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Gudrun Balke-Aurell

Changes in Ability as Related to Educational and Occupational Experience

ACTA UNIVERSITATIS GOTHOBURGENSIS

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PART I

BACKGROUND AND PURPOSE

1 INTRODUCTION

The importance of schooling for individual development is indisputable. One significant aspect of development is that of intelligence. Adaptation of education to intellectual qualities is one aspect of the relationship between intelligence and education. Another aspect, investigated in the present study, is the modification of intelligence in accordance with educational experience.

In the research on the structure of intelligence where the results on several test batteries have been factor analyzed, certain distinct abilities, group factors of intelligence, have consistently shown up. The definitions and number of the group factors differ depending upon the actual theoretical contexts.

Though two tests measuring the same ability covary more than two tests measuring different abilities, all intelligence tests have some of their variance in common. This is explained by the concept of general intelligence or, in terms congruent to »group factors», the general intelligence *(g)* factor.

The theoretical basis of this investigation is a structuring of intelligence mainly according to the hierarchical tradition of factor analysis which means that the general intelligence factor is looked upon as the main factor, primary to the group factors. The change in intelligence due to education is then analyzed as the change in intelligence factors related to certain aspects of education.

The groups investigated are two ten per cent random samples of Swedish males born in 1948 and 1953 respectively, both tested at 13 and 18 years of age. The major part of the analyses is focused upon whether change in verbal/reasoning versus spatial/technical intelligence is influenced by verbal or spatial/technical educational experience. Since adolescence is the time when many individuals start their working life the influence of occupational experience upon intelligence is also considered from the same aspects as that of education.

For the population born in 1948 Härnqvist reported in 1968 an analysis of changes in general intelligence at different educational levels. Controlling for initial standing he found that the relative changes in general intelligence were strictly ordered in accordance with educational level reached. The higher (longer) the education the more positive was the change in general intelligence.

A replication study of Härnqvist's analysis is included in the present investigation and is based on the second sample, i.e. the 1953 cohort.

The content and organization of the school system have been intensively discussed during recent decades. The domains involved in the discussion have increased as a result of a broadening of the functions of the school. Most aspects of society are now taken into consideration - political, economical, cultural, and social - and the goals of education, earlier formulated within the school, have been placed in a broader perspective.

One aspect of this broadening is the growth of vocational education which earlier was often given at the working place but is now integrated into the general school system. The increasing work specialisation due to technical developments is another factor which forces the school into adapting to a greater degree to the demands of the labor market.

During the interval between the two cohorts the comprehensive school system was implemented in Sweden. The major part of those born in 1948 were exposed to the old segregated school system where selection to the lower secondary school and the vocational school took place after a certain number of years in elementary school. The majority of the 1953 age group attended the 9-year compulsory school in which some choice of study took place in the final grades. The first point of selection occurs after these nine years of study.

With the broadening of the functions of school and with the alteration of the school system in mind the analyses of changes in intelligence for the two cohorts may be studied from a comparative point of view. The question is, then, whether any difference in changes in intelligence for certain groups of individuals may be assumed to be a result of the change in school organization.

1.1 An outline of the research problem

As mentioned earlier, the main issue in the present investigation is to analyze changes in verbal/reasoning versus spatial/technical intelligence and relate these changes to educational and, for some individuals, occupational experiences.

In dealing with this issue, different opinions concerning the development of group factors, as well as environmental influence on this development, must be considered.

Opinions differ as to at what age the group factors appear as distinct abilities. From one point of view it is claimed that the group factors become distinct at an early age and only a minor part of potential development remains when an individual reaches his teens. According to another opinion, adolescence is considered as the crucial age period in the forming of group factors. As will be returned to later on, these divergent views are derived from different theories of the structure of intellect.

The discussion concerning the influence of environment upon intelligence development has continued over a long period and has included views of both »hereditarians» and »environmentalists». This debate will not be reviewed here but the crucial point in regard to the present investigation is whether specialized and structured environments such as educational settings during adolescence can be assumed to influence adult intelligence.

In simplifying the standpoints it can be said that according to one view the development of group factors occurs regardless of the type of education while according to the other view development is assumed to be influenced by certain environmental settings, among them education.

Several investigations have shown a relation between type of educational experience and development of the corresponding group factor. Two rivalling explanations in congruence with the opinions above can be set up. One is the causal interpretation that the development of a group factor is a result of training of this factor. The other explanation, which is a modification of the view that development is predetermined, is that group factors are potential early in life and show up in interests and attitudes which, in turn, influence the individual's choice of education. Thus, self-selection is assumed to be the cause of the relation between education and the development of intelligence.

The questions concerning the time for the appearance of group factors, as well as those dealing with environmental influence, can be empirically studied in different ways. One is a quasi-experimental setting where the abilities of a group of adolescents are studied before and after a specialized education. (»Specialized education» implies years of education and not only training courses of a week or a month.) If it is found that the ability factors of these individuals change, then the standpoint that development occurs only in early childhood would fall. If, in addition it can be shown that the group factors, when education is completed, have developed in accordance with the specialized education, then the view that development is not related to educational experience could be disregarded.

The two last interpretations, i.e. the causal and the self-selective, remain and a separation of these is difficult to perform. But, most likely, the potential ability mentioned in the statement based on self-selection will be expressed in the choice of areas of study. This, in turn, will supposedly be related to other factors, especially to a higher interest in these areas. Thus, if these factors can be measured before specialization in education takes place, their influence on the choice of study can, to a certain extent, be controlled. Then, if these factors do not predict the choice of study, then the standpoint that self-selection is the only cause of the relation between education and intelligence development would not be valid.

The assumptions above may also apply to a type of occupational experience which, in this investigation, is analyzed in the same way as type of education.

So far, it is the analyses of group factors that have been discussed. In the case of the general ability factor the research purpose is, apart from the value of a replication study in itself, to study whether the relative changes in intelligence can be assumed to be the same in a compulsory school system as they were in the segregated one. In addtion, when considering the development of the *g* factor, the different opinions concerning the development of the group factors and environmental influence can, of course, be transferred to be valid to the general intelligence factor as well.

In dealing with the relative changes in intelligence and their relation to educational and occupational experience it must be emphasized that only a part of that experience is studied, i.e. type of education and occupation in the case of the group factors, and level of education in the analysis of the general intelligence factor. Separate types of education within the broader areas are, for instance, not dealt with. Neither is attention paid to the fact that tasks within one occupation may vary between different places of work.

Another restriction, partly derived from the research design and partly from the educational environment *per se* is the type and number of group factors studied - verbal/reasoning versus spatial/technical. These are the most prominent group factors in previous educational research and also the most prominent in relation to educational settings. Both facts make this restriction less severe.

The final issue discussed in this investigation is, as has been previously mentioned, whether there are any differences in intellectual development between the cohorts which can be related to school reorganization. However, since the changes in intelligence can only be expressed in relative terms, the possibility to compare the cohorts from this aspect is restricted and only suggestions at a rather vague level can be made.

Thus, the issues in this investigation are:

- to study changes in verbal/reasoning-spatial/technical intelligence as related to type of educational and occupational experience;
- to study changes in general intelligence as related to level of education;
- to study the relation between school reorganization and changes in intelligence.

2 STRUCTURE OF INTELLECT AND INTELLIGENCE DEVELOPMENT

2.1 Intelligence factors

In the twentieth century one of the most widespread and long-lasting debates within the domain of behavioral research has concerned the concept of intelligence and, primarily, the organization of intelligence factors. The debate whose principal figures from a historical point of view were C E Spearman and L L Thurstone has been summarized, reported and discussed in a large number of publications (e.g. Vernon, 1961; Wiseman, 1968; Tyler, 1969; Cattell, 1971; Butcher and Lomax, 1972).

Spearman stated his theory about general intelligence in a wellknown paper from 1904 (e.g. Wiseman, 1968). In this paper he described human ability as being dependent upon one single and general factor. Later on, Spearman (1923, 1927) expounded his theory and stressed the importance of this *g* factor. The divergence between an individual's performance on different tests was explained by test specific factors without any importance as far as common ability, measured by several tests, was concerned. This two-factor theory became the basis of European research on intelligence factors.

Thurstone presented the multiple-factor theory in 1938 in which he defined eight primary factors (Primary Mental Ability - PMA) each measuring separate parts of human intelligence. The *g* factor of Spearman was, in this theory, nonexistent at this point in time. Many American researchers accepted this theory and followed the Thurstonian line.

The debate started around 1920 and concerned the dominance of the *g* factor, whether or not other ability factors exist, and which, if any, hierarchy between factors can be stated (Spearman, 1904; Burt, 1917; Brown and Thomson, 1921; Spearman, 1923, 1927; Kelly, 1928; Hull, 1928; Stephenson, 1931; Thurstone, 1938; Spearman, 1939). The most intensive phase of the debate ended in the 1940's when Spearman admitted the possibility of other ability group factors, subordinate to the *g* factor (cf McNemar, 1964) and Thurstone (Thurstone and Thurstone, 1941) found that the variance common to the PMA tests could be explained by a common factor, stated as secondary to the group factors.

The positions were, however, deeply rooted in Europe and America respectively and the development of theories about the factors, hierarchy, structuring, development, and environmental influence of intelligence has, as well as the tests constructed and the statistical methods used (Child, 1970), followed the directions outlined in the 1920-1930's. This fact is important to remember in the following discussion about investigations of these matters.

In continuing the work of Spearman, Cattell (1941) presented his theory of two general factors - one crystallized and one fluid intelligence. The first one, assumed to be influenced by learning, is strongly loaded in Thurstone's PMA, especially in the verbal, number, and reasoning factors. The second one, described as being mainly inherited, is shown in matrices and number series. This division of the *g* factor into two distinct parts is similar to that proposed by Hebb (1941) who labeled the parts intelligence A (potential) and B (realized), but the definitions of these parts differ from those given by Cattell (cf Horn, 1968).

Vernon, who also continued Spearman's work, proposed an hierarchical model (Vernon, 1950) in which two major group factors, one verbal-numerical-educational *(v:ed)* and one practical-mechanical-spatial-physical *(k:m),* are secondary to the *g* factor. If sufficient tests are included, these major factors are supposed to subdivide into several minor ones. The outline of this hierarchical model was first given by Burt (1917) who, in general, agreed with Spearman about the importance of the *g* factor but disagreed with the view that this factor is the only one. Undheim (1980a), in examining Cattell's ability theory, states that the VEK (verbal-educational-knowledge) group factor, which in a constructional sense is similar to Vernon's *v:ed* factor, is empirically equivalent to the Cattellian crystallized intelligence (Gc) when general intelligence has been partialed out. (After this manuscript was completed, Gustafsson et al., 1981, reported a study in which Spearman's, Thurstone's, Vernon's and Cattell's theories are integrated).

