Family Environments and Adult Cognitive Functioning

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Abstract

Individual differences in adult cognitive performance and cognitive styles are partitioned into effects attributable to heritability, shared perceptions of early family environment, unique perceptions of early family environment, and perceptions of current family environment as measured by the Moos scales. Data from the Seattle Longitudinal Study is examined for 537 parent-offspring and 294 sibling pairs. Significant effects of early family environment were found in the sibling dyads bud not in the parent-offspring dyads. Heritability was found to be greater in same-gender than cross-gender pairs, while the opposite finding occurred for shared perceptions of early family environment

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FAMILY ENVIRONMENTS AND ADULT COGNITIVE FUNCTIONING

Introduction

There is an extensive literature that has dealt with the relative contribution of inherited predispositions and the influence of both the shared and unique experiences occurring within the family of origin upon cognitive functioning in children. Much of this work is derived from twin studies because behavior geneticists have used the twin model as the most clearcut paradigm to investigate heritability of intelligence and many other traits (cf. Plomin, 1986). However, because twins represent a rather atypical subset of the general population, the role of family environments has also been investigated in parent-offspring and sibling pairs (e.g., Defries et al., 1976). Most studies report that roughly half of the individual difference variance in cognitive functioning is attributable to heritability. Very little variance on the other hand has been attributed to shared family environments. In fact it has been argued that the environment in the family of origin has quite unique influence upon different siblings (Plomin & Daniels, 1987).

Relatively little is known about the origin of individual differences in the later half of the life span as they might relate to inherited predispositions or to early influences transmitted through the family environment. Again twin studies dominate (e.g., Jarvik, Blum, & Varma, 1971; Plomin, Pedersen, Nesselroade, & Bergeman, 1988), and it is difficult to extrapolate to the more typical case of family similarities among nontwins.

In this talk I will present some findings from a large-scale longitudinal study of adult intellectual functioning, the Seattle Longitudinal Study (SLS; Schaie, 1996) that I believe may inform us on the relative contribution of heritability of certain cognitive traits and the extent to which current cognitive performance may be attributed to family influences that are shared with other family members during early life as well as the influences of the non-shared family setting currently being experienced by our subjects.

The Seattle Longitudinal Study

The research to be summarized here capitalizes on the longitudinal-sequential design of the SLS which offers the opportunity to compare young adult and middle-aged offspring with their middle-aged and old parents, as well as to compare sibling pairs from young adulthood to old age. The data for the parents and target siblings come from our inquiry into adult cognitive functioning that began some 35 years ago by randomly sampling 500 subjects equally distributed by sex and age across the range from 20 to 70 years from the approximately 18,000 members of a Health Maintenance Organization (HMO) in the Pacific Northwest (Schaie, 1983, 1989; 1996; Schaie & Hertzog, 1986). The survivors of the original sample were retested and additional panels were added in seven-year intervals; a total of over 5000 different individuals have been studied at least once. The sampling frame for the SLS represents a broad distribution of educational and occupational levels, covering the upper 75% of the socio-economic spectrum. This frame has grown to over 400,000 individuals, but the general characteristics of the HMO remain very comparable

to its structure at the inception of the study. The study design of the SLS is shown in Figure 1.

Insert Figure 1 about here

Throughout the course of the SLS our primary focus has been the investigation of psychometric abilities within the Thurstonian (1938) framework. However, we have also collected data on rigidity-flexibility, lifestyles, some personality traits, as well as the health histories of our participants (cf. Schaie & O'Hanlon, 1990). In order, to examine perceptions of shared environments we began to add appropriate scales for this purpose beginning with our 1989/90 data collections. Details of the measures included in the study reported here will be provided in the methods section below.

In this talk I will first summarize briefly what we have already learned about the heritability of cognitive functioning in adults and about the similarity of perceptions of family environments across generations. I will then turn in more detail to our most recent analyses which try to identify the contribution of family environments to adult cognitive functioning. We believe these analyses permit us to identify the salient family environment dimensions that influence adult cognitive functioning. They also permit us to provide estimates of the relative importance of heritability, early shared family environment, early non-shared family environments, and current family environment as they affect adult cognitive performance.

Methods

Subjects and Procedure

The participants in our family similarity studies consist of the adult offspring and siblings (22 years of age or older in 1990) of members of the SLS panels and their target relatives (i.e., the adult parents or sibling who had previously been studied). Panel members who participated in the fifth cycle of the SLS (1990-92) had a total of 3507 adult children. Of these, 1416 adult children (M = 701; F = 715) resided in the Seattle metropolitan area. They also had a total of 1999 siblings including 779 brothers and 1020 sisters.

The recruitment of the adult offspring and siblings began with a letter containing an update report on the SLS sent to all study participants tested in 1983/85. This letter also announced the family similarity study and requested that panel members provide names and addresses of siblings and adult offspring. A recruitment letter was then sent to all siblings and offspring thus identified. Those who agreed to participate in the study were tested in small groups or individually. Approximately 80% of the subjects tested resided in the Seattle metropolitan area. Other subjects were tested preferably when they visited their Seattle relatives, but approximately 150 subjects were tested in other locations throughout the United States. A total of 1176 relatives of our longitudinal panel members were tested. Of these 776 were adult offspring (465 daughters and 311 sons), and 400 were adult siblings (248 sisters and 152 brothers) of SLS participants.

Data on the target subjects (i.e., individuals who had previously been members of the SLS panel) were obtained during the 1991 longitudinal followup (data collection actually continued from mid-1990 to mid-1992). Subsequent to matching target subjects and their relatives, we were able to identify 512 parent-offspring and 294 sibling pairs on whom complete data is available; or a total sample of 1612 individuals. These consist of 106 father-son, 118 father-daughter, 115 mother-son, 198 mother-daughter, 51 brother-brother, 139 brother-sister, and 104 sister-sister pairings. The reduction in sample size occurred, because of substantial attrition in the number of study members whose relatives we had been able to assess earlier; among the older study members attrition was due primarily to death or sensory and motor disabilities that precluded further assessment or questionnaire response.

Table 1 provides a breakdown of parents, offspring and siblings by age and sex, using the 7-year cohorts conventionally employed in the SLS (cf. Schaie, 1983, 1996).

Insert Table 1 about here

Average age of the parents was 70.59 years (*SD* = 10.37) and 41.76 years (*SD* = 10.46) for the offspring. The parents averaged 14.22 years of education (*SD* = 2.75) as compared to 15.64 years of education (*SD* = 2.49) for their children. Total family income averaged $25,002 for the parents and $26,841 for the offspring, respectively.

Average ages for the siblings were 60.75 years (*SD* = 14.42) for the longitudinal study members and 59.62 years (*SD* = 14.77) for their relatives. The target siblings averaged 15.04 years of education (*SD* = 2.80) as compared to 14.90 years of education (*SD* = 2.72) for their brothers or sisters. Average incomes were $29,361 for the longitudinal study members, and $25,682 for their siblings.

Procedure. Potential subjects who agreed to participate were scheduled for group assessment sessions. Size of the groups ranged from 5 to 20 participants, depending upon the age of the subjects. The testing sessions lasted approximately 2 1/2 hours plus a "homework" package of questionnaires requiring approximately an additional hour of effort. Each session was conducted by a psychometrist aided by a proctor whenever more than 5 participants were tested simultaneously. Subjects were paid $25 for their participation.

Measures

While our data on cognitive functioning are based on formal psychometric assessment of our study participants, we must perforce rely upon our subjects ratings of their perceptions of their family environments. Our efforts to measure these perceptions were motivated by the fact that it is extremely difficult to measure current environments objectively. And it is of course virtually impossible to obtain information directly on the characteristics of family environments that pertained at earlier life stages. We therefore decided that it was necessary to infer these attributes by asking our subjects to

rate both their current environments and their retrospection of the family environment they experienced within their biological family of origin.

Primary Mental Abilities. The test battery administered to the participants in this study included multiple measures of cognitive abilities which broadly sample higher order constructs such as those espoused by Horn (1982). Thus fluid intelligence is represented by the abilities of Inductive Reasoning and Spatial Orientation, while Verbal Ability and Numeric Ability stand as representatives of crystallized intelligence.

A brief description of these abilities and their measures is given below. Test retest correlations for the ability measures come from a study of 172 individuals tested over a two week interval. Similar values for the other measures represent test-retest correlations over a seven-year interval.

Verbal Ability. Language knowledge and comprehension is measured by assessing the scope of a person's recognition vocabulary by matching one of four synonyms to a stimulus word (Thurstone & Thurstone,1949; test-retest correlation = .890).

Spatial Orientation. This is the ability to visualize and mentally manipulate spatial configurations, to maintain orientation with respect to spatial objects, and to perceive relationships among objects in space. The study participant is shown an abstract figure and is asked to identify which of six other drawings represents the model in two-dimensional space (Thurstone & Thurstone, 1949; test-retest correlation = .817).

Inductive Reasoning. This is the ability to educe novel concepts or relationships. The study participant is shown a series of letters (e.g., a b c c c b a d e f f e) and is asked to identify the next letter in the series (Thurstone & Thurstone, 1949; test-retest correlation = .884).

Numeric Ability. The ability to understand numerical relation-ships and compute simple arithmetic functions. The study participant checks whether additions of simple sums shown are correct or incorrect (Thurstone & Thurstone, 1949; test-retest correlation = .875).

Word Fluency. The ability to recall words easily is measured by asking the study participant to recall freely as many words as possible according to a lexical rule within a five minute period (Thurstone & Thurstone, 1949; test-retest correlation = .896).

Two summary scores can be generated from the PMA battery. The first is an Index of Intellectual Ability (an IQ equivalent). It takes the form of IQ = V + S + 2R + 2N + W. The second is an Index of Educational Aptitude (EQ; Thurstone, 1962) and takes the form of EQ = 2V + R.

