplements education. The results in this thesis reveal effects of family configuration on cognitive measurements despite the fact that governments in Sweden have been financially supporting the school system for a long time.

Several scientists (e.g., Blake, 1989; Ernst & Angst, 1983; Steelman, 1985) believe that the negative relationship reported between sibship size and intellectual development is spurious. These authors propose that the effect of sibship size is due to one or several unknown factors, which correlate with sibship size, and, consequently, are related to intellectual performance. One such suggested factor is socioeconomic status (e.g., Downey, 1995; Ernst & Angst, 1983; Kennett & Cropley, 1970; Kennett, 1973; Rodgers, 1988; Steelman, 1985). However, the welfare in Sweden has increased steadily over the last 60 years, and class inequalities and income differences have decreased (Hansen, Ringen, Uusitalo, & Erikson, 1993).

In this thesis, we have used education as a proxy for socioeconomic status, although Hansen et al. (1993) suggest that in Scandinavian countries education may not be as good a proxy for SES as commonly believed, as school reforms have created better possibilities and higher likelihood for higher education for all children despite birth order. However, it has also been suggested that child and adult SES are associated. High SES in childhood is a predictor for attaining economic and educational advantages in adulthood (Lynch, Kaplan, & Salonen, 1997).

After controlling for education within each age cohort (middle-age, young-old, and old-old), the results revealed no main effect of sibship size on intelligence or on either subcomponent (block design and word comprehension). However, the data suggest that those participants whose capacity is strongly influenced by age and gender are most affected. Evidence for this is a three-way interaction effect between sibship size, age, and sex, revealing a negative linear effect for men in the oldest age cohort (>65-year-olds) on word comprehension.

Moreover, data revealed no main effect of sibship size on executive function after controlling for education, although working memory showed a significant influence of sibship size in the oldest age cohort. This was not the case for verbal fluency, the other subcomponent. Working memory is thus the most reliable test after controlling for SES. The latter mentioned effect shows the same data patterns as reported in the overall analysis.

After establishing that the effect of sibship size on intelligence and executive function decreased when controlling for education, the next issue

is whether we can expect a similar pattern for recall and recognition. The results once again reveal a main effect of sibship size on both recall and recognition for the oldest age group (65-year-olds to 80-year-olds), and there is a main effect on recall for the young-old group (50-year-olds to 60 year-olds). These results contradict the view of the spurious effect of sibship size put forward by several authors (e.g., Downey, 1995; Ernst & Angst, 1983; Kennett & Cropley, 1970; Kennett, 1973; Rodgers, 1988; Steelman, 1985). Moreover, these results agree with the notion that the effect of the number of siblings partly remain even when socioeconomic is controlled, an effect that is present even though sibship size is negatively related to social class (e.g., Downey, 1995). However, these analyses show that education is still strongly related to effects of family configuration. The effects of sibship size are small in terms of explained variance compared to effects of education or age, although the effects of sibship size reported in this study are similar to the size of effects reported in studies on children and adolescents (e.g., Rodgers, 1984).

The effect of the number of siblings seems to be more stable for episodic memory in comparison to intelligence and executive functions. Will a similar pattern occur for birth order?

Once again, data revealed that episodic memory and the old-old group seems to be most affected by family configuration. The results showed impaired performance with ascending birth order on recall. This effect stays stable even when controlling for education. Furthermore, an interaction between birth order and age appeared when controlling for education and parental age in the middle age group. In addition, there was a birth order/age/sex interaction in the young-old age group that vanished after controlling for education.

In sum, it is evident from the present data that level of education is associated with the effects of family configuration. When education is controlled for, the effects of birth order and sibship size either disappears or is reduced. However, there is a possibility that the effects of sibship size and birth order are underestimated as we control for both education and diseases. There is a correlation around .70 between education and the g factor (e.g., Jencks et al., 1972). One possibility is to consider intelligence as more important for establishing the level of education than vice versa. To take it one step further, level of intelligence may be vital for avoiding diseases (Gottfredson, 2004). If this is true, the obtained effects of family configuration may be underestimated by controlling for education and diseases.