Guilford (1956) refined the factor analytic approach proposed by Thurstone (1938) and presented a model of the structure of intellect in which the intellect is classified into operations, contents and products which, in turn, are divided into categories (Guilford, 1967). This gives 120 interaction cells where each corresponds to a mental ability, separated from the others.

Humphreys (1962) preferred Vernon's hierarchical model and cautions against overemphasizing the importance of a factor just because it appears when factorizing a certain test battery. He returns to this later (Humphreys, 1976) when stating

> General intelligence is a broad attribute. Thus, the test items should be quite heterogeneous and the contribution of any one aspect should not be emphasized at the expense of other aspects. A vocabulary test is not a test of general intelligence, but neither is a test composed entirely of Raven's matrices. (p. 332)

When discussing special attributes, Humphreys (op. cit.) criticizes experimental cognitive psychology and its applications to measurement:

> In the light of the preceding discussion it is understandable why I get a little nervous when an experimental psychologist claims that he is studying problem solving but uses a single experimental situation which provides only a single score. (p. 333)

This comment will be returned to when the measurement of personality traits, other than the intellectual, is discussed.

Eysenck (1967) also critized the overemphasizing of the results of a factor analytic solution of a test battery. His critique stems, however, from a different point of view compared with that of Humphreys, namely, that a certain test result can be achieved in many different ways since solutions of different items require different mental processes. Thus, he agreed with Guilford's model of intelligence but rejected its subdivision and non-hierarchical nature. The error of overemphasizing a factor solution, together with several other »research defects», is also discussed by Horn (1979).

In their discussion of how to measure change, Cronbach and Furby (1970) point out that at different stages of development different mental processes may contribute to the performance of a task within one operationally defined variable. They state that the quantitative assessment of changes is important but warn against assuming that the changes are in one particular psychological variable.

Research on human abilities is discussed by Tyler (1972) in her review of that research during the late 1960's. She described the period as »an era of revolt against the IQ-dominated technology» (p. 177) and points out that one reason for this can be the changes in the goals of education from »a mechanism for successive screenings into an institution to develop the abilities for all youth» (p. 177).

This new perspective of the goals of education can be said to have become even broader, as mentioned earlier (chapter 1), with most areas of society involved in its formulation. The research on intelligence factors and their structure has become less prominent during recent decades. This research has become more oriented towards the *use* of the factors, for instance in instructional contexts (Bruner, 1966; Gagné, 1967;, Bloom, 1976; Glaser, 1977), in examining group differences (Jensen, 1969; Vernon, 1969), in studying social and regional inequalities (Coleman, 1966; Jencks, 1972; Jackson et al. 1973), and in ATI (aptitude-treatment-interaction) research. The study of ATI was established by Cronbach (1967) as a branch of the Thurstonian tradition. Later on (Cronbach, 1970), this research integrated the hierarchical model of Vernon (cf Gustafsson, 1976).

Another branch of research based on the use of intelligence factors concerns educational influence on intelligence change which is reviewed in a following section.

Summary. The research on the structure of intelligence has mainly followed two lines: one where the general intelligence factor is emphasized and the other where the starting point is the group ability factors. The first tradition was founded by Spearman and refined by Burt and Vernon, who suggested the hierarchical group factor theory, and by Cattell and Horn who adopted the subdivision of the general intelligence factor into fluid and crystallized intelligence.

The second tradition, established by Thurstone, is the multiple-factor theory. Guilford extended this theory and classified the intellect by operations, content and products.

During recent decades the incongruity between the theories has, for the most part, vanished and most of the research has been oriented towards the *use* of the theories, where the contexts and purposes of investigations have governed the choice of the bases of research.

2.2 Development and differentiation of intelligence

Intellectual development and differentiation have been the subject of study and theory construction parallel with the discussion about the ability factors. These two aspects are, of course, interrelated - the development of an intelligence factor cannot be found before the factor is differentiated.

In a cross-sectional analysis of results of the Stanford-Binet test Thurstone and Ackerson (1929) stated the theory of rapid development at early ages and its levelling out at adolescence, which has since been accepted by many researchers.

As Humphreys (1962) points out, the research on intelligence development at first followed the two lines in intelligence factorizing mentioned earlier. The Americans concentrated on investigating the development of separate intelligence factors, while European research focused upon *g* factor change. Later on, the general factor and the group factors, primary as well as secondary, were studied in both Europe and America, but the different definitions of intelligence as well as definitions of primary and secondary factors make the results somewhat difficult to compare. Added to this, the refusal by some investigators to accept or tolerate the theories of the opposite side makes an interpretation confusing.

General intelligence is described by Vernon (1969) as »the common element in a whole host of distinguishable, but overlapping, cognitive abilities» (p. 355) when he discusses different conceptions of cognitive growth. He also notes that, when investigating a homogeneous population, it is most profitable to study different mental abilities as proposed by Thurstone and Guilford. When a heterogeneous population is studied, however, the *g* factor is focused upon because the range of cognitive abilities is then wider, thus making the common element stronger and the group factors weaker and less distinct. The matter of different populations also explains why the theories about the structure of intelligence became so different and deeply rooted in Europe and America respectively - the investigation groups differed in degree of homogeneity.

Cooley (1976) agrees with this and adds that any explanation of general intelligence will be indirect because it will always be found to be a function of several mental mechanisms (cf McClelland, 1973). He also emphasizes the importance of the concept of general intelligence in studies of education. This statement is made in a discussion of the papers of Carroll and Tyler in Resnick (1976). In a comment on Cooley, Carroll remarks: »I regard the attempt to identify the 'essence' of a g factor as hopeless» (p. 61).

Bloom (1964) reviews investigations on the development of the *g* factor and concludes that over 90 per cent of this ability at the age of 18 is developed at the age of 13. These calculations are based on Anderson's (1939) formulation of the »overlap hypothesis», i.e. that the correlation between two measurements at different ages is looked upon as a percentage of elements common on the two occasions. In this formulation, an absolute scale with equal units and a defined zero is presumed (cf Bloom, 1964).

The question of how to measure development and change in intelligence has been extensively discussed (Thurstone, 1928; Thurstone and Ackerson, 1929; Harris, 1963; Bloom, 1964; Thorndike, 1966; Härnqvist, 1968; Werts and Linn, 1969; Cronbach and Furby, 1970; de Gruither and van der Kamp, 1976; Werts and Hilton, 1977). The problems brought up include comparable units, absolute scaling, composition of intelligence at different ages, estimates of growth curves, methods of correction in regression analyses, and estimates of gains. Later on, some of these problems will be returned to.

When looking upon the *g* factor as composed of fluid and crystallized intelligence, Cattell (1971), in an elaborate examination of empirical research on abilities, concludes that fluid intelligence reaches its maximum at the age of 15 while crystallized intelligence is presumed to develop until the thirties. This is also discussed by Horn (1968) and Undheim (1980a).

In the theory of transfer, proposed by Ferguson (1956), it is assumed that a change in one ability factor results in a change in another because some parts in the first are transferred to the second. The fact that the general factor always shows up in factor analyses of intelligence tests is explained by the transfer between the special factors measured in the tests. Ferguson (op. cit.) also points out that during adolescence abilities are more stable, which gives a greater predictability, as well as being more differentiated.

The theory of age differentiation first stated by Burt in 1919 (cf Anastasi, 1958) and strongly proposed in America by Garrett (1946) implies that intelligence is undifferentiated in childhood and becomes more differentiated and specialized as the individual grows up. The differentiation theory, which has its roots in the results of research on neurological development and maturation (Undheim, 1979), is reviewed by Anastasi (1958, 1967, 1970). Anastasi (1970) discusses the factor analytic research in this area and concludes that the simple differentiation hypothesis first stated must be modified in relation to individual experience and group differences. This conclusion corresponds with the views of most of the investigators (e.g. Husén, 1951; Ferguson, 1956; Hunt, 1961; Berglund, 1965; Coleman, 1975), i.e there is a consensus that the appearance of an ability pattern in one way or another depends upon the type of training obtained. Later on, when environmental influence on intelligence is discussed, this will be returned to.

On the whole, it is agreed that intelligence becomes more differentiated with age and that this differentiation seems to be affected by the type of training obtained. When this differentiation starts and ends and if there are any integrative phases (Vernon, 1961; Härnqvist, 1960) have been subjects of discussion.

Burt (1954) stated that a verbal factor appears at an early age and he was able to separate this factor in 8 year old children. He also found that a numerical factor is distinct at about the age of 12. This last result corresponds with that of Björsjö (1951).

Vernon (1961) concludes that the growth period of the *k:m* factor occurs during puberty, i.e. starting at about the age of 11 and that this factor is useful from the age of 13 as a predictor of success in mechanical occupations. This conclusion is based on several investigations but is valid for boys only. As regards the verbal factor, Vernon (op. cit.) finds it more difficult to state the age period of development, but notes that it occurs earlier than that of the *k:m* factor. Vernon also points out that differentiation does not occur at all automatically - it depends upon the type of educational and vocational training.

The developmental periods found by Vernon correspond with the results shown by Härnqvist (1960) who analyzes verbal, spatial and inductive abilities in children from 11 to 16 years of age. Härnqvist also finds that there is a more rapid growth of spatial and verbal abilities between the ages of 13 to 16 compared with inductive ability. Härnqvist (1973) reanalyzes these data by using the method of canonical correlation analysis. The results show that the PMA-profiles are fairly stable between consecutive years in the age groups studied.

Berglund (1965) concludes that the growth of verbal ability is lowered after the age of 13 compared with spatial ability which grows at the same rate at the age of 13 as it does at 16. He notes, however, that the development of the verbal factor continues until the age of 16.

Stability and change in intelligence are discussed by Bloom (1964). In regard to specific types of mental abilities he points to the lack of longitudinal research where individuals are followed from infancy to adulthood. In discussing Thurstone's (1955) cross-sectional analysis of PMA development Bloom finds differential rates of development for different abilities. To mention some of the results, Bloom finds that the S and R factors both reach about 75 per cent of adult (18 years) performance at about the age of 13 and that the V factor attains 65 per cent at the same age.