Rigidity-Flexibility. The multiple dimensions of this construct are measured by the Test of Behavioral Rigidity (TBR; Schaie, 1955; Schaie & Parham, 1975; Schaie & Willis, 1991). The TBR was designed to measure the three dimensions of Psychomotor Speed (PS; test-retest correlation = .88), Motor-Cognitive Flexibility (MCF; test-retest correlation = .67), and Attitudinal Flexibility (AF; test-retest correlation = .84). Factor scores on these dimension

are estimated from linear combinations of the scores yielded from the three TBR sub-tests:

The Capitals Test. Participants copy a printed paragraph that contains some words starting with capital letters, others spelled entirely in capitals, and some starting with a lower case letter and their remainder in capitals. In the second half of the test, the paragraph is copied again, but in reverse form, i.e. substituting capitals for lower case letters, and lower case letters for capitals (adapted from Bernstein,1924).

The Opposites Test. Subjects respond to three lists of words (at a third-grade level of difficulty). The first list requires providing the antonym, the second list the synonym of the stimulus word., and the third list contains selected stimulus words from the previous lists which are responded to with an antonym if the stimulus word is printed in lower case letters, but with a synonym if printed in capitals (after Scheier and Ferguson, 1952).

The TBR Questionnaire. This is a 75-item true-false questionnaire that contains 22 rigidity-flexibility items (attitudinal flexibility) and 44 masking social responsibility items from the California Psychological Inventory (Gough, 1957; Gough, McCloskey, & Meehl, 1952; Schaie, 1959; Schaie & Parham, 1974). It also contains 9 (behavioral flexibility) items suitable for adults obtained from the Guttman-scaling of a perseveration scale first used by Lankes (1915),

Family environment. Moos and Moos (1986) constructed a 90-item true-and-false family environment scale measuring 10 different dimensions (each

measured by nine items) three of which they described as relationship, five as personal growth and the remaining two as system maintenance an change dimensions. The purpose of these scales were to provide an assessment instrument to examine environmental context of adaptation (Moos, 1985, 1987). We adapted eight of these scales for our purposes by selecting five items per scale and presenting each statement in Likert scale form (1 = strongly disagree, 2 = somewhat disagree, 3 = in between; 4 = somewhat agree; 5 = strongly agree). The eight dimensions included for our purpose and examples of statements scored in the positive direction on each dimension follow:

a. Cohesion (Relationship). Example: "Family members really help and support one another."

b. Expressivity (Relationship). Example: "We tell each other about our personal problems."

c. Conflict (Relationship). Example: "Family members hardly ever lose their temper."

d. Achievement Orientation (Personal Growth). Example: "We feel it is important to be the best at whatever we do."

e. Intellectual-Cultural Orientation (Personal Growth). Example: "We often talk about political and social problems."

f. Active-Recreational Orientation (Personal Growth). Example: "Friends often come over for dinner or to visit."

g. Organization (System Maintenance). Example: "We are generally very neat and orderly."

h. Control (System Maintenance). Example: "There are set ways of doing things at home."

Two forms of the Family Environment Scale (FES) were constructed: The first asked that the respondents rate their family of origin (i.e., past tense statement with respect to their parental family); the second form requested the same information (in present tense) with respect to their current family. They were then instructed to do the ratings with respect to the family grouping identified by them. In other words, for the parents this implied rating the "empty nest" family. In recognition of the fact that significant numbers of our young adult and older study participants lived by themselves, an alternate form was constructed which allowed defining the current family as those individuals (whether or not related by blood or marriage) that the respondent considered as his/her primary reference group and with whom the respondent interacted at least on a weekly basis.

A confirmatory factor analysis was conducted on a random half of the sample of relatives for both forms to determine whether the retained items clustered on the factors described by Moos. The obtained fit (Family of origin: $X^2(701) = 1235.56$, $p < .001$, GFI = .842, RMS = .084. Current family: $X^2(701) = 1254.48$, $p < .001$, GFI = .839, RMS = .089) was then confirmed on the second random half (Family of origin: $X^2(701) = 1266.05$, $p < .001$, GFI = .842, RMS = .090. Current family: $X^2(701) = 1357.07$, $p < .001$, GFI = .829, RMS = .089). Factor intercorrelations for both scales are shown in Table 2.

Insert Table 2 about here

Although we obtained a good fit for the primary dimensions of the Family Environment Scale, we were unable to reproduce the higher order structure postulated by Moos. Our findings will therefore be reported only with respect to Moos' primary dimensions.

Family Contact. As a measure of the intensity of family contact we asked respondents to indicate on a set of Likert scales the nature of their relationship, the number of years the respondent and their relative had lived in the same household, their physically visiting, talking on the telephone, writing letters, or obtaining news of their relative via a third party. Item scores were then summed to obtain a single contact score (a high score implying closeness and frequent contact).

Analyses

Ordinary least-squares regression (stepwise) was used to estimate the regression of each ability measure from the target (parent or panel-member sibling) upon the ability measure of the offspring or sibling-relative. The square root of the doubled regression coefficient represent the proportion of individual differences' variance attributable to heritability. Next we estimated the regression of the parental current family perceptions upon the offspring ability measures (respectively the target sibling family of origin upon the ability measures for the relative siblings). The square root of the doubled regression

coefficient represents the proportion of individual differences variance due to perceptions of the shared family environment. We then estimated the regression of the offsprings' and siblings' perception of their family of origin upon the abilities to obtain an estimate of the unique (non-shared) effect of the subjects' early family environment (cf. Rowe & Plomin, 1981), Finally we estimated the regression of both offspring's and siblings' current environment on their ability performance.

Results of the Family Studies

Family similarity in cognitive performances

We have previously reported our findings on cognitive similarity (Schaie, Plomin, Willis, Gruber-Baldini, & Dutta, 1992; Schaie, Plomin, Willis, Gruber-Baldini, Dutta, & Bayen, 1993). Briefly, we found that significant family similarities were observed for parent-offspring and sibling pairs for all ability measures, except perceptual speed, as well as for cognitive style measures of rigidity-flexibility. However, it should be noted that family similarity was greater for the parent-offspring than for the sibling dyads. Also patterns of similarity coefficient differed across gender combinations in both data sets. The magnitude of correlations for the ability measures were comparable for those found between young adults and their children (DeFries et al., 1976). Our data also strongly supported stability of parent-offspring correlations over as long as 21 years,

We had suspected that cohort effects in parent-offspring correlations would result in higher correlations for earlier cohorts, because of a decline in shared environmental influence attributed to an increase in extra-familial influences in more recent cohorts. This proposition could be supported only for the attitudinal trait of social responsibility (systematic cohort differences on this variable have previously been reported, e.g., Schaie and Parham, 1974). For the cognitive abilities, once again counter-intuitively, there seems to be stability or even an increase in family similarity for more recent cohorts. Finally, ability level differences within families equalled or approximated differences found for similar cohort ranges within a general population sample (cf. Schaie, 1996; Willis, 1989). When broken down by cohort groupings, such differences became generally smaller for the more recently born parent-offspring pairs.

Perceptions of family environments

We analyzed data for our adult siblings with respect to within generation similarities and differences, and we studied parent-offspring pairs to determine these relations across generations. Because of the possibility of shifts in these relationships for successive cohorts we also included a cohort variable, classifying our offspring into those born prior to World War II, those born during the war years and immediately thereafter, and into the early and late baby boomers (Schaie & Willis, 1995).

Our first and most dramatic conclusion was that there is a clear differentiation for parents, offspring, and sibling in the perceived level of all

family dimensions between the family of origin and the current family. . They see their current families as more cohesive and expressive but also characterized by more conflict than was true for their families of origin. What these changes reflect, of course, may simply express generally greater openness and engagement in family interactions. More intensive family interactions may also be represented by the reported increase in intellectual-cultural and active-recreational orientation from the family of origin to the current family. At the same time we found lower levels of perceived control, family organization and achievement orientation. Perhaps these judgments are another way of the increasing complexity of modern American families (cf. Elder, 1981; Elder & Rudkin, 1995; Hareven, 1987). When our parent-offspring sample is broken down into four distinct cohort groups, we noted further that the shift in perceived family level occurred primarily for perceptions of the family of origin, with much greater stability for the perception of current families.

Second, we found that sibling pairs share substantial variance in the perception of their family of origin (i.e., the family which they shared in childhood and adolescence) over all family dimensions that we examined. However, this commonality does not extend to their perception of their current (non-shared) families. The only exception to this finding was a low correlation for intellectual cultural orientation and family organization. In spite of the lack of similarity of current family environments in siblings, we do find that the best predictor for the level of each dimension of the current family turns out to be the corresponding level reported by each person for their family of

origin. Perhaps, perceptions of the family environment of origin may be one of the factors entering into marital assortativity, even though such perceptions may differ for and may differentially affect the perceptions of current family environments by different siblings.

Third, supporting evidence for the continuity of family values and behaviors (cf. Bengtson, 1986) was provided by substantial correlations between the parents' description of their current family environment and their offspring's description of their family of origin. Even though there is a substantial time gap in the period rated, these two rating do refer to the same parental family unit. These relationships were particularly strong for the three dimensions most closely reflective of value orientations (achievement, intellectual-cultural, and active-recreational) and for family organization.

Fourth, we concluded that the intensity (frequency) of contact between parents and offspring has virtually no impact upon the similarity of reported family environments. However, there were family environment dimensions (particularly level of family cohesion) that could predict almost a fourth of the variance in the total family contact scores.

Finally, we suggested that the hierarchy of the magnitude of shared perceptions, from low correlations when describing non-shared environments, to moderately high correlations when describing commonly experienced environments provides at least indirect evidence for the contention that self-descriptions of family environments (perceptions) may well be useful indicators of the actually experienced environments.

Family environments and cognitive performance

In our most recent analyses we now put together the two data bases and ask about the extent to which family environments influence current cognitive performance. We shall present findings for the mental abilities, their composites, and the measures of cognitive style, as well as for a Scale of Social Responsibility, for which trait we assume zero heritability (see Tables 3 and 4).