Component dissimilarities

It has been suggested that verbal abilities are more affected by sibship size compared to other measures (e.g., Marjoribanks, 1976a, 1976b; Mercy & Steelman, 1982; Nisbet, 1953a, 1953b; Scott & Nisbet, 1955; Steelman, 1985; Zajonc & Markus, 1975). The results presented in this thesis are interesting in that respect. We found the effects of number of siblings to be significant for executive functions, recall, and recognition, and as strong as the effect for word comprehension, findings that contradict the predictions of several scientists (e.g., Mercy & Steelman, 1982; Nisbet, 1953a, 1953b; Scott & Nisbet, 1955; Steelman, 1985; Zajonc & Markus, 1975.) These findings lead to more questions about the underlying mechanisms of sibship size, as the reports of a stronger association between sibship size and verbal ability, compared to nonverbal ability, has previously been used as evidence for an environmental explanation of the effects of family configuration (e.g., Steelman, 1985). The environmental explanation may still be accurate if sibship size indirectly can affect other cognitive measurements. For example, sibship size influences verbal ability and verbal ability influences performance on intelligence (e.g., Nisbet, 1953, 1953; Scott & Nisbet, 1955).

Our result reports no effects of sibship size on block design, which is a subcomponent of intelligence. This agrees with the first prediction and results reported by scientists (e.g., Mercy & Steelman, 1982) that verbal tests are more sensitive for the impact of sibship size in comparison to block design. Furthermore, there is some support for the suggestion made by Scott and Nisbet (1955) that the effect of sibship size on verbal ability may persist into adult life, although this seems to be true also for other cognitive abilities we have examined.

The findings in the present thesis also suggest that the components of executive functioning are more dissimilar than the components of the intelligence measures regarding effects of family configuration. Especially working memory showed a different pattern than the other three components and acts in a more linear pattern. It is questionable, however, whether verbal fluency is an appropriate measure of executive functions.

Data obtained in the thesis may be seen as support for the statement that working memory and intelligence are different constructs (e.g., Ackerman et al., 2005). Evidence for this view is that the working memory measure differs from the block design and word comprehension measures, which are subcomponents of intelligence.

Recognition seems to be less sensitive for the effects of sibship size and birth order than recall. Both sibship size and birth order have larger influence on recall than on recognition. One explanation is that recognition requires less cognitive demands than recall (e.g., Nilsson, Law, & Tooling, 1988; Nyberg et al., 2003). This is interesting, as we interpret our results as indicating that the effect of sibship size on intelligence and executive

function is strongest for those participants whose prerequisites for managing working memory and fluency tasks are known to be poor. The results also suggest that the effect of sibship size can be demonstrated for those participants whose capabilities in cognitive tasks are strongly affected by age and gender. A similar negative and linear pattern has been revealed for cognitive tasks such as recall and recognition. Based on these findings, we predict that even stronger effects of family configuration can be expected if the cognitive demands are further increased.

We also expected interactions between family configuration and age to occur in recall rather than in recognition assessments. In the literature, episodic tasks have been shown to be especially sensitive to reveal memory impairments in older individuals. However, no interactions involving sibship size and birth order were revealed in the overall analyses, although some interactions occur in the young-old and old-old groups. In line with previous expectations, more interactions occurred in recall than in recognition. However, most of these interactions vanished after control for education. Thus the present thesis contradicts the idea that effects of sibship size and birth order change with age. A possible reason for the variation of influence birth order has on different tasks may be that episodic memory tasks are more sensitive in revealing negative age-related effects in participants in comparison to ordinary intelligence tests (cf. Holmgren et al., 2006).

Scientists claim (e.g., Tooling, 1985) that semantic memory, which is related to intelligence, is more sensitive for formal education than episodic memory, because the aim with education is to acquire skills and knowledge of the world. These facts, in combination with the environmental theories of family configuration, made us expect the measurements of intelligence to be more sensitive for sibship size than episodic memory. The influence on episodic memory makes the results presented in this thesis especially interesting, and further investigations about sibship size, birth order, and episodic memory are certainly justified.

Considering the complex interaction of many variables within the field of family configuration, it makes analyses of causal relations difficult. However, the data in this thesis are interesting, since they suggest the childhood family configuration to be more associated to adult cognitive abilities than previously thought. The literature claims that general intelligence is inherited and unaffected permanently by childhood rearing environment (e.g., Bouchard, 1998; Plomin et al., 2001). Our result showing a larger sibship size effect with increasing age contradicts the opinion that *g* is not permanently affected by rearing circumstances that siblings share (Bouchard, 1998, Gottfredson, 2004; Plomin et al., 2001). However, Plomin and Petrill (1997) compiled the explained variance of heritability reported in several studies (e.g., McGue, Bouchard, Iacono, & Lykken, 1993; Plomin, 1986; Pedersen, Plomin, Nesselrode, & McClearn, 1992), and there was an

increase of heritability from 40% in childhood, to 60% in early adulthood, and to 80% in later life (60 years and above).