Bayley analyzes mental growth in the Berkeley Growth Study in several papers (e.g. Bayley, 1968). In this report, mental growth and its correlations with certain behavioral measures are discussed. The rather small investigation group is followed from infancy to 36 years of age and Bayley concludes that the verbal scores appear to be the most stable ones and that this stability is shown at an early age.

In an analysis of the PMA, Meyer och Bendig (1961) find stable relative positions in the abilities, especially in V, R, and N, in children between 13 and 17 years of age. This result corresponds with those of Tyler (1958) and Khan (1972) and the degree of stability seems to be greater for boys than for girls.

Hopkins and Bracht (1975) find that the correlation between verbal test scores is quite high from grade four and every higher grade investigated, while a correspondingly high correlation between nonverbal scores is established from grade seven. These results may be partly artificial, however, since different test batteries are used in the grades lower than four and in the grades from four and higher.

The differentiation in the PMA factors is also discussed by Undheim (1980b). He criticizes many of the investigations made, partly because they over-generalize results from cross-sectional studies and partly because the »primary» factors are replaced by narrow ones, not useful as predictors. Undheim (1979 and 1980b) concludes that a distinct differentiation is evident from the middle of the teen-ages and not before.

This review of differentiation has followed two lines corresponding with those of Vernon (1969) mentioned earlier. When heterogeneous groups are studied the *g* factor dominates which, in turn, results in the group factors being assigned a lower significance with no possibility of showing up at an early age (Burt, 1954; Björsjö, 1951; Elmgren et al., 1959; Härnqvist, 1960; Vernon, 1961; Berglund, 1965; Cattell, 1971; Ljung, 1965).

When, on the other hand, homogeneous groups are investigated some of the different abilities become more distinct at an earlier age (Bayley, 1955; Meyer and Bendig, 1961; Thurstone, 1955; Tyler, 1958).

Summary. The research on intelligence development and differentiation has been based on the two theories of structure of intelligence mentioned earlier.

The rapid development of general intelligence in early childhood is generally accepted. It is also accepted that group factors become more differentiated with age, but opinions differ when determining at what ages these factors will appear. This difference can mainly be explained by the divergent starting points of research in accordance with the two research lines mentioned above.

Within the hierarchical tradition, group factors are found in children at about 10 years of age, the verbal factor somewhat earlier and the spatial factor a few years later. These factors seem to develop during adolescence.

Within the multiple-factor theory the group factors are established at an earlier age which, in turn, results in a lesser potential for development remaining during adolescence.

2.3 Influence on intelligence development

2.3.1 Introduction

Longitudinal investigations concerning influences on intelligence development often suffer from shortcomings such as only nonrandomly assigned groups being available for analyses of treatment effect, and discrepancies between the statistical methods which are used partly to compensate the nonrandomness and partly to study change. However, in the two following sections the term influences will be used when the intentions and conclusions of research concern the importance of environmental variables on intelligence development. The shortcomings mentioned above will be discussed in chapter 3.

2.3.2 Educational and occupational influence on intelligence development

The theory of intelligence, its development and differentiation also deals with hereditary versus environmental influences on intelligence. The arguments concerning the proportions of genetically as opposed to environmentally determined intelligence will not be discussed here. Instead, the review will concentrate upon investigations in the influence of environment and especially the educational environment on the development of intelligence. By choosing this starting point, the assumption that intelligence is affected by environment is accepted.

The environmental influence on intelligence and intelligence test scores is mentioned by Thorndike, Colvin and Woodrow in their contributions to a symposium in 1921 (see Tyler, 1969). These contributions were, however, mainly aimed at defining intelligence and discussing intelligence tests. The suggestions about environment may be looked upon more as contributions to the heredity/environment debate than to the discussion concerning the extent of the environmental influence.

Anastasi (1958) reviews the early research on the amount of schooling and intelligence. She points out that high correlations between intelligence tests and the highest grade reached in school were shown in the 1920's. In 1945, Lorge published his longitudinal investigation on the educational effect on a sample of boys in New York. The investigation can be discussed from a methodological viewpoint: the dropout percentage in the twenty-year follow-up is, for instance, very large. The conclusion that

> Society must recognize that the restriction of educational opportunities because of race, color, and economic circumstance may mean the attenuation of its chief human resource - the functioning intelligence of its citizenry. (Tyler, 1969, p. 186).

can, however, be used to describe the research done in this area during the last three decades.

Earlier, Anastasi (1936) and Woodrow (1938) had pointed out the training effect on group factors tests. Research at this time was, however, concentrated on short-time and special training effects.

Husén (1948) concludes that the higher the education, the higher the score of the *g* factor. He also notes that, for lower educational levels, the test score is higher for the boys who live in large cities compared with those in other regions. Husén (1950) describes a longitudinal investigation of boys between 10 and 18 years of age which showed that for those who passed lower secondary school and above, intelligence had increased compared with the other boys. Husén (op. cit.) also concludes that high social class affects intellectual development while high income does not. This investigation is criticized by Anastasi (1958) because initial differences in motivation, persistence, and home environment were not taken into consideration. Anastasi also points out that the only way to attain full control of initial differences is to assign individuals at random to different educational groups. This aspect will be discussed in chapter 3.

The same conclusion concerning the educational effect is reached by Härnqvist (1959). Svensson (1962) discusses Lorge's, Husén's and Härnqvist's investigations and asks if it is the qualitative aspects of education or the length of education that produces the rise (cf Vernon, 1948). Svensson (op. cit.) also concludes that education is not finished at the time of the final testing in Husén's and Härnqvist's investigations and that this would probably result in a lower limit of intelligence development for the boys at the highest educational level. Svensson (op. cit.) reports on his longitudinal investigation of children from 11 to 16 years of age and concludes that there is a tendency for pupils in positively selected classes to get higher intelligence scores than those in non-selected and negatively selected classes with comparable initial standing.

These investigations are also discussed by Härnqvist (1968) together with Quensel's (cf Härnqvist, 1968) criticism of methodological aspects of Husén's and Härnqvist's analyses.

In this study (Härnqvist, 1968), a *g* factor change, dependent upon different levels of education, was demonstrated. This investigation forms the basis of the present one and is separately discussed in chapter 4. Dahlbäck (1980) replicates, using a sample born in 1953, Härnqvist's (1968) analysis of *g* factor change but in a more restricted population than that of the Individual Statistic Project (ISP) - those living in the Stockholm area. The ISP instruments are used and the results correspond with Härnqvist's, i.e. the changes are positive for those at the higher educational levels and negative for those at the lower ones.

Cattell (1963, 1971), in his theory of fluid and crystallized intelligence, regards the Gc, as mentioned earlier, as being influenced by learning and education.

In the case of the group factors, the study of change dependent upon education has mostly been concentrated on technical and engineering education. Thus, Blade and Watson (1955) compare engineering and college students' changes in a spatial visualization test. A more positive change for the engineering than for the college students at the end of the first study year is noted. This advantage is maintained but not increased during the next two years of education. A similar result was reached in an earlier study (Churchill et al, 1942) of engineering students.

Doppelt and Bennett (1951) find that verbal and numerical abilities are more consistent compared with space relations because the two first abilities are bound to and practiced in school, while the space relations constitute a more »nonschool» ability. The same conclusion is reached by Meyer and Bendig (1961).

Dockrell (1966) finds that verbal ability increases more in lower-class than in middle-class grammar school pupils. When these two social classes among technical school students are compared, no difference in spatial ability between the groups shows up. Dockrell explains this by saying that education may have effect only when home environment is not enough stimulating.

Spatial relations are also the subject of a study by Stallings (1968), who examines educational effects on a group of engineering students. For this group, »school» ability shows a positive change during the time of study.

Ferguson (1954, 1956) assumed, in his theory of transfer, that differentiation in ability is affected by learning, which Vernon (1950) also points out. Dubois (1962) examines Ferguson's transfer theory when he studies the education and training of electrical engineers. He concludes that technical education ought to be general and not specific because transfer has its greatest effect on ability in the former type.

The influence of type of education on verbal and quantitative ability respectively is studied by Nichols (1964) using one group of college students and one group of students at a technical school. The latter group displays an increase in quantitative ability in relation to verbal ability. A subgroup consisting of students in chemistry also displays this result, but to a lesser degree than the other technical students. A positive change in verbal ability is found in the group of college students studying linguistic subjects.

Guilford (1967) makes a thorough analysis of the concept of intelligence and refers also to several studies concerning environmental and training effects on ability factors. In connection with educational influence, he discusses a study by Broyler, Thorndike and Woodyard, who examine the ability changes after one year at High School. Pupils studying theoretical subjects increased their verbal ability, pupils studying economic subjects increased their numerical ability, and pupils studying »shop type» subjects increased their spatial-visual ability. Guilford summarizes the result by stating that there is a pronounced training effect upon ability factors. Gagné (1967) reaches the same conclusion but also points out the importance of pre-task ability.

The changes in verbal, numerical, and spatial test scores have also been analyzed by Meuris (1970), who used a group of secondary school students. The differentiation in abilities was greater in the second year of study where pupils studying classical subjects got higher scores on the verbal tests while those studying natural science subjects increased their spatial and numerical scores.

Hayes (1962) presents a motivational-experiential theory of intelligence. The motivational aspects are the hereditary ones which, together with environmental differences, result in experiential differences. The educational influence is emphasized in the sense of forming differences in ability on the basis of motivational-experiential differences. Hunt (1968) agreed with this theory about the inheritance of motivation, which he describes as intrinsic motivation. Hunt (op. cit.) reviews the changing views of intelligence and states the great importance of childhood experience in intelligence formation.

Occupational influence on intelligence change has rarely been investigated. Kohn and Schooler (1973, 1978) discuss this influence from the point of view of vocational guidance. They question the assumption that underlies the testing in vocational guidance, i.e. that all correspondences between occupation and personality can be said to be a result of selection and of individual modification on the job. They tested an opposite assumption, namely that occupational experience has substantial impact upon psychological functioning. In doing this, 3000 men were interviewed with regard to ten dimensions of occupational demands. Among these, it is shown that intellectual flexibility and demands on intellectual resources are affected by type of work.

Summary. As regards educational influences on general intelligence, the conclusions of earlier research are fairly unanimous in the sense that higher or longer education results in a positive change in general intelligence. How much the self selection and influences of background factors affect this result is difficult to state.

In the case of the influences on group factors, it is mostly those connected to technical studies that are investigated. Verbal education influences on verbal ability are often analyzed together with those within the technical domain in order to obtain a basis of conclusions concerning this last domain. The results show that a certain degree of change in ability occurs after education corresponding to that ability, but, again, the rivalry hypothesis based on self-selection can not be rejected.