Parent-Offspring data. In the parent-offspring data set we find significant heritabilities for the five primary mental abilities and the derived summative indices, as well as for Psychomotor Speed. However, none of the regression coefficients for the abilities upon the parental perceptions of their current family environment (the estimate of shared environment) are significant. It seems that the time since our adult offspring shared the current family of their parents is simply too long.

Nevertheless, there were a number of significant regressions for the offspring perception of the family of origin (the unique experience of their early environment). These regressions accounted actually for more variance then the subjects' perception of their current environment (see below). Cohesion related positively to Spatial Orientation. Expressivity was negatively related to Verbal Meaning, Spatial Orientation, Inductive Reasoning, Motor-Cognitive Flexibility and Psychomotor Speed, but positively to Social Responsibility. Perceived conflict related positively to Number and negatively to Word Fluency. Achievement orientation related positively to Number and Motor-Cognitive Flexibility. Intellectual-Cultural orientation related positively to Verbal

Meaning Inductive Reasoning and the Index of Educational Aptitude as well as to Social Responsibility. It related negatively to Spatial Orientation. Active-Recreational orientation related positively to Inductive Reasoning, but negatively to Verbal Meaning Number, Educational Aptitude and Social responsibility. Organization related negatively to Inductive Reasoning and Motor-Cognitive Flexibility. Finally, perceived Control related negatively to Verbal Meaning, Spatial Orientation and the combined indices.

Significant regressions for the effect of the current environment were also found. Cohesion related positively to Word Fluency and the IQ index, but negatively to Attitudinal Flexibility. Expressivity related positively to Verbal Meaning, Educational Aptitude, Attitudinal Flexibility and Psychomotor Speed. Conflict related positively to Social Responsibility. Achievement orientation related negatively to Attitudinal Flexibility. Intellectual-Cultural orientation related positively to Verbal Meaning, Attitudinal Flexibility and Psychomotor Speed. Active-Recreational orientation related positively to Spatial Orientation. Organization related negatively to the IQ index and Attitudinal Flexibility. Control related positively to Social Responsibility but negatively to Attitudinal Flexibility.

Insert Table 3 about here

Sibling data. Significant heritabilities are again observed for the Primary Mental Abilities (except for Inductive Reasoning) and their composite indices,

as well as for Attitudinal Flexibility and Psychomotor Speed. Substantial regressions are also found for the shared environment in the family of origin. Cohesion influences negatively Word Fluency, intellectual aptitude and Psychomotor Speed. Expressivity relates negatively to Verbal Meaning, Educational Aptitude and Motor-Cognitive Flexibility. Achievement orientation relates positively to Motor-Cognitive Flexibility and Social Responsibility. Intellectual-Cultural orientation relates positively to Verbal Meaning, Word Fluency, the combined indices, Motor-Cognitive Flexibility and Psychomotor Speed. Active-Recreational Orientation relates positively to Number. Organization relates negatively to Spatial Orientation and Motor-Cognitive Flexibility. Finally, Control relates positively to Spatial Orientation.

Smaller but significant contributions are provided by the unique perceptions of the family origin. These include a positive correlation between Expressivity and Social Responsibility, but negative relations of that dimension with Spatial Orientation Inductive Reasoning, the combined indices and Motor-Cognitive Flexibility. Conflict relates negatively to Verbal Meaning.. Intellectual-Cultural orientation relates positively to Attitudinal Flexibility, but negatively to Word Fluency and Psychomotor Speed. Active-Recreational Orientation relates positively to Spatial Orientation, Inductive Reasoning, Word Fluency and intellectual aptitude, as well as to Motor-Cognitive Flexibility and Psychomotor Speed, And Control relates positively to Word Fluency but negatively to Social Responsibility.

Significant regressions are also found for the influences of perceptions of the current family environment. Here Cohesion relates positively to Spatial Orientation and Number. Expressivity relates positively to Verbal Meaning Inductive Reasoning, educational aptitude. Motor-Cognitive Flexibility and Psychomotor Speed. Conflict relates negatively to Motor-Cognitive Flexibility. Achievement orientation relates negatively so Social Responsibility. Intellectual-Cultural orientation relates positively to Verbal Meaning, Word Fluency, educational aptitude, Psychomotor Speed and Social Responsibility. Active-Recreational orientation relates positively to Attitudinal Flexibility. Organization relates negatively to Spatial Orientation, Inductive Reasoning, the combined indices, Motor-Cognitive Flexibility and Attitudinal Flexibility. Control relates negatively to Verbal meaning and Attitudinal Flexibility,

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Insert Table 4 about here

Proportions of Individual Differences Accounted for by Heritability, Shared Early Environment, Unique Early Environment and Current Environment

We now come to the critical issue of the extent to which individual differences in cognitive performance in adulthood can be allocated to heritability and shared early environment, and how much is due to the unique influences of early and current family environments. We examine this question

only for the sibling data, because all of the influences of interest are most clearly represented in this data set.

We first note that heritability ranges from zero for Social Responsibility to a high of 58.7% for Inductive Reasoning. The total contribution of all family environment sources by contrast ranges from a low of 8.1% for Number to a high of 50.2% for Spatial Orientation. When we consider the joint effect of heritability and early shared environment, the proportion of explained individual differences ranges from a low of 10.2% for Social Responsibility to a high of 79.6% for Psychomotor Speed. For the primary mental abilities these values are Verbal Meaning, 42.9%; Spatial Orientation, 66.7%; Inductive Reasoning, 58.7%; Number. 18.2%, and Word Fluency, 65.8%. Table 7 and Figures 2 to 4 show the detailed breakdown into the various sources of variance.

Insert Table 7 and Figures 2 - 4 about here

Proportion of Individual Differences by Gender Pairing

Because of our previous findings of substantial differences in heritability for cognitive performance by gender pairings, we also explore these differences for the impact of family environment on adult cognition. We again examine these matters for the sibling data only. Because of sample size limitations for the brother-brother dyads, we contrast data for the sister-sister and sister-brother pairs. As shown in Table 8 and Figures 5 to 9, we found substantial

differences in proportions of variance accounted for between the different gender parents. With the exception of Attitudinal Flexibility, proportions of variance due to heritability substantial larger in the same gender than the cross-gender pairs. Differences for the effects of the shared early environment also impressive. These effects are substantially larger for the same gender pairs for Verbal Meaning, Number, Educational Aptitude, Attitudinal Flexibility, Psychomotor Speed and Social Responsibility. But they are substantially larger for the cross-gender pairs for Spatial Orientation Inductive Reasoning, Word Fluency and Motor-Cognitive Flexibility. Some differences were also found in the unique effects of the early environment. These were larger for same gender pairs for Number, Intellectual Aptitude, Motor-Cognitive Flexibility, Psychomotor Speed and Social Responsibility By contrast proportions of variance were greater for Verbal Meaning, Inductive Reasoning and Word Fluency in the cross-gender pairs. Proportions of variance due to the unique current environment were generally small in the sam-gender pairs, but they exceed 10% of the variance accounted for in the cross-gender pairs for all variables except Inductive Reasoning, Number, and Attitudinal Flexibility.

Insert Table 8 and Figures 5-9 about here

Discussion

Given the assumption that individual's perceptions of family environments are reasonable representations of such environments we find

that the impact of shared early environment upon adult cognitive performance can be demonstrated in sbiling but not in parent-offspring dyads. This discrepancy is readily explained by the fact that the parental family perceptions must be measured by inquring about their current family (which is the family of origin of the offspring), On the other hand, the sibling's perception of the famiy origin involves retrospection to that time interval most of which was shared with the target sibling. However, influences of the unique early environment (involving the subject's own retrospection) and current environment yielded significant proportions of variance in adult cognitive performance in both the parent-offspring in sibling samples..

We once again noted significant differences in both heritability and shared early environment estimates between same-gender and cross-gender pairs. In genera, heritability estimates were higher in same gender pairs, while the effect of shared early environment was greater in cross-gender pairs for most (but not all) variables.

What were the family environment dimensions that were most salient in predicting adult cognitive performance? As far as the early environment was concerned there was a clear positive effect of a strong intellectual-cultural family orientation. On the other hand high levels of family cohesion had a negative effect. Interestingly enough high levels of expressivity suppressed flexible attit ıdes and reported social responsibility in sister-ɜister but not in brother-sister dyads.

High expressivity estimates from the unique perceptions of the early environment also seemed to have negative effects on several cognitive variables, while the unique perception of high active-recreational orientation had positive impact. By contrast, positive influences on cognitive performance and positive cognitive styles of the current family environment involved primarily high levels of cohesion, expressivity and intellectual cultural orientation coupled with low levels of family organization.

This study makes somewhat strong assumptions about the utility of perceptions as measures of family environment and further investigations with better estimates of early environment as reported by the adult parents is needed. Nevertheless, we think that it is fair to conclude that we have provided strong evidence for the importance of early family environment (both shared and uniquely experienced) in understanding family similarity in adult cognitive performance. While we do not wish to deny the important contribution of genetic transmission of individual differences in cognition, and the not insignificant contribution of current family environments, we nevertheless here call attention to the even stronger influence of early family environment in shaping cognitive performance throughout the life-span.

References

Bengtson, V. L. (1986). Sociological perspective on aging, the family and the future. In M. Bergener (Ed.), *Perspectives on aging: The 1986 Sandoz lectures in gerontology.* New York: Academic Press.

Bernstein, E. (1924). Quickness and intelligence. *British Journal of Psychology, 3*(7).

Defries, J. C., Ashton, G. C., Johnson, R. C., Kusi, A. R., McClearn, G.E., Mi, M. P., Rashad, M. N., Vandenberg, S.G., & Wilson, J. R. (1976). Parent-offspring resemblance for specific cognitive abilities in two ethnic groups. *Nature, 261* (5556), 131-133.