It has been claimed that specific cognitive abilities, such as verbal and spatial abilities, are more influenced by heritability than memory and processing speed (e.g., Thapar, Petrill, & Thompson, 1994). If this is correct, then it is surprising that our data reveal larger impact of recall with increasing age, since environmental factors are assumed to decrease with age. Birth order is also sometimes considered as a strictly environmental factor. Support for this statement is a study of biological and adoptive families conducted by Scarr and Weinberg (1977).

Parental age is another underlying factor suggested to contribute to the effects of family configuration. How will this factor affect the data in this thesis?

Wichman, Rodgers, and MacCallum (2006) believes it is important to control for mother's age at birth because it can influence sibship size and the conditions in the home under which children develop. Therefore, maternal age can capture many between-family environmental factors that may have an impact on children's intelligence. Paternal age is also associated with low birth weight. Risk factors for low birth weight (< 2500 grams) are first child-birth and teenage fathers (Tsung-Hsueh Lu, Fung-Chang Sung, and Chung-Yi Li, 2003). James (1969) reported that birth weight increases with birth order. In other words, a first-born child weighs less than second, and the second child weighs less than the third. This tendency disappears after the birth of the fifth child. It has also been reported that children with low birth weight endure increased risk of developing diseases (e.g., type 2 diabetes, coronary heart disease, and osteoporosis) in adult life (Barker, 1998). Shenkin, Starr, and Deary (2004) reviewed literature on the association between normal birth weight (>2500 grams) and childhood intelligence. They found a small positive relationship between birth weight and intelligence even after controlling for confounders.

The literature shows that parental age, birth weight, and health are variables that might be confounded with the effect of sibship size and birth order on cognitive abilities. Therefore, we have controlled for these potential confoundings by controlling for parental age and excluding individuals who suffer from diseases known to be associated with low birth weight. Another reason for excluding diseases is the relationship to lifestyle and socioeconomic status (e.g., Bäckman et al., 2004; Lee, Kawachi, Berkman, & Grodstein, 2003). The diseases excluded are dementia, heart attack, circulation disorders, stroke, hypertension, and diabetes (e.g., Bäckman, Jones, Small, Agüero-Torres, & Fratiglioni, 2003; Nilsson & Söderlund, 2001; Stachran, Ewing, Deary, & Frier, 1997).

We find that the effects of sibship size and birth order stay robust even when we control for parental age. Our data reveal no effect of parental age on cognitive performance. This result adds to the somewhat inconsistent

picture of what is found on studies of children. Several authors report both positive (e.g., Kalmijn & Kraaykamp, 2005; Record, McKeown, & Edwards, 1969) and negative (e.g., Malaspina et al. 2005) effects of parental age on children's intelligence score.

Sibship size and birth order as predictors of heart-related diseases

Several previous studies have demonstrated an association between sibship size, birth order and adult diseases, e.g., allergy (Karmaus, 2002), Alzheimer's disease (Moceri, et al., 2000), certain cancers (Hsieh, Tzonou, & Zavitsanos, et al., 1992; Vineis, et al., 2000; Westergaard, Melbye, Pedersen, et al., 1997), diabetes (Bingley, Douek, Rogers, & Gale, 2000). If family configuration functions as a predictor of these diseases mentioned above, we expect that sibship size and birth order may influence heart-related diseases as well. Another reason to expect that family configuration may have an effect on heart-related diseases is the assumption that precursors of adult cardiovascular diseases and hypertension are primed in fetal life or early postnatally (Amann, Plank, & Dötsch, 2004; Berenson, 1995). Study III in this thesis is support for that assumption.

The overall results of Study III reveal that sibship size might be a factor to be considered as a predictor of myocardial infarction and circulatory disorders, stroke, and hypertension. Being born in a family with many siblings constitutes a risk factor for developing these diseases. The association between sibship size and heart-related diseases was further reduced after inclusion of age, sex, parental age at birth or participant, life style (alcohol consumption and smoking), and, in particular, education. This suggests that at least some part of the association of sibship size was mediated through education.

The overall result revealed a significant main effect of birth order for stroke, but not for cardiovascular disease and hypertension. When controlling for covariates, there was still a tendency for statistical significance for birth order. The latter effect suggests that being born early in a sibship might be a risk factor for stroke.

Our results are in line with the results obtained by Bingley, Douek, Rogers, & Gale (2000). These authors reported that risk of type 1-diabetes, adjusted for parental age at birth of participant, was highest in first-born children and decreased with ascending birth order.