2.3.3 Influence from other factors on intelligence development

Ferguson (1956) states the general view that different environmental demands lead to the development of different ability patterns. One part of these demands lies within the social and economical context. Socio-economic factors act on intelligence development in two ways - indirectly and directly. The indirect way means that different socio-economic groups have different aspirations with regard to education and occupation which, in turn, influence intellectual development. The direct way means the encouragement of different types of activities that stimulate different types of intellectual functioning. Of course, this can also be looked upon as indirect - the socio-economic class never influences development *per se* - but the classification of this influence as direct means that the different activities are activated and controlled by the home environment.

The great influence of socio-economic background on educational choice (in fact upon choice of educational level) with the accompanying restriction on the potential for individual development is noted by many researchers from Lorge (1945) up to now (e.g. Härnqvist, 1958; Coleman, 1966; Jencks, 1972; Husén, 1972; Sewell and Hauser, 1975; Härnqvist, 1978; Levin, 1979). Härnqvist (1966) and Härnqvist and Svensson (1980) have studied this influence from different points of view within the framework of the Individual Statistics Project.

The influence on occupational choice is also discussed in the references given above, and is also concentrated upon the level or status of occupation. Holland (1966) discusses different environmental models and personality types important when making a vocational choice, and, from a sociological viewpoint, Kohn (1969) points out the differences in aspirations when he discusses definitions of »class».

Härnqvist (1978) states that socio-cultural differences in the choice of educational level have been resistant to change in spite of the reorganization of the school system which was made in order to prevent such differences. He also gives a description of models of educational and occupational choice.

Regarding direct influence on intelligence arising from different aspects of the complex socio-economic variables, research has mainly concerned children younger than those studied in the present investigation and has also concentrated on an over-all measure of school performance. Transferring some of the results to the intention of the present investigation, it can be noted that parental stimulation and expectations of the child found by Lynn (1959), Fraser (1959), Lavin (1965), Uguroglu and Walberg (1979), and Thorlindsson and Bjørnsson (1979) are supposed to affect the development of general intelligence. This is also discussed by Wolf (1966) but for children younger than the present samples. Wiseman (1966) points out, when analyzing the effect of social factors on intelligence development, that the impact of environment on attainment gets progressively weaker the higher the age of the group investigated is.

Regional factors also affect intelligence development (Jarl, 1955; Wiseman, 1966; Härnqvist, 1968; Härnqvist and Stahle, 1977). This is mainly due to differences in educational opportunities.

Another type of variable whose influence on intelligence can be said to be both indirect and direct is interests. They guide the choice of education as well as providing the individual with experience in different fields.

The indirect aspect of interest influence can, in turn, be divided into interest in type of education and interest/aspiration in level of education (cf Lavin, 1965 and Härnqvist, 1978). In its relation to socio-economic factors it is discussed in the previously mentioned reports. These are mostly concerned with the »aspiration» type of interests. Interest in type of education is discussed by Vernon (1953) and

Härnqvist (1978) who conclude that interests influence choice of education, especially in technical areas. They also state that the stability of interests is weaker than the stability of ability and achievement. The same conclusions are reached by Cronbach and Gleser (1965) and Holland (1966, 1968) as regards occupational choice during adolescence.

As to the direct interest influence on intelligence, most research is oriented towards mechanical-technical-spatial interests. Thus, Blade and Watson (1955) find that technical leisure time activities are rather strong predictors of the scores on a spatial visualization test. Bloom (1964) also finds this result for males. Lavin (1965) views interests more as a means of predicting academic achievement and finds that research in this field is rather weak - it is made in selected groups, often no control of sex differences is made and the definition of the concept of interest is diffuse. Härnqvist (1978) also draws the same conclusions.

One group of variables, which is of importance in predicting intelligence, connected with both socio-economic and interest factors, is educational achievement. These variables are investigated in relation to predicting educational outcome (Lavin, 1965; Schwarz, 1971; Sewell and Hauser, 1975; Bloom, 1976; Uguroglu and Walberg, 1979), to studying under- and overachievers (Lavin, 1965; Svensson, 1971; Bloom, 1976) and in relation to examining the variables that underlie socio-economic differences mentioned earlier. All the investigations point to the importance of these variables in explaining individual differences.

Summary. Influences from factors other than educational and occupational have been investigated partly in order to handle the problem of self-selection (indirect influence) and partly to find the factors which in themselves influence intelligence development (direct influence).

It is mostly socio-economic factors that show up as predictors of final general intelligence. In research aimed at this complex variable, mostly children younger than those in the present investigation are studied but »parental stimulations and expectations» seem to constitute a variable that can also be applied to an adolescent group.

Interest in higher education, i.e. educational aspiration, and educational achievement seem to have an indirect influence on general intelligence. In the case of special interests, however, the results of investigations differ. Mainly technical interests are investigated and it seems as if these exert both direct and indirect influence on the change in abilities in the technical field.

3 METHODOLOGY

3.1 Design and measurement of change

The study of educational effects has been subject to a lengthy discussion about research design and analytic methods. The discussion will not be given in full here but some important points will be examined.

As mentioned earlier, random assignment of individuals to different sorts of education is, in fact, the only way to assess the effects of education. This is an impossible design and the opinions concerning if and how this obstacle can be overcome differ:

> If, as often happens, randomized assignment is impossible, then there is often no way to determine what is the appropriate adjustment to be made for initial differences between groups, and hence often no way to show convincingly by statistical manipulations that one treatment is better than another. (Lord, 1963, p. 38).

> Does this let down the bars and give approval to the descriptive journalism which so often passes for science in our fields? I think not, if we vigorously attend to the specific plausible rival hypothesis appropriate to each situation. (Campbell, 1963, p. 214).

The opinions lying behind the statements above do not, however, seem to differ to the same degree as the statements: they both point to the weaknesses and restrictions in non-experimental designs. Lord, from a statistical point of view, rejects the possibilities of overcoming the weaknesses while Campbell, from an educational standpoint, accepts some weaknesses in the choice between trying to make the best of the situation and not making anything at all of it. They are close to each other, however; Lord by mitigating his statement by writing the word »often» at crucial moments, and Campbell by using the word »vigorously» in order to strengthen his permissive statement.

Cronbach and Furby (1970) examine different methods of measurement of change in several types of research designs. They argue against statements of change based on comparisons between initial and final scores and present a thorough discussion based on propositions stated by Lord (1956, 1958, 1963) and McNemar (1958).

Cronbach and Furby (op. cit.) discuss the methods of estimating both gains and differences and specify four kinds of purposes underlying this type of estimation: measurement of change as a consequence of treatment; measurement of growth rate based on special attributes of persons; selection of individuals to be given special treatment; operationalizing a concept. Investigations within the first domain are subdivided according to type of assignment and number of treatments and one group of investigations is described as »comparisons of treatment groups not formed at random» which is applicable to the present investigation. They recommend that, in this case, each value observed should be expressed as a deviation from an estimated final score based on a regression equation of the total group and they discuss methods of correcting the raw values used in regression equations. Among others they refer to the method used by Härnqvist (1968) which is related to that proposed by Lord (1960).

In their discussion, Cronbach and Furby (op. cit.) distinguish between linked and independent data and recommend including information on additional variables in the regression estimates as well as making separate analyses within treatment groups. They warn against overly strained interpretations of treatment effect when groups are nonrandomly assigned to treatment and point out that when within-group regressions differ significantly the difference between effects of treatment depends on the level of the initial value, i.e. there is a significant interaction between initial level and treatment effect.

In a later paper Cronbach et al. (1977) discuss methods of comparing treatments of nonrandomly assigned groups by analysis of covariance where neither homogeneity of regressions nor covariate equivalence are assumed. They return to the conclusion that initial bias can be avoided by analyzing the within-treatment regressions but state that this method does not form any basis for studying the treatment effect. This effect can be obtained when the basis of the analysis is total within-group regression and initial differences are adjusted for. Cronbach et al. (op. cit.) recommend including several factors designed as predictive and selective in the adjustment.

Blalock (1964) thoroughly discusses the handling of data in non-experimental research. He questions the necessary simplification of reality which occurs when data are adapted to statistical methods and warns against interpreting time sequences as causal relationships.

Campbell and Stanley (1963), in their well-known article on experimental and quasi-experimental research, analyze the sources of errors which may lead to erroneous interpretations of effects in quasi-experimental research. This analysis still constitutes the general outline for discussing designs in studies of educational effect and will be returned to later in this study.

In the discussion concerning analysis of treatment effect in groups not assigned at random, i.e. quasi-experimental designs, one difference between investigations of this type is not fully emphasized: the effect of the nonrandomness is greater when both assignment and regression equation are based on the same variable than when they are experimentally independent - a condition that will be further discussed in relation to the results.

3.2 Statistical methods

The discussion concerning the statistical methods used in determining educational effects has partly been connected with the discussion concerning non-experimental designs but it has also concerned the development of the statistical methods *per se*. This has resulted in a vast catalogue of methods of handling data and has, together with the rapid development of computer facilities which makes the methods widely available, led to contradictions and confusions in research results (Pedhazur, 1975). Pedhazur (op. cit.) points out that the risk of compensating for the lack of theoretical formulations by using sophisticated analytical technique has become greater.

The measurement of interrelated characteristics and the validity of the measurements have, together with the measurement of change, constituted the topics in the discussion of methods used to assess educational effects (Harris, 1963; Härnqvist, 1968; Werts and Linn, 1969; Blalock, 1971; Cronbach et al, 1972; Pedhazur, 1975; de Gruijter and van der Kamp, 1976; Werts and Hilton, 1977; Cronbach et al, 1977; Cook and Campbell, 1979).

The analytic methods used in studies of educational effects consist of variance partioning and analysis of effects (i.e. regression analysis). Among the references given above the unstandardized regression coefficient is suggested as the best basis for estimating the »effect». Pedhazur (1975) also points out the problems when multicollinearity exists and that slight changes in the intercorrelations may cause substantial changes in the magnitude of the regression coefficients (see below).

The errors of measurement in the independent variable is another crucial point in regression analysis. When reliability is high, it is meaningful to correct the regression (Härnqvist, 1968; Cronbach and Furby, 1970). Problems arise, however, when more than one independent variable is used (cf Cochran, 1968) since the different variables have different degrees of reliability which, together with multicollinearity, form a complex pattern to be solved in a multiple regression equation.