Elder, G. H., Jr. (1981). History of the family: The discovery of complexity. *Journal of Marriage and the Family, 43,* 489-519.

Elder, G. H., Jr., & Rudkin, L. (1995). Intergenerational continuity and change in rural America. In V. L. Bengtson, K. W. Schaie, & L. Burton (Eds.), *Societal Impact on Aging: Intergenerational Perspectives* (pp.). New York: Springer.

Gough, H. G. M., H., & Meehl, P. E. (1952). A personality scale for social responsibility. *Journal of Abnormal and Social Psychology, 42,* 73-80.

Hareven, T. K. (1982). Family history at the crossroads. *Journal of Family History, 12,* ix-xxiii.

Jarvik, L. F., Blum, J. E., & Varma, A. O. (1971). Genetic components and intellectual functioning during senescence: A 20-year study of aging twins. *Behavior Genetics, 2,* 159-171.

Lankes, W. (1915). Perseveration. *British Journal of Psychology, 7*, 387-419.

Moos, R. H., & Moos, B. (1986) *Family Environment Scale manual* (2nd ed). Palo Alto, CA: Consulting Psychologists Press.

Plomin, R. (1986). Development, genetics, and psychology. Hillsdale, NJ: Erlbaum.

Plomin, R., & Daniels, D. (1987). Why are two children in the same family so different from each other? *The Behavioral and Brain Sciences, 10*, 1-16.

Plomin, R., Pedersen, N. L., Nesselroade, J. R., & Bergeman, C. S. (1988). Genetic influence on childhood family environment perceived retrospectively from the last half of the life span. *Developmental Psychology, 24*, 738-745.

Rowe, D. C., & Plomin, R. (1981). The importance of nonshared (E1) environmental influences in behavioral development. *Developmental Psychology, 17*, 517-531.

Schaie, K. W. (1955). A test of behavioral rigidity. *Journal of Abnormal and Social Psychology, 51*, 604-610.

Schaie, K. W. (1983). The Seattle Longitudinal Study: A twenty-one year exploration of psychometric intelligence in adulthood. In K. W. Schaie (Ed.), *Longitudinal studies of adult psychological development* (pp. 64-135). New York: Guilford Press.

Schaie, K. W. (1996). *Intellectual development in adulthood: The Seattle Longitudinal Study*. New York: Cambridge University Press.

Schaie, K. W., & O'Hanlon, A. M. (1990). The influence of social-environmental factors in the maintenance of adult intelligence. In R. Schmitz-Scherzer, A. Kruse & E. Olbrich (Eds.). *Altern - Ein lebenslanger Prozess der Sozialen Interaktion* [Aging - A lifelong process of social interaction] (pp. 55-66). Darmstadt: Steinkopf Verlag.

Schaie, K. W., & Parham, I. A. (1974). Social responsibility in adulthood: Ontogenetic and sociocultural change. *Journal of Personality and Social Psychology, 30,* 483-492.

Schaie, K. W., & Parham, I. A. (1975). *Manual for the Test of Behavioral Rigiditity.* Palo Alto, CA: Consulting Psychologists Press.

Schaie, K. W., Plomin, R., Willis, S. L., Gruber-Baldini, A., & Dutta, R. (1992). Natural cohorts: Family similarity in adult cognition. In T. Sonderegger (Eds.), *Psychology and aging: Nebraska Symposium on Motivation, 1991* (pp. 205-243). Lincoln, NE: University of Nebraska Press.

Schaie, K. W., Plomin, R., Willis, S. L., Gruber-Baldini, A. L., Dutta, R., & Bayen, U. (1993). Family similarity in adult intellectual development. In J. J. F. Schroots (Ed.), *Aging, health and competence: The next generation of longitudinal research* (pp. 183-198). Amsterdam, The Netherlands: Elsevier.

Schaie, K. W., & Willis, S. L. (1991). Adult personality and psychomotor performance: Cross-sectional and longitudinal analyses. *Journal of Gerontology: Psychological Sciences, 46,* P275-284.

Schaie, K. W., & Willis, S. L. (1995). Perceived family environments across generations. In V. L. Bengtson, K. W. Schaie, & L. Burton (Eds.), *Adult intergenerational relations: Effects of societal change* (pp. 174-209). New York: Springer.

Scheier, I., & Ferguson, G. A. (1952). Further factorial studies of tests of rigidity. *Canadian Journal of Psychology, 6*, 19-30.

Thurstone, L. L. (1938). *The primary mental abilities.* Chicago: University of Chicago Press.

Thurstone, L. L., & Thurstone, T. G. (1949). *Examiner Manual for the SRA Primary Mental Abilities Test (Form 10-14).* Chicago: Science Research Associates.

Thurstone, T. G. (1962). *Primary mental abilities for grades 9-12.* Chicago: Science Research Associates.

Willis, S. L. (1989). Cohort differences in cognitive aging: A sample case. In K. W. Schaie & C. Schooler (Eds.), *Social structure and aging: Psychological processes* (pp. 94-112). Hillsdale, NJ: Erlbaum.

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Footnotes

[1]Regression coefficicients are reported only for values that reach a $p <$ .10. This level was chosen because regression values for heritability and shared environment are doubled before extimating proportion of variance accounted for.

Table 1

Age and Sex Distribution of Study Participants

	Parents (Targets) (1991)			Offspring (Relatives) (1990)			Siblings (Targets) (1991)			Siblings (Relatives) (1990)		
Age Range	M	F	T	M	F	T	M	F	T	M	F	T
22 - 28	-	-	-	19	19	38	-	-	-	1	2	3
29 - 35	-	-	-	53	76	129	2	11	13	6	13	19
36 - 42	-	-	-	52	85	137	14	10	24	9	19	28
43 - 49	-	11	11	50	66	116	19	20	39	10	22	32
50 - 56	15	29	44	26	37	63	13	21	34	13	15	28
57 - 63	31	52	83	16	20	36	15	23	38	18	27	45
64 - 70	41	60	101	3	7	10	28	29	57	22	38	60
71 - 77	61	67	128	1	5	6	21	27	48	25	28	53
78 - 84	43	56	99	-	1	1	15	18	34	6	14	20
85 - 91	14	28	42	-	-	-	2	4	6	2	4	6
92 +	9	10	19	-	-	-	-	2	2	-	-	-
Total	224	313	537	221	316	537	129	165	294	112	182	294

Table 2

Intercorrelation of Family Environment Scales

(Family of Origin Above Diagonal, Current Family Below Diagonal)

	Cohesion	Express.	Conflict	Achievement Orientation	Intell. Cultural	Active-Recreational	Organiz.	Control
Cohesion		.860	.664	.372	.434	.524	.272	-.133
Expressivity.	.837		.341	.339	.483	.515	.033	-.208
Conflict	.565	.323		.065	.161	.210	.256	-.286
Achievement-Orientation	.274	.239	.009		.430	.369	.333	.289
Intellectual-Cultural	.492	.562	.251	.234		.659	.056	-.130
Active-Recreational	.448	.453	.093	.445	.606		.138	-.038
Organization	.346	.235	.346	.234	.149	.186		.393
Control	-.013	-.121	-.155	.209	-.216	.006	.448	

Table 3

Regression Coefficients for Parent-Offspring Study

Predictors	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency	IQ	EQ
Parents' Ability (Heritability)	.161	.217	.281	.183	.245	.219	.210
Parent's perception							
C				o			
E			x				p
C					o		
A				c			
I			n				t
A					c		
O					r		
C					o		
Offspring's perception of family of origin							
Cohesion		.166					
Expressivity	-.172	-.145	-.182			-.116	-.190
Conflict				.105	-.140		
Achievement				.091			
Intellectual-Cultural	.123	-.102	.083				.122
Active-Recreational	-.131		.081	-.076			-.089
Organization			-.086				
Control	-.119	-.142				-.096	-.118
Offspring's perception of current family							
Cohesion					.104	.075	
Expressivity	.123						.123
Conflict							
Achievement							
Intellectual-Cultural	.103						
Active-Recreational		.073					
Organization						-.071	
Control							

(Continued on next page)

Table 3

Regression Coefficients for Parent-Offspring Study (Continued)

Predictors	M		R	Social
Parents' Status (Heritability)		.201		
Parent's perception				
Cohesion				
Expressivity				
Conflict				
Achievement				
Intellectual-Cultural				
Active-Recreational				
Organization				
Control				
Offspring's perception of family of origin				
Cohesion		.		
Expressivity	-.153	-.131		.154
Conflict				
Achievement	.086			
Intellectual-Cultural				.128
Active-Recreational				-.131
Organization	-.115			
Control				
Offspring's perception of current famuly				
C		-		
E		.	.	
C				.
A		-		
I		.	.	
A				
O		-		
C		-		.