Larger sibship size has been considered to increase the probability of exposure to infectious agents (infection is linked with crowded living conditions), and a crowded home may be associated with lower socioeconomic status. Birth order, on the other hand, is suggested to influence the age of exposure to childhood infections. The theory behind is

that first-born children are exposed first when they enter daycare or school (Mucci, Hsieh, Williams, Dickman, Björkman, & Pedersen, 2004). It is suggested that sibship size and birth order has an impact on early-life infection patterns, and infectious agents have sometimes been considered as causing prostate cancer (Nomura & Kolonel, 1991) and diabetes, type 1- and 2 (e.g., Hales & Barker, 1992; Ziegler, Hummel, Schenker, & Bonifacio, 1999). There is also evidence that type 2-diabetes and cardiovascular diseases share the same environmental risk factors and the same underlying genetic construct (Kao et al., 2005). However, the underlying factors remain largely unknown (Karmaus, Arshad, & Mattes, 2001). The question of an underlying mechanism that explains a causal relationship is still to be answered. It should also be noted that earlier studies of birth order have reported inconsistent results (see Bingley, 2000). Thus, the role of family configuration should be examined more fully, especially within the domain of cardiovascular diseases, as such studies are largely lacking.

The results in the present study should be interpreted with cautiousness because of the small numbers of participants suffering from stroke ($N = 98$), hypertension ($N = 595$), and myocardial infarction and circulatory disorders ($N = 332$) distributed over the whole range of numbers of siblings and birth order.

Commonly, epidemiological studies comprise a large number of participants. In comparison to such studies (e.g., Mucci et al. 2004), the size of the Betula project (in this case 1025 participants) is quite small. Despite this fact, the data reveal a weak relationship between family configuration and diseases.

Methodological reflections

There are several methodological considerations in studies examining family configuration. With this in mind, a presentation of advantages and limitations using data from the Betula project will be discussed below.

It is important to emphasize that the aim of the present thesis is not to evaluate the validity of the theories that offer an explanation for the influence of family configuration on cognitive measures. Without within-family data, a test of a cause-effect relationship is not advisable, as several authors (e.g., Galbraith, 1982; Guo & VanWey, 1999; Retherford & Sewell, 1991; Rodgers, 1984; Zajonc, 1983) believe it is necessary to use longitudinal within-family data to test these theories. Unfortunately, the Betula project does not generate within-family data.

Several cross-sectional studies have been criticised for containing selection bias, such as the data of Belmont and Marolla (1973), which were based on Dutch military men. This kind of sample makes it difficult to decide whether the effects are due to socioeconomic status, race, region,

birth order, family size, or other variables (Rodgers, Cleveland, Oord, & Rowe, 2000). However, the design of the Betula project restricts possible selection biases as the study has been based on local and regional data sources, although it has been reported small differences between the Betula samples and the Swedish population, such that there is less formal education and lower income in the population than in the Betula samples (Nilsson et al., 1997).

However, the relatively large amount of information collected in the Betula study allows for some control of potentially important factors, such as education a proxy for socioeconomic status, parental age at time birth of subject, age of subject, and gender. Some of these factors are possible confounders according to Steelman (1985).

Health is another variable that might be confounded with sibship size and birth order, as health is related to life style and socioeconomic status (e.g., Richardson et al., 2004; Ganji & Kafai, 2003). Since considerable amounts of health data are available in the Betula study, some reduction of the risk of confounding could be achieved by excluding individuals who suffer from diseases (i.e., dementia, heart attack, circulation disorders, stroke, hypertension, and diabetes) known to affect cognitive performance. Several of these diseases are also linked to low birth weight.

Another advantage with the design of the Betula project is the possibility to compare results of cross-sectional and longitudinal data. Applying a cross-sectional design makes it promising to control for sources of variation in life-span development such as cohort effects and to examine, for example, whether the patterns are the same for middle-age, young-old, and old-old (i.e., age range 35 to 90), assuming the elderly participants have more siblings than the younger participants.

When using a longitudinal approach, practice effects may have to be attended to. Practice effects in Betula studies were examined by Rönnlund, Nyberg, Bäckman, and Nilsson (2005). These authors reported an amount of 1.5 T-scores of practice effect for both the younger and the older age cohort regarding episodic memory.