Bergman (1972) and Werts and Hilton (1977) note that it is hard to make the appropriate correction for measurement errors, even in simple regression analyses, and that the correction is affected by sampling errors.

Defining an inappropriate model for regression analysis is known as »specification error». The use/misuse of independent variables in multiple regression analysis is included under this heading. The accessibility of a variable is not by any means a sufficient reason for using it in a regression analysis (Pedhazur, 1975). If multicollinearity exists the regression coefficient of one variable may be greatly affected by the inclusion of another variable and the interpretation of the coefficients as indices of effects will be hard to make. Kendall (1957) exemplifies this effect by showing that a regression coefficient may even change its sign when a new variable is entered. The only interpretation that can be made about the importance of an independent variable is the relative importance (Blalock, 1964; Gordon, 1967/68).

Multiple regression analysis is described in most statistical handbooks and is thoroughly discussed by Kerlinger and Pedhazur (1973) who proceed from the theory of multiple regression while Cooley and Lohnes (1971) take their starting point in multivariate methods and the handling of computer programs.

Kerlinger and Pedhazur (op. cit.) recommend cross-validation in estimating the degree of shrinkage of multiple correlation. Cross-validation can also be used to control for the estimated weights of variables, i.e. the regression coefficients.

The selection of variables for prediction can be made from several points of view based on practical as well as theoretical considerations. In order to find the minimum number of variables necessary to make as good a prediction as possible, the methods are forward, backward, and stepwise regression analysis, of which the last method is recommended by Kerlinger and Pedhazur (op. cit.).

Kerlinger and Pedhazur also discuss the significance test used to estimate the contribution of a new variable as well as the tests of variables already within the equation. They point out that meaningfulness of a variable is more important than statistical significance and that sample size may have too great an effect on variables entered into the equation.

In determining the importance of an independent variable only the relative weight can be assessed. This relative weight is best defined by the standardized regression coefficient, while the unstandardized coefficient is more appropriate for comparing populations (Blalock, 1964; Kerlinger and Pedhazur, 1973).

Cooley and Lohnes (1971) recommend that, in canonical correlation analysis, the interpretation of canonical factors should be based on correlations between the variables originally observed and each of the derived variables, i.e. the canonical factors. They also point out that each squared canoncial correlation coefficient represents the proportion of variance common to the corresponding pair of canonical factors.

The use of causal models is treated in Blalock (1971). It is stated that such models are not the solution to how to interpret causality but a help in testing hypotheses about it. In the papers (Blalock, op. cit.) the handling of measurement errors is also discussed.

Causal models in which latent variables are handled have been developed during the last decade. One of these is the analysis of linear structural relationships (LISREL) which was introduced by Jöreskog (1973) and fully described in Jöreskog (1977) and Jöreskog and Sörbom (1978). The method is also discussed and used by Gustafsson and Lindström (1978, 1979) and by Munck (1979).

By this method multicollinearity as well as measurement errors of variables observed are handled. A latent variable is derived from one or more observed variables and the pattern of relations between latent as well as observed variables displays causality links which are impossible to state by means of regression analysis.

Two steps are taken when using the LISREL method. The first step is to create factor-analytic models from the observed variables, both the independent and the dependent separately. This is done in order to discover, from the relations between the observed variables, the factors that explain the interrelationship in each of the sets of variables observed. In doing this, the measurement errors in the observed variables are taken into consideration, with no assumption of uncorrelated errors.

The second step in the analysis is to form a relationship between the independent and dependent variables in which the causal relations are given. Both steps can be made for several groups at a time.

LISREL has, together with other latent-trait models, been criticized for overinterpretation of data which, in turn, may lead to oversimplification and loss of reality (Horn, 1979; Lohnes, 1979). In this connection, Pedhazur's (1975) warning against sophisticated analytical techniques can again be noted.

4 DESIGN AND INTENTIONS OF THE PRESENT INVESTIGATION

4.1 The Individual Statistics Project

This study originates from the Individual Statistics Project (ISP) which was started in 1961 and supported by the Swedish Council for Social Science Research and in collaboration with the National Bureau of Statistics and the National Board of Education. The nationwide project follows samples from two birth cohorts, 1948 and 1953, more specifically individuals born on the 5th, 15th and 25th any month of 1948 and 1953.

The first collection of data was made when the individuals were 13 years of age and additional information has thereafter been collected at several times. In this study, the information gathered at the time of military enrollment is used as the final time of the follow-up which means that data for men only are analyzed. The investigation period is thus five years, i.e. the two cohorts are followed from 13 to 18 years of age.

For a more extensive description of the design and purpose of the project the reader is referred to Svensson (1971) and Härnqvist and Svensson (1973). In the following only those parts of the project connected with the present investigation will be dealt with.

When the sampled individuals were 13 years old, information was collected partly from official records, e.g. type of class and school marks, and partly from the individuals, e.g. background information and results on tests and questionnaires.

The information collected was not exactly the same in 1966 as in 1961. One difference was due to the changes in the Swedish school system mentioned earlier (chapter 1) which shows up in types of class and marks. Another difference stemmed from expansions within the project - several of the questionnaire items were changed for the 1966 collection, partly to improve the information and partly to update the items. In chapter 7, a more elaborate examination of the data collected will be made.

When the men in the samples were enlisted for military service, i.e. in 1966 and 1971, they took a series of tests and questionnaires. In collaboration with the National Institute of Military Psychology, the ISP obtained information on education (level and type) and occupation as well as ability test results.

The present information is completely based on the individuals' statements and, except for the changes in the school system, the data are the same in 1966 and in 1971.

The 1948 sample forms the basis of a new research project (LING) which was started in 1980. A large part of this sample received a postal questionnaire in the spring of 1980 concerning the individuals' actual education as well as their opinions on education as regards occupational possibilities, social environment and satisfaction with their own knowledge and competence. The total follow-up group consists of 8 433 men and women. An average of 75 per cent returned a completed questionnaire.

4.2 Previous ISP investigations on intelligence change

In chapter 7, a full description of the ability tests used within the ISP is given. In the present section, earlier ISP investigations, which are based on the test results and concern intelligence change, are presented.

The ability tests given at 13 years of age are, as regards content, not identical to those used at 18. In the first test battery there is a balance between tests of verbal, reasoning and spatial ability. In the second test battery, which is the full battery given to every man when enrolling, spatial and technical abilities have been assigned a greater weight compared to the initial battery.

Since the test batteries are not identical, it is impossible to study changes in ability directly. Consequently, Härnqvist (1968), in the first study of intelligence change within the ISP, made a canonical correlation analysis in order to form components common to both batteries.

In this analysis, which was made of the 1948 cohort, two common components were found to be significant. The first component has high loadings in every one of the seven tests, except for Form-board, with some predominance in Opposites and Instructions (verbal) and Number series (reasoning). It was stated that this factor measures general intelligence and in the following this is referred to as the *g* factor.

The second component derived from the batteries describes two factors, a verbal/reasoning bipolar to a spatial/technical one. Härnqvist suggested that some rotation of the factors could be made to separate these two parts. He did not do this, however, because this separation would make the two new factors too weak in the following analyses. Härnqvist therefore kept the factor unrotated, and this factor is referred to as the *v-s* factor in the following.

After transformation of the test scores based on the canonical analysis, Härnqvist investigated the changes in the *g* factor due to different educational levels. He also combined the 21 different levels of education into four main levels. These are:
1. Compulsory education
2. Vocational education
3. Lower secondary education of academic type
4. Upper secondary education

In a regression analysis of the *g* factor, Härnqvist assessed the relative changes in each level that had occured during the five-year period. At the lowest levels, which belong to the first main level, there are pronounced negative changes, and at the highest levels, belonging to the fourth main level, the changes are equally pronounced but positive. The levels between these extremes gradually show more positive changes the higher the level is. This investigation will be returned to in chapter 10 where the results of the 1953 cohort are compared with those of the 1948 cohort.

In the second stage of his investigation, Härnqvist reanalyzed the *g* factor changes controlling for influences from some background variables (parents' education, father's occupation, and place of residence). This was done in order to determine to what extent educational level and change in the *g* factor were explained by the individual's social background. In this analysis the changes were still pronounced and ordered according to the levels, but the changes were smaller compared with the first analysis.

In the third stage of his investigation, Härnqvist made a brief study of the *v-s* factor. This investigation was based on the grouping of individuals at the four main educational levels. He concluded that the individuals at the highest level changed most in the verbal direction while those at the second level (vocational education mostly) changed most in the spatial/technical direction. Härnqvist also concluded that the grouping at the four levels was unsatisfactory when this second factor was analyzed since the levels do not match the content of the *v-s* factor.

The 1948 cohort was also studied by Balke-Aurell (1973) who analyzed, by using the method of multiple regression analysis, the changes in the *v-s* factor as regards different types of education and occupation. It was found that educational and occupational environments predict the changes in this factor between the ages of 13 to 18. This analysis will be returned to when the results from the present investigation are given (chapter 9).

4.3 The purpose of this investigation

The main purpose of this investigation is, as was mentioned earlier, to study the effect of different types of education and occupation on change in verbal/reasoning - spatial/technical *(v-s)* intelligence. In doing this, the four main levels of education described in the previous section will be kept apart and the types of education and occupation will be classified according to the emphasis of verbal or spatial/technical components. After this, the *v-s* changes, determined by linear regression analysis, will be related to the specific training given in education and occupation.

Separate analyses are made of the 1948 and 1953 cohorts which makes it possible to validate the analyses of intelligence change. An attempt is also made to relate the results to the reorganization of the school system that occurred in the interval between the two cohorts.

A replication study of Härnqvist's analysis of changes in the general intelligence *(g)* factor as related to main educational levels is made in the case of the 1953 cohort. This replication study is also related to the reorganization of the school system.

In order to, as far as possible, isolate the effect of educational and occupational experience on changes in the *g* and *v-s* factors, multiple analyses based on background and individual variables at 13 years of age will also be reported. These analyses are made using quite different techniques; the first one, made by Balke-Aurell (1973) of the 1948 cohort, is a multiple regression analysis and the second, applied to the last cohort, is a causal model dealing with latent variables, namely the method for estimation of linear structural relations (LISREL).

4.4 The present investigation as related to previous research and methodology

4.4.1 Previous research

The different traditions in Europe and America concerning the research on the structure and differentiation of intelligence is one reason for divergent assumptions and conclusions. Another reason, also included in the first one, is the constellation of investigation groups - homogeneous or heterogeneous.