Table 4

Regression Coefficients for Sibling Study

Predictors	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency	IQ	EQ
Target Sibling's Ability (Heritability)	.194	.254	.383	.142	.239	.252	.248
Target Sibling's perception							
Cohesion					-.246	-.204	
Expressivity	-.179						-.127
Conflict							
Achievement							
Intellectual-Cultural	.200				.217	.210	.178
Active-Recreational				.159			
Organization		-.179					
Control		.265					
Sibling's perception of family of origin							
Cohesion							
Expressivity		-.158	-.255			-.166	-.142
Conflict	-.101						
Achievement							
Intellectual-Cultural					-.133		
Active-Recreational		.153	.119		.174	.145	
Organization							
Control					.099		
Sibling's perception of current family							
Cohesion		.136		.209			
Expressivity	.168		.216				.195
Conflict							
Achievement							
Intellectual-Cultural	.170				.158		.154
Active-Recreational							
Organization		-.165	-.168			-.186	-.190
Control	-.125						

(Continued on next page)

Table 4

Regression Coefficients for Sibling Study (Continued)

Predictors	Motor-Cognitive Flexibility	Attitudinal Flexibility	Psychomotor Speed	Social Responsibility
Target sibling's status (Heritability)		.164	.260	
Targett sibling's perception				
Cohesion			-.248	
Expressivity	-.123			
Conflict				
Achievement	.231			.160
Intellectual-Cultural			.265	
Active-Recreational				
Organization	-.178			
Control				
Sibling's perception of family of origin				
Cohesion				.212
Expressivity	-.219			
Conflict				
Achievement				
Intellectual-Cultural		.131	-.168	
Active-Recreational	.162		.113	
Organization				
Control				-.119
Siblring's perception of current famuly				
Cohesion				
Expressivity	.272		.117	
Conflict	-.126			
Achievement				-.194
Intellectual-Cultural			.128	.362
Active-Recreational		.165		
Organization	-.194	-.145		
Control		-.190		

Table 5

Proportion of Variance by Source for Parent-Offspring Study

Variables	Heritability	Shared Early Environment	Unique Early Environment	Unique Current Environment
Verbal Meaning	11.1	-	7.6	2.6
Spatial Orientation	18.8	-	7.9	0.5
Inductive Reasoning	31.6	-	5.4	-
Number	13.4	-	2.5	-
Word Fluency	24.0	-	2.0	1.1
IQ	19.2	-	2.2	1.1
EQ	17.6	-	7.2	1.5
Motor-Cognitive Flexibility	-	-	4.3	-
Attitudinal Flexibility	-	-	-	11.1
Psychomotor Speed	16.2	-	1.7	2.5
Social Responsibility	-	-	6.1	3.6

Table 6

Proportion of Variance by Source for Sibling Study

Variables	Heritability	Shared Early Environment	Unique Early Environment	Unique Current Environment
Verbal Meaning	14.7	28.8	1.0	7.2
Spatial Orientation	25.8	40.9	4.8	4.5
Inductive Reasoning	58.7	-	7.9	7.5
Number	8.1	10.1	-	4.4
Word Fluency	22.8	43.0	5.8	2.4
IQ	25.4	34.2	4.9	3.5
EQ	24.6	19.1	2.0	9.8
Motor-Cognitive Flexibility	-	40.3	7.4	12.8
Attitudinal Flexibility	10.8	-	1.7	8.4
Psychomotor Speed	27.0	52.6	4.1	3.0
Social Responsibility	-	10.2	6.0	16.9

Table 7

Regression Coefficients By Gender Combination for Sibling Study

Predictors	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency	IQ	EQ
			Brother-Sister Pairs				
Target Sibling's Ability (Heritability)	.182	.142	.344		.211	.179	.209
Target Sibling's perception							
Cohesion			-.304		-.460	-.172	
Expressivity							
Conflict							-.169
Achievement		.200		.334			
Intellectual-Cultural					.338		
Active-Recreational			.279			.204	
Organization		-.321					
Control		.220					
Sibling's perception of family of origin							
Cohesion			.421		.188		
Expressivity		-.166	-.349				
Conflict	-.333		-.297			-.154	-.234
Achievement							
Intellectual-Cultural				-.174	-.388		
Active-Recreational	.200				.260		.240
Organization	.149						
Control					.267		
Sibling's perception of current family							
Cohesion	.246			.215			.268
Expressivity	.	.240	.296			.244	
Conflict							
Achievement							
Intellectual-Cultural	.181				.210		
Active-Recreational		.211	.123	.156		.171	
Organization	-.408	-.217	-.250		-.132	-.293	-.423
Control							

(Continued on next page)

Table 7

Regression Coefficients by Gender Combination for Sibling Study (Continued)

Predictors	Motor-Cognitive Flexibility	Attitudinal Flexibility	Psychomotor Speed	Social Responsibility
		Brother-Sister Pairs		
Target sibling's status (Heritability)		.225	.261	
Targett sibling's perception				
Cohesion				
Expressivity	-.296			
Conflict	-.198			-.145
Achievement	.306			.235
Intellectual-Cultural				
Active-Recreational	.216			
Organization			-.136	
Control	-.210			
Sibling's perception of family of origin				
Cohesion				.228
Expressivity				
Conflict			-.134	
Achievement	.206			
Intellectual-Cultural	-.179			
Active-Recreational		-.186		
Organization				
Control				
Siblring's perception of current famuly				
Cohesion				
Expressivity	.336		.232	
Conflict				
Achievement				-.181
Intellectual-Cultural				.440
Active-Recreational		.189	.220	
Organization	-.268		-.196	
Control		-.251		

(Continued on next page)

Table 7

Regression Coefficients By Gender Combination for Sibling Study (Continued)

Predictors	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency	IQ	EQ
			Sister-Sister Pair				
Target Sibling's Ability (Heritability)	.419	.385	.395		.324	.300	.420
Target Sibling's perception							
Cohesion							
Expressivity							
Conflict							.243
Achievement							
Intellectual-Cultural					.166	.183	
Active-Recreational	.252			.328			
Organization							
Control		.218		-.224			
Sibling's perception of family of origin							
Cohesion	-.322		-.268	-.344		-.355	-.252
Expressivity					-.181		
Conflict		-.197					
Achievement			-.302				-.196
Intellectual-Cultural							
Active-Recreational							
Organization	-.167						
Control				-.249	-.189		
Sibling's perception of current family							
Cohesion	.246			.222		.201	
Expressivity							
Conflict							
Achievement	-.197						
Intellectual-Cultural							
Active-Recreational							
Organization					.269		
Control							

(Continued on next page)

Table 7

Regression Coefficients by Gender Combination for Sibling Study (Continued)

Predictors	Motor-Cognitive Flexibility	Attitudinal Flexibility	Psychomotor Speed	Social Responsibility
		Sister-Sister Pairs		
Target sibling's status (Heritability)		.185	.395	
Targett sibling's perception				
Cohesion				.448
Expressivity		-.412		-.289
Conflict				
Achievement				
Intellectual-Cultural			.355	
Active-Recreational				
Organization			.215	
Control				
Sibling's perception of family of origin				
Cohesion			-.206	.186
Expressivity	-.382			
Conflict	-.203	.254		
Achievement				
Intellectual-Cultural			-.300	
Active-Recreational	.246		.243	
Organization			-.236	-.294
Control				
Siblring's perception of current famuly				
Cohesion				
Expressivity	.193			
Conflict				
Achievement				
Intellectual-Cultural				.285
Active-Recreational				
Organization		-.192	.230	
Control				

Table 8

Proportion of Variance by Source and Gender Pairing for Sibling Study

Variables	Heritability		Shared Early Environment		Unique Early Environment		Unique Curren Environment	
	S/S	**B/S**	**S/S**	**B/S**	**S/S**	**B/S**	**S/S**	**B/S**
Verbal Meaning	59.3	13.2	21.3	-	10.8	17.3	8.6	26.1
Spatial Orientation	49.0	8.1	19.0	71.6	3.9	3.5	-	14.9
Inductive Reasoning	62.4	27.7	-	40.1	16.9	22.7	-	9.5
Number	-	-	62.1	44.6	18.0	3.0	4.9	7.0
Word Fluency	42.0	9.6	17.0	69.7	6.7	17.4	7.2	3.3
IQ	36.0	12.8	13.4	28.2	12.6	2.3	4.0	17.5
EQ	67.6	17.4	22.7	11.4	9.7	11.3	-	25.1
Motor-Cognitive Flexibility	-	-	-	82.7	24.9	5.0	3.7	12.3
Attitudinal Flexibility	13.7	20.2	67.8	-	6.5	3.5	3.7	9.9
Psychomotor Speed	38.2	27.2	42.0	7.4	16.6	1.8	3.2	14.0
Social Responsibility	-	-	81.5	30.5	11.1	5.2	7.4	22.7

Figure Captions

Figure 1. Design of the Seattle Longitudinal Study.

Figure 2. Sources of variance in individual differences in cognitive performance for five primary mental abilities.

Figure 3. Sources of variance in individual differences for the indices of intellectual ability and educational aptitude.

Figure 4. Sources of variance in individual differences for cognitive styles and social responsibility.

Figure 5. Sources of variance in individual differences by gender for Verbal Meaning, Spatial Orientation and Inductive Reasoning.

Figure 6. Sources of variance in individual differences by gender for Number and Word Fluency.

Figure 7. Sources of variance in individual differences by gender for the indices of intellectual ability and educational aptitude.