Some studies (e.g., Guo & VanWey, 1999) have reported problems with measuring sibship size, as siblings may experience a small change (i.e., one or two children added) or no change at all in sibship size during the time between test occasions. Advantages with Betula data from that point of view is the large range of sibship size from 1 to 16, and measurements take place after families have stopped expanding.

Another benefit with Betula data is the accessibility of standardised tests. In the first study, standardised tests assessing visuo-spatial (i.e., the block design test of Wechsler Adult Intelligence Scale) and verbal components (i.e., word comprehension) of intelligence were used. According to Steelman (1985), standardized assessments allow comparison between nations that otherwise would be contaminated by local variations in grading or

educational standards. However, this also brings us to the limitations of using data from the Betula study to examine family configuration. Since the design was originally planned to measure health and development of memory in adulthood and old age, the test battery was selected on those premises. As a consequence, other cognitive measures are underrepresented in the study. The Betula test battery is based on theories and definitions of memory put forward in the eighties. In so far as these theories and definitions are changed or under debate (e.g., Blair, 2006), questions about internal validity could arise.

Another disadvantage is that the database does not include enough information about children's home environment during their growth. For instance, did the siblings share the same environmental influences, such as parents, culture, friends, school, and neighbourhood? Other questions of interest are related to family characteristics, such as family income, parents' education, single parents, divorce, and addition of other adults in the household. It is not clear how long the siblings lived together, and there is no information about spacing between siblings, adoption, and half-sibling ship. There are also no data available for controlling the values and attitudes of the parents. It has been suggested that parents who are oriented towards providing their children with an environment of learning and knowledge may have fewer children on average, as they may believe that larger families cannot contribute the environment they want to create (Guo & VanWey, 1999).

Finally, another shortcoming is the limited number of cases distributed over age groups and family size, making it difficult to control for a possible confounding of family size and birth order. An attempt was done in the first study but data were collapsed across the age variable.

CONCLUSIONS

The aim of the present thesis was to shed some light on childhood family configuration and to examine the relation to cognitive adult performance and health.

The overall results indicate that healthy individuals in adulthood and old age show a decrease in performance on intelligence and executive functions as a function of increasing sibship size. The extension of this pattern from childhood to adulthood and old age is evidence for the consistency of the sibship size effect on cognitive measures. When controlling for education within each age group, the effects on intelligence and the subcomponents vanished, as did the effects on executive functions, except for the working memory subcomponent, indicating a rather complex pattern of factors behind the phenomenon of sibship size effects.

The results also reveal a birth order effect on working memory. The data show that first-born children perform at a higher level than later-born children. Study II replicates and extends the findings reported in study I in that impairment can be demonstrated not only for intelligence and executive functions but also for episodic memory. The effects of family configuration show the same trend over different cohorts and across adulthood and old age. Furthermore, the effects seem to be quite robust over time, as shown by the longitudinal study.

Study III demonstrated that sibship size and birth order may function as predictors of heart-related diseases. The results show that being born in a large sibship has an effect on myocardial infarction, stroke, and hypertension in old age, and being born early in a sibship might be a predictor of stroke.

The results presented in this thesis are of importance for increased understanding of the influence of childhood factors on cognitive functions and health in adulthood and old age.

Future directions

Future studies should focus on siblings of the participants in the Betula project. By letting the adult siblings perform the same cognitive tests and health examinations as their siblings in the Betula project, possibilities to examine the nature-nurture question will arise. Such a study would offer us the ability to make a longitudinal within-family examination, and thereby increase the knowledge about the influence of childhood family configuration on adulthood cognitive performance. Such a study will also contribute to bringing several new markers to the Betula battery, and thereby provide a good basis for future research.

Another important study would be to examine young families today, since family configurations seem to have changed somewhat in the last three-four decades. Thus it is likely there will be more divorces and remarriages and fewer children born per parents (3.7 in 1957 to 2.1 children per women 2006) than in the Betula samples studied so far. Also, day-care centres, preschools, and working parents make a difference.

A larger set of tasks is needed to further examine how to generalize the results of the present thesis, especially regarding results of intelligence and executive functions.

There is also a need for a comparative disease approach. As stated by Karmaus and Johnson (2005) researchers need to ask if there is a common underlying mechanism for various immune disorders (allergic disorders and diabetes) that causes similar relationships regarding birth order. In addition to these diseases mentioned above, heart-related diseases (Holmgren et al.,

2007) show similar relationship patterns with regard to birth order. What are the protective factors in higher birth orders?

Finally, of importance is to replicate the third study to examine if similar relationship patterns between sibling structure and heart-related diseases will occur.

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