A third reason for the different results has to do with the type of study - longitudinal or cross-sectional. Most of the studies are cross-sectional with concomitant complexity in drawing conclusions about development. A fourth aspect is the tests used in the investigations; group tests or individual tests, general ability tests or tests like the PMA battery, narrow or broad factor tests, verbal or non-verbal and so on. A fifth difference is the statistical methods used when change in intelligence is analyzed. Furthermore, the groups studied (age, sex, education) will of course place limits on the conclusions as to development as will the sampling technique.

In order to relate the present investigation to the opinions regarding the structure of intelligence, Härnqvist's (1968) discussion, in the first ISP study of intelligence change, will be reviewed.

As mentioned earlier, Härnqvist found two significant common components when analyzing the initial and final tests by the method of canonical correlation. (A third factor shows such weak correlation between occasions that it is not used in any further analysis.) The first component is defined as a general intelligence factor and the second as a factor contrasting verbal/reasoning with spatial/technical ability. Härnqvist concludes that

> The two components could be rotated in a Thurstonian fashion so as to become one verbal and reasoning factor and one spatial factor. (p. 61)

He prefers, however, to keep the axes where they are and continues:

> This structure corresponds quite closely to the hierarchical structure preferred in British factor analysis: a first general and a secondary contrast between a 'verbal-numerical-educational' (v:ed) and a 'practical-mechanical-spatial-physical' (k:m) factor. (p. 61)

This hierarchy of ability factors, described by Vernon (1950), is also the starting point for this investigation. In the final LISREL analyses (chapter 11), however, the two group factors are reorganized in a way more similar to that proposed by

Thurstone. This rearrangement is made in order to obtain group factors which are separated and to give these factors the greatest possible part of explained variance, i.e. to make them more predictive.

The fact that the ability factors develop at different rates was concluded earlier. As to the environmental influence, this has its greatest effect when the factor is developing. From the standpoint of a hierarchical structure of intelligence, the environment in early childhood is more crucial to *g* factor development than to group factors since the development of the *g* factor occurs earlier than the group factors. In spite of this, Härnqvist (1968) finds, as mentioned earlier, evidence of educational influence on the *g* factor during the period between 13 and 18 years of age. These results may, however, not be looked upon as contradictory since the hypothesis of growth includes a minor part of *g* factor development during adolescence.

A different point of view is the theory of fluid and crystallized intelligence (Cattell, 1971; Horn, 1968). Crystallized intelligence is assumed to be influenced by fluid intelligence and by the environment while fluid intelligence is more genetically determined. One conclusion drawn from this may then be that *g* (seen as an average of Gc and Gf) factor development at rather late ages can be assigned to Gc development, while Gf and a part of Gc develop earlier.

When, on the other hand, the starting point of investigation lies in a multiple factor theory, the differentiation of group factors is assumed to occur at an earlier age which results in a relatively smaller increase during adolescence compared with the development of the second-level factors in a hierarchical model.

The investigations of educational influence on the change in intelligence factors have mostly concerned secondary (selective) school students and, in the case of the group factors, mainly students in technical lines. The results emphasize these aspects of educational influence. The present investigation is based upon the total range of an age cohort and the question is whether this influence can be said to be valid for all educational levels and for groups with different degrees of specialization in education and occupation.

In the present investigation, the occupational influence has been studied in the same way as the educational influence. By this it is expected that experiences act in the same way irrespective of being gained at school or at work.

The effects of other variables are classified as indirect (acting as self-selectors or as mediators of educational and occupational choices) and direct (acting as predictive variables *per se)*. This classification agrees with the division into selective and predictive variables given by Cronbach et al. (1977). In the multiple analyses in the present investigation it is not possible to separate the direct and indirect effect of these variables. However, this is done in the LISREL analyses.

Of these other variables, the socio-economic ones are most frequently investigated and appear to be the strongest, both as indirect and direct variables, in predicting change in general intelligence. These variables are also incorporated in this investigation.

As regards the factors underlying the socio-economic influence, the parental attitude towards higher education is the only one examined in this investigation. This variable must be interpreted with caution, however, since the attitude measured is the parental attitude as the child perceives it (chapter 7).

»Interests» are also assumed to have some influence, both indirect and direct. However, little research has been done in this area and the conceptions of what »interest» means and how it should be measured differ. In this investigation, »interests» are measured by recording actual leisure time activities, preferred activities, interest in school work, and, in one question only, educational aspiration. The leisure time activities are grouped in several areas (chapter 7), e.g. verbal and technical domains.

»Educational achievement» is measured by school marks. These are also influenced by study ambition and interest in school work.

This division into different groups of variables is not meant to indicate that these variables are and act distinctly and independently of each other. On the contrary - the intellectual, socio-economic, regional, educational, interest, and achievement variables interact and, as Lavin (1965) states, interpretation of causality between variables of this type must be made with caution. Also, for example, the fact that one interest variable is distinct in one person's answer and not in another's may not always mean that the first individual has a greater interest in school work than the second - the questions and the way of answering them impose, together with the coding procedure, restrictions on measurement (cf Humphreys, 1962; Eysenck, 1967; and Horn, 1979; in their criticism concerning overemphasizing the results of factor analyses of intelligence tests).

4.4.2 Methodology

In chapter 3 the quasi-experimental design and the sources of errors which may lead to erroneous interpretations of results was discussed.

The present investigation is looked upon as a quasi-experiment. The treatment variables are education (level and type) and occupation (type) and the effect variable is intelligence change.

In the first stage the changes, i.e. the difference between the predicted and observed final scores, are estimated by simple regression analysis based on initial and final scores obtained by the method of canonical correlation analysis. As regards the *v-s* factor this is done for groups formed on the basis of type of education or occupation within each educational level and for both cohorts separately. In the analysis of the *g* factor (1953 cohort), the simple regression analysis is based on the total group and changes are estimated with regard to educational level. The regressions in all simple regression analyses are corrected for unreliability in initial scores (cf. Cronbach and Furby, 1970). This will be discussed later in this section.

In the second stage the estimated changes are based on multiple regression analysis. The analyses are accomplished in the same way as in the simple regression apart from the multiple initial variables which are all observed (and not derived). These analyses are made using the 1948 cohort (Balke-Aurell, 1973).

The last type of analysis, made in the 1953 cohort, is performed by the LISREL method. The reasons for using this method are partly to test and validate the results of the former analyses, mainly the simple regression ones, partly to try to extract further information from the data and partly to test, on methodological grounds, how the method works when a large group is analyzed and where the data have not been initially prepared to suit the method.

In the first LISREL analyses, the influences of the explanatory (latent) variables on the educational treatments (level and type) and on the final intelligence are analyzed. The treatment effects are given by the regressions of final intelligence on educational level and type. The results will be given in path diagrams.

In a further step using the LISREL method, analyses of covariance between latent variables are performed. This type of analysis has recently been reported (Sörbom, 1978; Sörbom and Jöreskog, 1981). According to this type of analysis the estimated changes are differences in final adjusted scores between educational levels or between types of education and occupation.

The first two methods mentioned, simple and multiple regression, can be found in most statistical textbooks and only special techniques within the methods used in this investigation are discussed in this section.

Since the LISREL analyses comprise several steps, each of which includes many rather unfamiliar procedures and symbols, the different steps will be described in connection with the account of the analyses performed.

In the canonical correlation analysis (Cooley and Lohnes, 1971), the variance in battery 1 explained by component 1 (here denoted s_{11}^2) is the average of the sum of squared correlations between the original variables and the component:

$$S_{11}^2 = \frac{r_{11}^2 + r_{21}^2 + r_{31}^2}{3}$$

In the simple regression analyses, the errors of measurement of the independent variable are corrected for by the within-group reliability. The within-group reliability

$$r_{tt_w}$$

is estimated from subscale reliabilities, standard deviations and canonical weights by Härnqvist (1968) from the 1948 sample.

The corrected within-group regression is

$$b_{w_c} = b_w \frac{1}{r_{tt_w}}$$ (Härnqvist, 1968, p.53)

The weakness of this correction is the assumption that the errors of measurement are the same at all levels, i.e. for all subgroups (cf. Bergman, 1972; Werts and Hilton, 1977).

In the multiple regression analysis, it is difficult to correct for the errors of measurement which, in turn, are rather high. The difficulty increases as the number of variables increases and consequently corrections are not made in these analyses. Besides, multicollinearity exists which further complicates the interpretation of the results.

The stepwise method is used in the multiple analyses, since it is necessary to study the changes in the regressions of the variables in the equation when a new variable is entered. This results, however, in difficulties when the increase, brought about by a new variable, is tested since the increase given by an »old» variable may then fall below the significant limit.

Because of this, the increases are not tested for significance; instead, an absolute limit of one half per cent (for small samples, $n < 200$, the limit is one per cent) of increase is used. Another reason for this decision is the fact that the results of multiple regression analyses are so elusive - multicollinearity, relative weights, errors of measurement - that a test of significance might give an illusion of more definitive results than are actually the case (cf Kerlinger and Pedhazur, 1973).

The multiple correlation coefficient is the product-moment correlation between the predicted and the observed y, and this coefficient squared is the variance in y explained by the x's. Sampling errors increase the multiple correlation. Because of this, the correlation is corrected for shrinkage by a formula given in Guilford (1956 a, p. 399):

$$\bar{R} = \sqrt{1 - (1 - R^2)\frac{N - 1}{N - k}}$$

The difficulties involved in multiple regression analysis, i.e. the multicollinearity and the errors of measurement, are handled in the LISREL analyses. However, the restriction as regards interpreting the weights of the independent variables remains (cf. Blalock, 1967; Kerlinger and Pedhazur, 1973).

PART II

DATA AND PREPARATORY WORK

5 SAMPLES

Within the ISP, samples from two birth cohorts, 1948 and 1953, are followed from 13 years of age. The samples consist of every individual born on the 5th, 15th, and 25th in any month of these years.

In this investigation, the males in the samples are followed up at the time of military enrollment, i.e. at 18 years of age. This means that the duration of the investigation periods is five years.

5.1 The 1948 cohort

The collection of information on the individuals in the first sample has, as regards this investigation, been made in three steps:

- at 13 years of age (1961)
- at 18 years of age (1966)
- additional information at 18 years of age (1969)

The second collection provided the ISP with information about the individuals' test result and the part of the educational code that gives the educational level, i.e. the first two digits of a four-digit code.