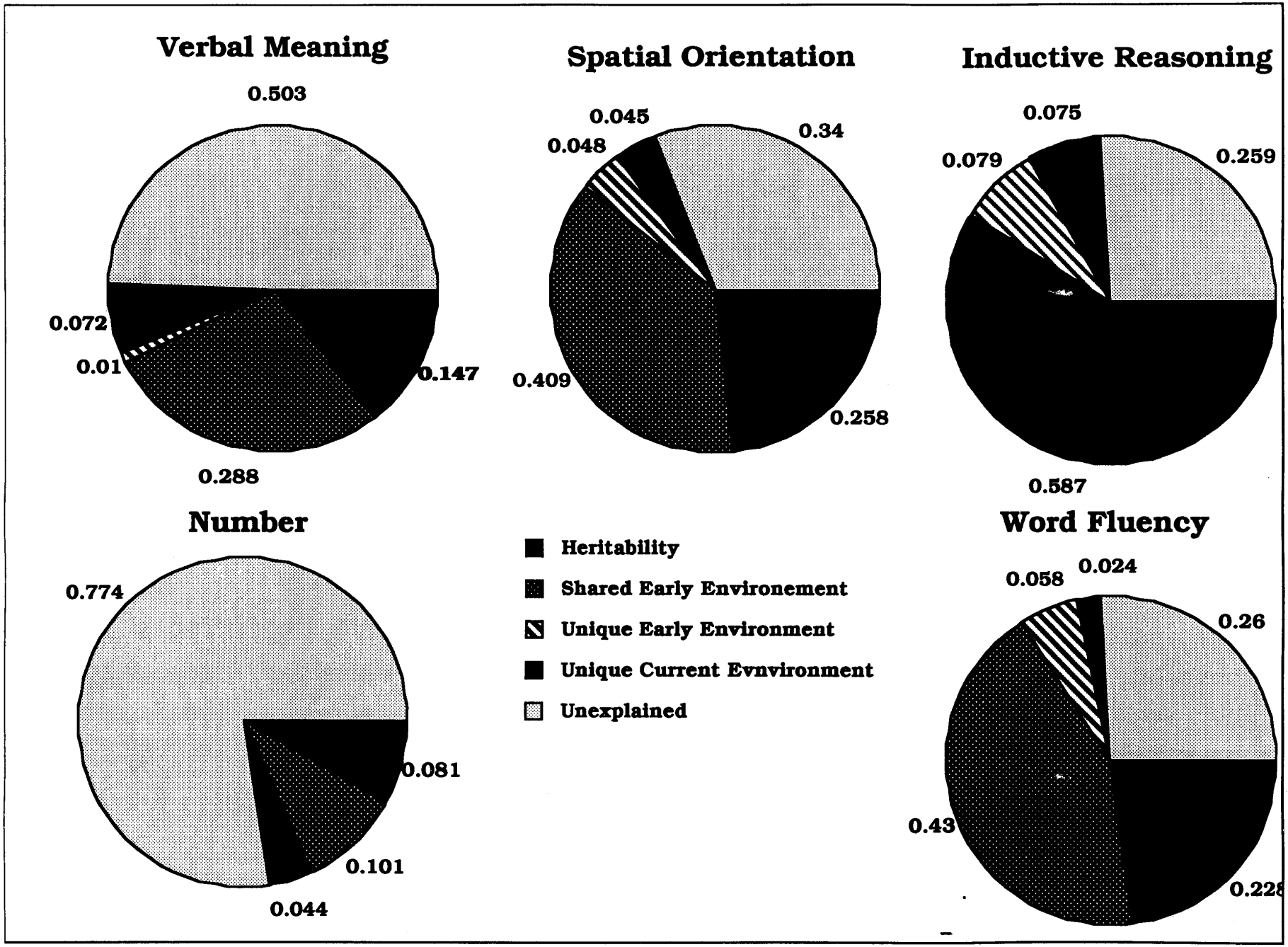
Figure 8. Sources of variance in individual differences by gender for Motor-Cognitive Flexibility and Attitudinal Flexibility.

Figure 9. Sources of variance in individual differences by gender for Psychomotor Speed and Social Responsibility.

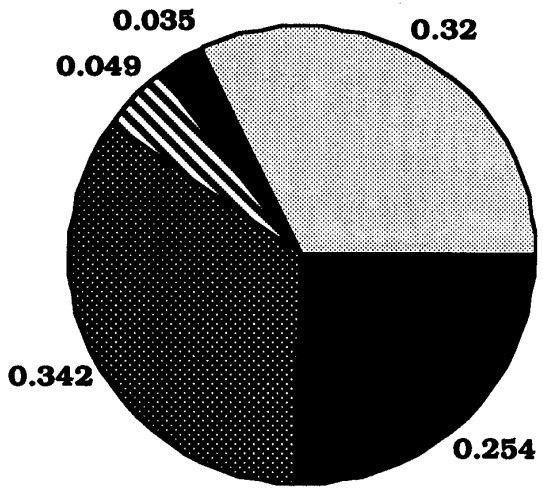
Figure 1. Basic Design of the Seattle Longitudinal Study (SLS)

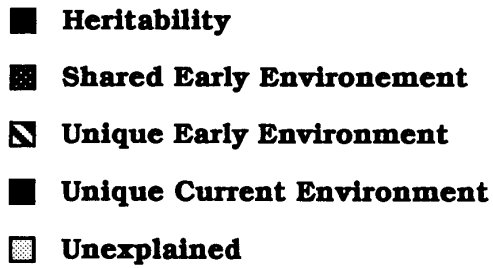
Study Waves					
1956	1963	1970	1977	1984	1991
S_1T_1 (N = 500)	S_1T_2 (N = 303)	S_1T_3 (N = 162)	S_1T_4 (N = 130)	S_1T_5 (N = 92)	S_1T_6 (N = 71)
	S_2T_2 (N = 997)	S_2T_3 (N = 420)	S_2T_4 (N = 337)	S_2T_5 (N = 204)	S_2T_6 (N = 161)
		S_3T_3 (N = 705)	S_3T_4 (N = 340)	S_3T_5 (N = 225)	S_3T_6 (N = 175)
			S_4T_4 (N = 612)	S_4T_5 (N = 294)	S_4T_6 (N = 201)
				S_5T_5 (N = 628)	S_5T_6 (N = 428)
					S_6T_6 (N =690)

S = Sample; T = Time of Measurement


Verbal Meaning
0.503
0.072
0.01
0.147
0.288
Spatial Orientation
0.045
0.34
0.048
0.409
0.258
Inductive Reasoning
0.075
0.079
0.259
0.587
Number
0.774
0.081
0.101
0.044
Heritability
Shared Early Environement
Unique Early Environment
Unique Current Evnvironment
Unexplained
Word Fluency
0.058
0.024
0.26
0.43
0.228

Intellectual Ability (IQ)





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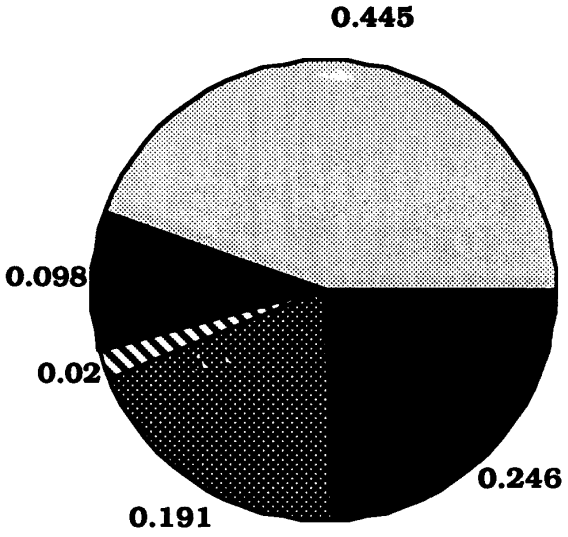
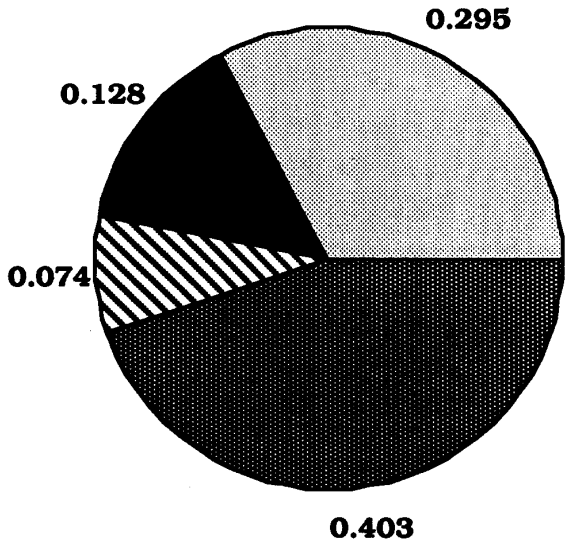


Motor-Cognitive Flexibility



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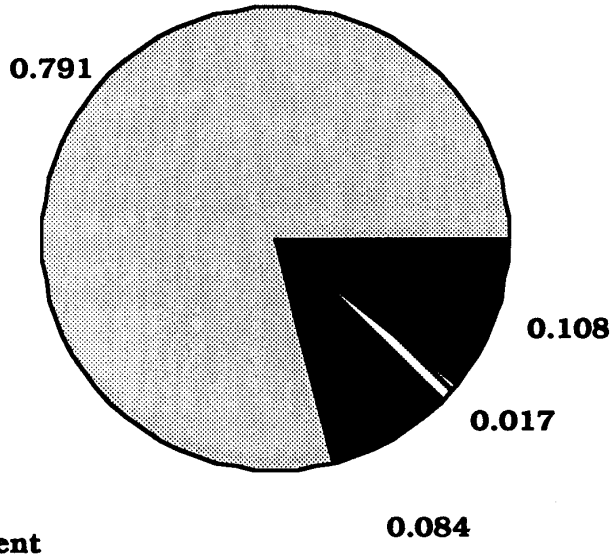
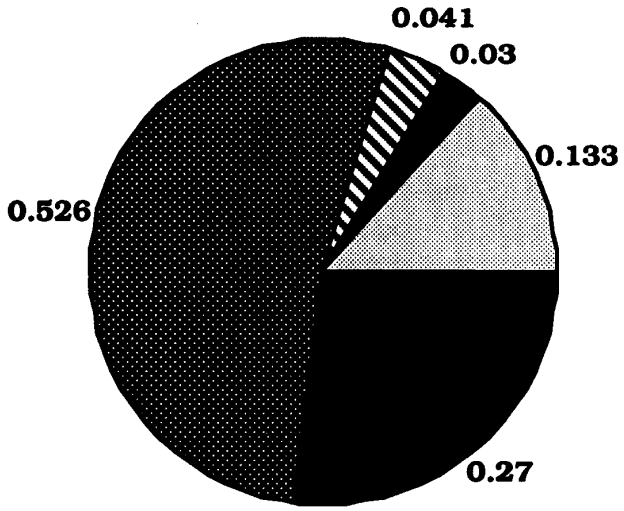
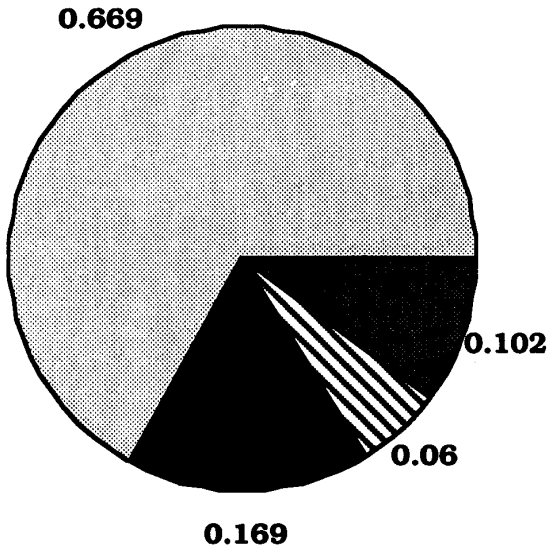


Heritability
Shared Early Environement
Unique Early Environment
Unique Current Environment
Unexplained

Psychomotor Speed



Social Responsibility



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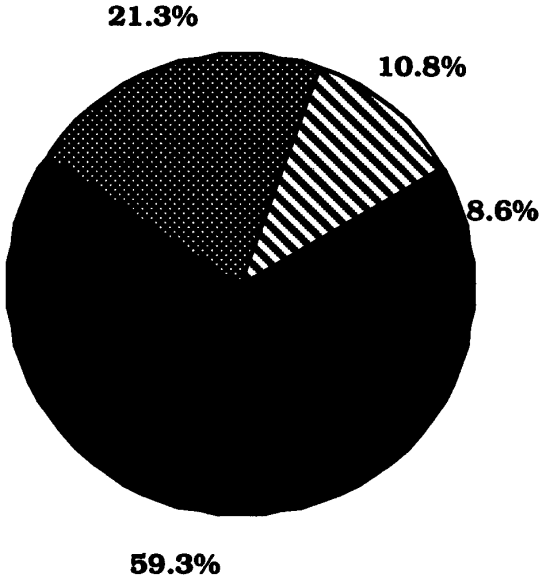

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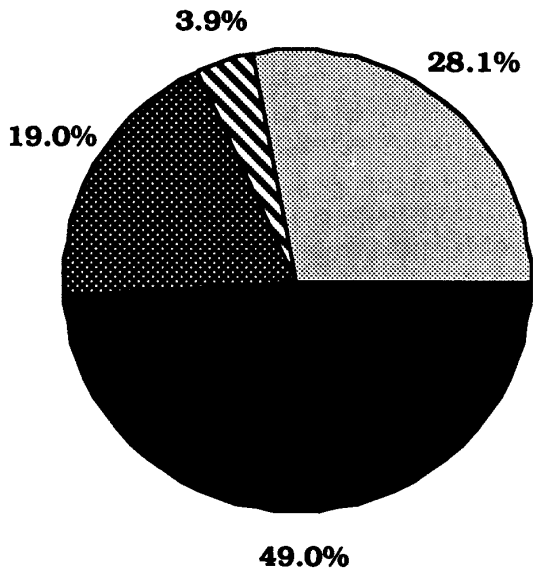
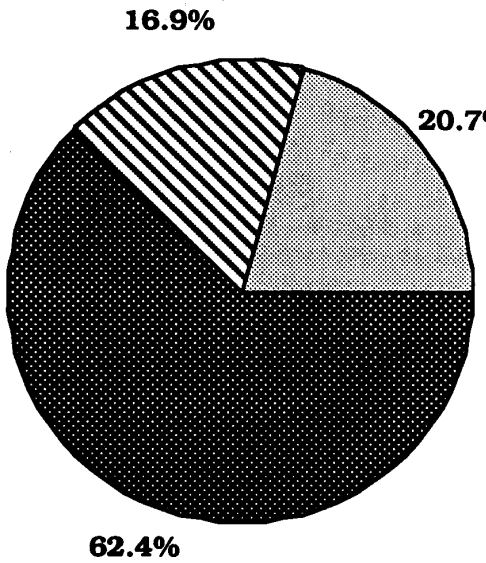
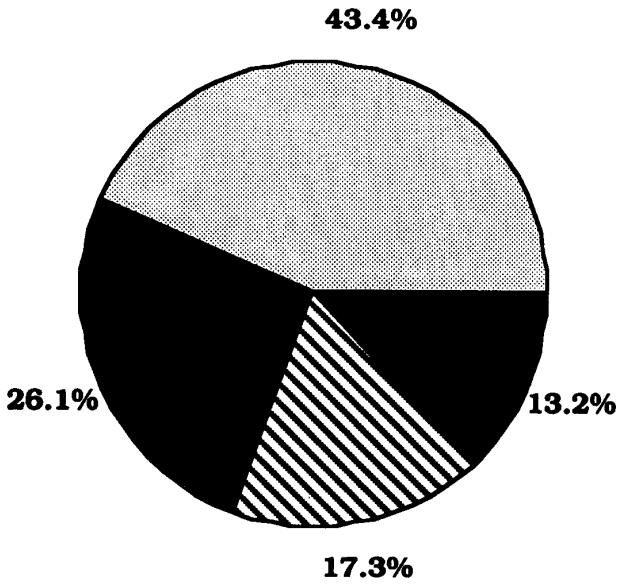
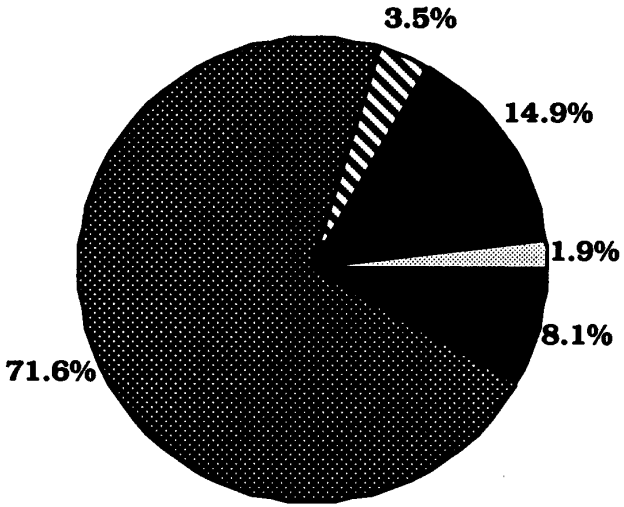
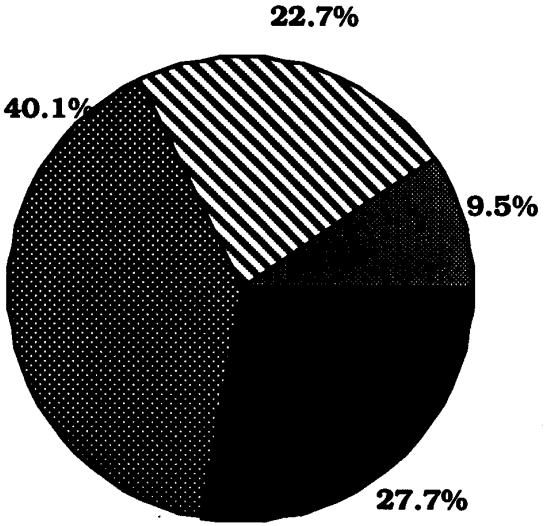