In an analysis where the changes in ability factors are related to experience of corresponding areas in education and occupation it is, however, necessary to know the kind of educational and occupational experience involved. For this reason, an additional collection was made in 1969. This consisted of information given in 1966 on the individuals' study lines and occupations and was obtained from the National Institute of Military Psychology, as was the other data about the men at the age of 18 (chapter 4).

In Table 1, the numbers in the 1948 sample are shown. For a more comprehensive listing of the dropouts during the investigation steps (1)-(5), the reader is referred to Härnqvist (1968) and Svensson (1971).

Table 1. The ISP sample of male individuals born in 1948.

(1)	Sample size in 1961 estimated from population statistics		6208
(2)	Sample size in 1961 with complete official information and test scores		5382
(3)	Actual sample size in 1961 (2) related to estimated sample size (1)		86,7%
(4)	Sample size in 1966, found in (2) with complete information on test scores and educational level in 1966		4616
(5)	Actual sample size in 1961-1966 (4) related to estimated sample size in 1961 (1)		74.4%
(6)	Sample size of the 1969 collection of additional information found in (4)		4507
	Drop-outs:		
	(a) No information on study line	10	
	(b) Wrong study line code	13	4494
	(c) Missing or incomplete information on occupation	14	
	(d) Wrong occupational code	37	4443
(7)	Actual sample size 1961-1966-1969 in (6b) related to estimated sample size in 1961 (1)		72,4%
(8)	Actual sample size in 1961-1966-1969 in (6d) related to estimated sample size in 1961 (1)		71.6%
(9)	Size of the complete follow-up sample in 1966-1969 (6d) related to the size of the basic sample in 1961 (2)		82.6%

Svensson (1971) starts from a more specialized view in his investigation where he examines the relative achievement in relation to, among other factors, home environment. For this type of study it is necessary to have a complete set of information about marks, scores on achievement tests, parents' education, and father's occupation. For this reason, Svensson's analysis includes fewer individuals than when only primary information and test results are needed.

Apart from this distinction, Svensson's analysis of the dropouts can be transferred to the present investigation. According to Svensson, there are quite distinct reasons for the dropouts in the 1961 ISP sample. The estimated sample size is calculated from official statistics and consists in a small part (0.5%) of children disabled for normal education. These children have not been investigated within the ISP.

Another small dropout group consists of the boys who, because of migration, were not on school records at the time of testing. Those who were absent from school when the tests and the inventory were given, form another dropout group and a last group consists of those without complete primary information or without test scores.

Svensson (1971) analyzes the dropouts and concludes that these cannot seriously affect the data except in the case of the first group, but the intention of the ISP is to investigate normal individuals and consequently this dropout has been ignored.

Härnqvist (1968) found that, due to immigration, the 1948 population in 1968, when the men are 18 years old, is larger than five years earlier. The follow-up sample in 1966 is, however, smaller than expected because a number of 18 year old men were ordered to wait one year for enrollment. The reason for this was a trade union conflict involving employees engaged in the enrollment procedure and this unfortunately affected men at the upper secondary level more frequently than others.

Other types of dropouts in this second collection consist partly of persons with incomplete data and partly of institutionalized persons. These groups are very small and the drop-outs cannot have any effect of the representativeness of the sample.

To summarize Härnqvist's analysis of the dropouts in the second collection, this follow-up sample can be regarded as being a fairly representative sample of the population - men born in Sweden in 1948 and attending schools within the general educational system at the age of 13.

In the 1969 additional collection 109 men could not be identified, probably because of coding and punch-card mistakes. This group was about twice the size before correction.

The occupational code also includes codes for those who are participating in some sort of education. Because of this, the code includes every man. The »educational» part of the code is, however, somewhat undifferentiated and is only used here as a check of the actual educational code.

The incomplete and faulty recording of occupations accounts for a large number of the 74 dropouts at the additional collection. This is probably due to barely legible answers and to the recorders' inability to quickly find the exact occupational code among the fifteen hundred he had to choose from.

When summarizing this analysis of the dropouts of the sample of men born in 1948 it can be concluded that the participants are representative of the population from which the initial random sample was drawn. In the case of the data collection in 1961 the dropouts cannot seriously affect the representativeness of the sample. In the case of follow-up collections made in 1966 and in 1969 certain attention must be paid to the fact that men attending upper secondary school are somewhat more frequently represented in the dropout group than others.

Some notations, which concern the numbers in the analyses to be presented later on, have to be made. When Härnqvist's (1968) investigation is reported, i.e. the canonical correlation analysis and the simple regression analysis of the *g* factor, the number is 4616, i.e. step (4) in Table 1. In the present study, the analyses of the *v-s* factor and the multiple analysis of the *g* factor are based on the number in (6 d) which is 4443.

5.2 The 1953 cohort

The second sample of the ISP consists of individuals born in 1953. The collection of data were made when these individuals were at the same ages as those in the first sample. The years of observation were 1966 and 1971 respectively.

Svensson (1971) analyzes the dropouts in the first data collection of these individuals. As mentioned in the section above, Svensson's examination group is more restricted than the one in the present investigation. Rovio-Johansson (1972) examines the dropouts in 1966 without this restriction.

A summary of these analyses and a description of the dropouts in the second step of collection of data is shown in Table 2. The individuals born in 1953 are fewer than those born in 1948. The percentage figures in Table 1 and Table 2 are, however, strikingly alike.

The conclusions concerning the representativity of this second sample in 1966 are the same as those concerning the first sample in 1961, i.e. the droputs cannot seriously affect the result (Svensson, 1971).

The second step when data from 1971 were incorporated in the ISP data bank, was performed in 1975. This collection consists partly of a different type of dropouts compared with the first sample.

In the data collection in 1975, some districts of military enrollment lost some of their individual records. A postal and telephone inquiry about the loss gave no

Table 2. The ISP sample of male individuals born in 1953.

(1)	Sample size in 1966 estimated from population statistics				5518
(2)	Sample size in 1966 with complete official information and test scores				4759
(3)	Actual sample size in 1966 (2) related to estimated sample size (1)				86.2%
(4)	Sample size in 1971				5470
	Dropouts:				
	(a)	(4) not found in (2)	711		
	(b)	(2) not found in (4)	524		4235
	(c)	No information on test scores in 1971	187		4048
	(d)	Missing or incomplete information about education	27		4021
	(e)	Wrong study line code	2		4019
	(f)	Missing or incomplete information about occupation	168		
	(g)	Wrong occupational code	4		3847
(5)	Actual sample size in 1966-1971 in (4c) related to estimated sample size in 1966 (1)				73.4%
(6)	Actual sample size in 1966-1971 in (4e) related to estimated sample size in 1966 (1)				72.8%
(7)	Actual sample size in 1966-1971 in (4g) related to estimated sample size in 1966 (1)				69.7%
(8)	Size of the complete follow-up samle (4g) in relation to the size of the basic sample in 1966 (2)				80.8%

additional information. The loss in this case is about 2 percent (100 men). Among the districts with missing records one is dominated of forestry and two are medium-sized towns in industrial and agricultural districts.

This loss is, however, small and consists of varying educational and occupational areas. Consequently, there is no reason to suspect that the loss affects the representativeness of the sample in any serious way.

The dropouts in the collection of data from 1971 can be described in the same way as the former additional collection; the dropouts at this second step are mainly incomplete, wrong or missing occupational codes. These dropouts are greater than in the first sample and are dominated by men at the highest educational level. A description of the reorganization of the enrollment in 1970 must be made in order to explain this.

Before this year, the enrollment committees moved to several places in each district. The time for enrollment was concentrated to the autumn. In 1970, the enrollment districts were enlarged, the enrollment committees given permanent offices and the time for enrollment extended over almost the whole year, from autumn to summer.

A consequence of this, as regards the ISP, is that the test results for two individuals is at the most separated by about 10 months compared with the corresponding maximum separation in the first sample - about two months. The probable effect of this is an increase in the dispersion of the test results compared. Because of the age of the individuals, however, this increase is probably very limited.

Another effect of the extended enrollment period is that the men at the higher educational levels in this second sample have had more time to »settle down» in an occupation at the time of the second data collection. Some men also have had time to start a university education.

These two facts make the list of occupations and academic study streams more extensive than earlier, and increases the risk of the recorder making faulty notes, which is probably more frequent in the case of »new» occupations and study lines.

To summarize the dropouts in the second sample, there are two groups that can jeopardize the representativeness of the sample: the loss of some individual records concentrated to three enrollment districts and lack of codes for some highly educated individuals' occupations. In view of the fact that the final sample consists of 3 847 men and that the number of dropouts is about 200, it can be concluded that the effect of these dropouts can hardly be of any considerable size.

In this section, it has also been noted that the dispersion of the final test results in the 1953 sample is probably somewhat greater than in the 1948 sample since the period for enrollment was extended.

The numbers which form the bases of the different analyses vary more in the investigation of this second cohort compared to that of the first one. Thus, in the canonical correlation analysis the number is 4048 (4 c); in the analysis including only level of education - 4021 (4 d); in the analyses where type of education is considered - 4019 (4 e); and in the analyses concerning type of occupation - 3847 (4 g).

6 THE SCHOOL SYSTEM IN SWEDEN 1961-1971

This investigation extends over a period of ten years. During this time alterations in the general school system occurred in Sweden as well as in many other countries.

The 9-year experimental school was introduced in 1950 and in 1961 about one third of the 13 year old pupils were attending this school. (The school terms are given in English throughout this report. The Swedish designations are shown in Appendix 1.) No selection of pupils took place during the nine years but in the last three grades they had to choose between subjects and courses and in the last grade the choices consisted of three different lines, one theoretical, one practical, and one theoretical/practical. (The term »line» used in this report refers to the different streams in the Swedish school system, where pupils in each line are separated from those in the other lines. The subjects and courses differ, in varying degrees, between the lines.)

In 1961 two thirds of the pupils attended the old school system (Yearbook of educational statistics, 1978) with a seven- or eight-year elementary school from which a selection based on marks was made after four, five or six years. The schools to which the pupils were admitted as a result of this selection were theoretically oriented and the lower secondary school was the most common one. Male pupils had to attend this school before entering the upper secondary school where, in turn, a new selection took place.

The vocational school and the theoretically/practically oriented continuation school were alternatives to the lower and upper secondary schools.

In 1962, a change-over to the 9-year comprehensive school was decided by the Swedish parliament. This school was compulsory and similar to the 9-year experimental school. No selection took place during the nine years. In the seventh and eighth grades, some choices of subjects and courses were done and in the last grade the pupil had to choose between nine lines, five mainly theoretically and four more practically oriented. The first selection occurred after the nine years and the schools to which the pupils were admitted were mainly the upper secondary school, continuation school and vocational school. Entrance to these schools was based on line in grade nine and marks.