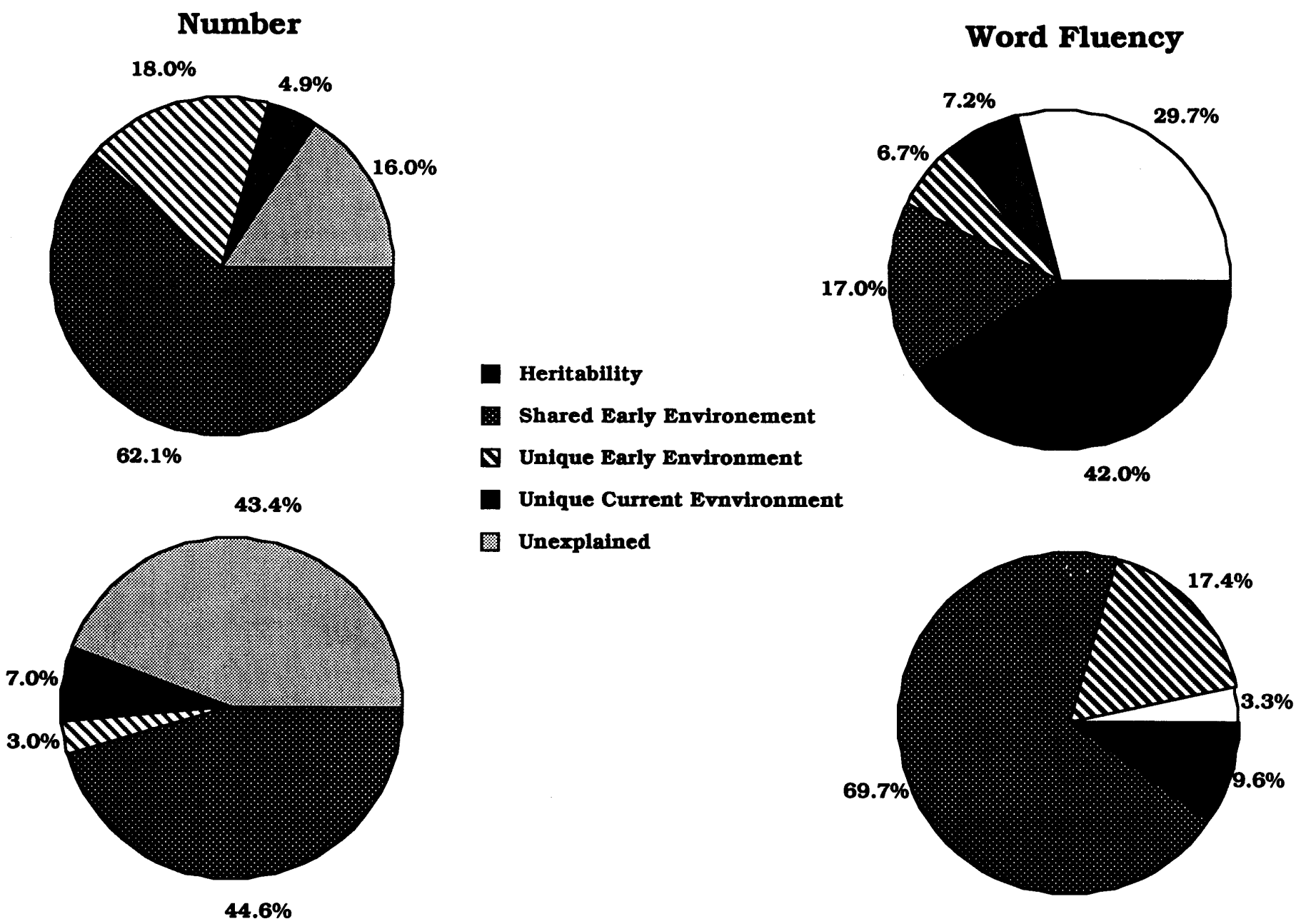
Inductive Reasoning



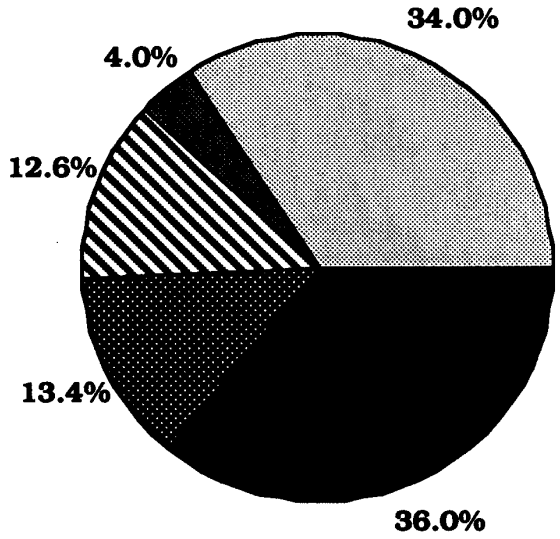




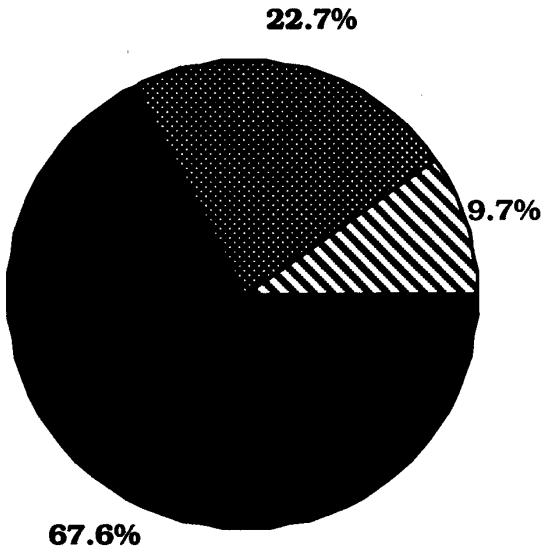


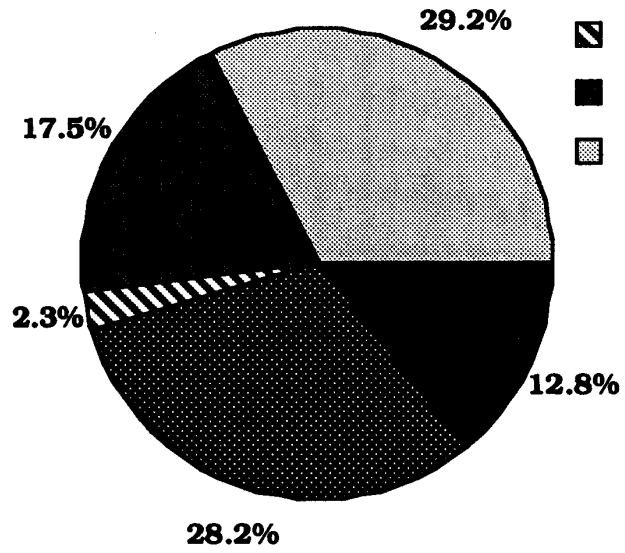

Number
18.0%
4.9%
16.0%
62.1%
Word Fluency
7.2%
29.7%
6.7%
17.0%
42.0%
Heritability
Shared Early Environement
Unique Early Environment
Unique Current Evnvironment
Unexplained
43.4%
7.0%
3.0%
44.6%
17.4%
3.3%
69.7%
9.6%

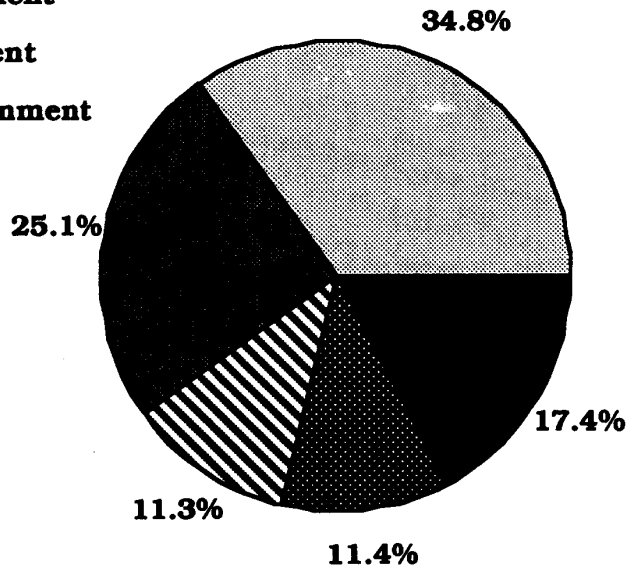
Intellectual Ability



Educational Aptitude

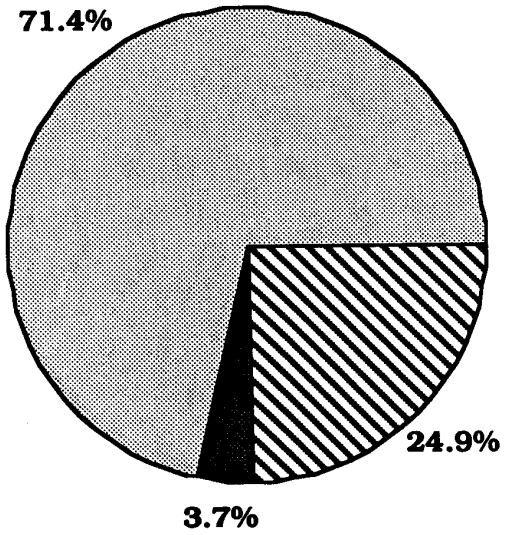




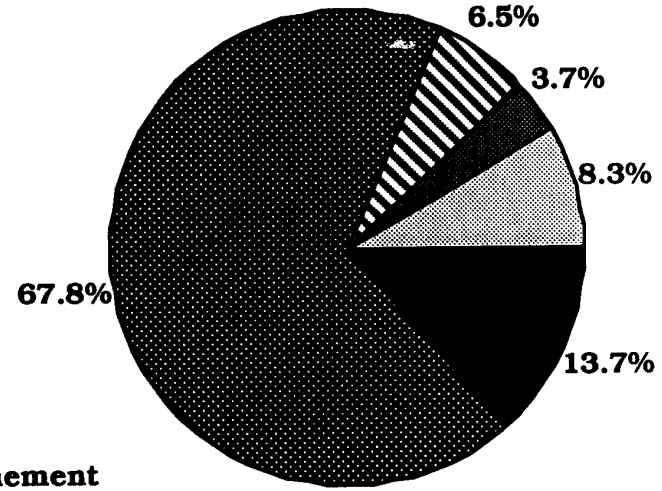


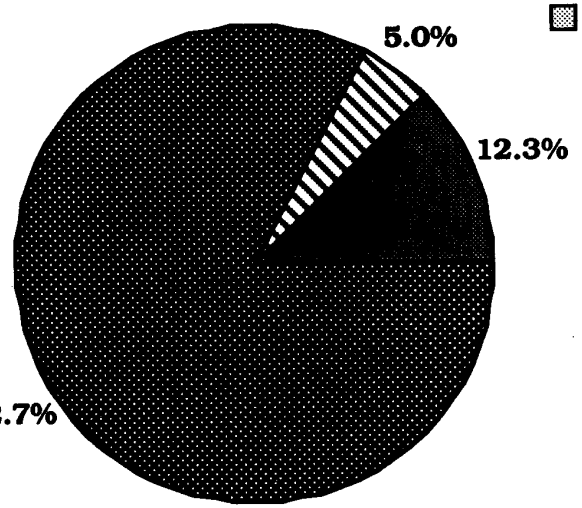
- Heritability
- Shared Early Environement
- Unique Early Environment
- Unique Current Evnvironment
- Unexplained

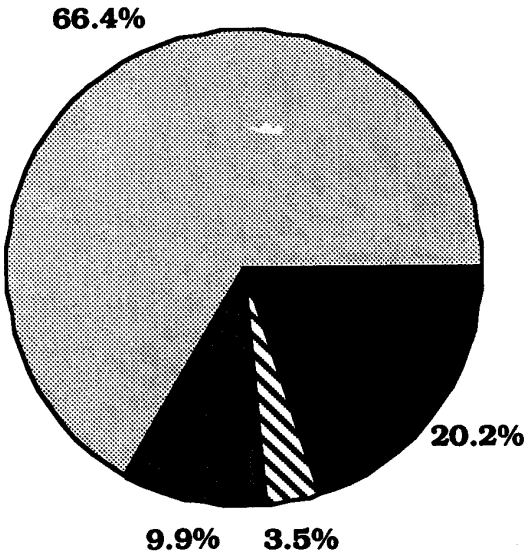
Motor-Cognitive Flexibility



Attitudinal Flexibility







- Heritability
- Shared Early Environement
- Unique Early Environment
- Unique Current Evnvironment
- Unexplained