In the lower and in the higher secondary schools a seven-point scale of marks, based on »absolute» achievement, was used. The marks in the elementary school were, as are those in the experimental and comprehensive schools, based on a relative grading system. The seven-point scale used in the elementary school was replaced by a five-point scale in the experimental and comprehensive school systems. The relative marks are based on nationwide achievement which, in some subjects, is established with assistance of standardized achievement tests. Besides achievement, the grading in the comprehensive school includes other aspects of individual qualities such as team-work and aptitudes for study at an upper secondary level.

The implementation of the 9-year comprehensive school was completed in 1971. In 1966, however, 80 per cent of the 13 year old children attended the comprehensive schools and, consequently, about 20 per cent attended schools within the old school system (Yearbook of educational statistics, 1978).

The upper secondary school prepared for higher education. The continuation school and the vocational school still functioned as alternatives after compulsory education. In addition there were folk high schools for adult education. Vocational education was expanded in the 1960's, and the number of students more than doubled during that period (Yearbook of educational statistics, 1978).

In 1969 it was decided that the upper secondary school, the continuation school and the vocational school should be combined into one integrated upper secondary school. This school comprises twenty-one study lines, five of which are academically oriented and last for three or four years. The other sixteen lines extend for two years and are divided into theoretical and practical lines. The curriculum of this integrated school was confirmed in 1970 and implemented in 1971.

This retrospect of educational reforms in Sweden should be concluded with a comment on changes at the university level. The main changes were proposed by a commission formed in 1968 (U 68) and were implemented in 1977. The intentions of this reform were to widen university education as regards type of courses and admission.

7 INSTRUMENTS

7.1 Tests

7.1.1 Initial test battery

The test battery given to the samples at 13 years of age, in 1961 and in 1966 respectively, is identical between occasions and consists of three parts: Opposites, Number series, and Metal folding. These are all paper-and-pencil tests and consist of 40 items each. The tests were administered in spring by the classroom teachers in accordance with detailed written instructions.

The test battery was constructed especially for the ISP, and has also been used by Gustafsson et al (1981) and within the Project Metropolitan (e.g. Jansson, 1975; Dahlbäck, 1980). The subtests measure verbal, reasoning and spatial factors of intelligence according to a Thurstonian classification of abilities (cf. Härnqvist, 1968, p. 59):

Opposites: To find the opposite of a given word among four choices. 40 items, 10 minutes. Example: ANONYMOUS - approved; well-known; famous; coloured.

Number series: To complete a number series, of which six numbers are given, with two more numbers. 40 items, 18 minutes. Example: 5, 7, 11, 17, 25, 35 - -

Metal folding: To find the three-dimensional object among four choices that can be made from a flat-piece of metal with bending lines marked in the drawing. 40 items, 15 minutes.

All answers are written directly in the test booklet. This booklet also contains the interest and attitudes inventories.

7.1.2 Final test battery

The test battery given in connection with the military enrollment is the same in 1966 and in 1971. A change-over to answer forms, prepared for optical reading, was made in the period between the military enrollments of the two cohorts. The test battery is also composed of paper- and pencil tests (c.f. Härnqvist, 1968, p. 59):

Subtest A, Instructions: To follow verbal instructions to mark, cancel, or write things. For a few items, simple information of a very general nature is needed. A few items imply changes of directions on dials or simple diagrams. The main character of the test is, however, decidedly verbal. 40 items, 12 minutes.

Subtest B, Concepts: To select among five verbally expressed concepts the one that does not belong to the same class as the others. This test seems to tap both verbal and reasoning abilities. 40 items, 7 minutes.

Subtest C, Form-board: To find among four choices the set of pieces that can be fitted together to form a given flat board, with lines between pieces marked on it. A spatial test, but two-dimensional in contrast to the Metal folding test above. 25 items, 4 minutes.

Subtest D, Mechanical comprehension: A variation of the well-known Bennett test. 52 items, 15 minutes.

As can be seen seen from the descriptions above there is a greater proportion of the spatial-technical factor in the final battery compared with the initial.

7.1.3 Test statistics

Basic statistics of the initial and final tests are shown in Tables 3-5.

The means in Table 3 indicate, for the initial tests, an increase in test results for the boys born in 1953 compared with those born in 1948. The means of the initial tests are fairly near the midpoint of the score range. The distributions of the initial test scores are approximately normal for both samples (Svensson, 1971).

In the final tests, Concepts and Mechanical comprehension display small variations between the samples. The means of the other tests, Instructions and Formboard, differ both by about a quarter of one standard deviation between samples but in opposite directions - in the case of Instructions the first sample attains a higher mean but in the case of Formboard it attains a lower mean compared with the second sample. The lower mean of Instructions in the last sample probably depends in part on the change-over to an answer form, prepared for optical reading, mentioned earlier. It is natural that this rather unusual way of answering has its greatest effect on the first test given, i.e. Instructions.

Table 3. Means and standard deviation of the initial and final tests.

		No. items	1948 $\bar{x}$	(n = 4616) sd	1953 (n = 4048) $\bar{x}$	sd
1.	Opposites	40	22.1	6.8	23.5	6.7
2.	Number series	40	19.5	8.0	20.2	8.3
3.	Metal folding	40	21.7	7.4	22.4	7.6
4.	Instructions	40	27.4	5.5	24.9	5.4
5.	Concepts	40	22.4	6.2	23.0	6.3
6.	Formboard	25	12.2	4.3	13.9	3.8
7.	Mech.compr.	52	32.9	7.9	32.4	8.0

The means of the final tests vary in relation to the mid-points of ranges. Concepts and Formboard have means near the mid-points of the ranges but Instructions and Mechanical comprehension seem to be somewhat easy.

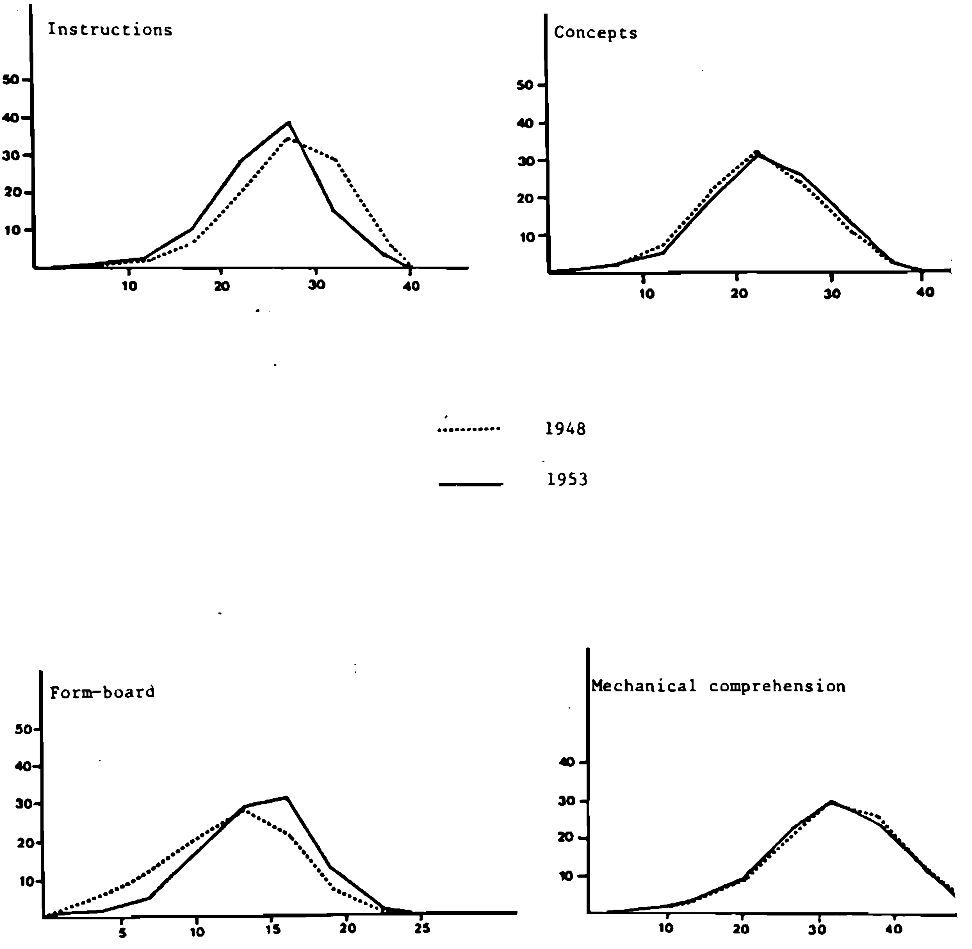


Figure 1. Distributions of the final tests in the 1948 and 1953 samples.

The distributions (Figure 1) vary as the means indicate but all are approximately normal. The distribution of Instructions for the 1948 sample is the one that deviates most but the skewness can be considered to fall within the limits of the normal distribution.

The reliability estimates (Table 4) of the tests have been obtained from earlier studies. For the initial tests Svensson (1971) bases these calculations on all the pupils born on the 15th of May in 1948 and in 1953 respectively and the coefficients are calculated according to the Kuder-Richardson formula 20. The estimates of the two samples are identical - a difference of .01 can be ignored - and therefore only the estimates based on the 1948 sample are shown in Table 4.

The estimates for the final tests are split-half reliabilities calculated by the National Institute of Military Psychology on a one per cent sample of the 1964 enrollment population (Ståhlberg, 1971). The reliability estimates are all about .90.

Table 4. Reliability of the intelligence tests.

1.	Opposites	.87	
2.	Number series	.92	n = 349
3.	Metal folding	.88	
4.	Instructions	.90	
5.	Concepts	.90	n = 513
6.	Form-board	.87	
7.	Mech. compreh.	.87	

The correlations between the tests (Table 5) are very similar for the two samples. The greatest difference is .05 which is shown in the correlations between Instructions and Concepts.

For the initial tests the coefficients are ordered as expected. Opposites and Number series have the highest intercorrelations and Opposites and Metal folding the lowest. Among the intercorrelations of the final tests, the ones between Instructions and Concepts are the highest and differ from the other coefficients, which are all about the same size.

The correlations between the subtests in the two test batteries vary between .32 and .66. The verbal and reasoning subtests in the two batteries (Opposites, Number series and Instructions, Concepts, respectively) show the highest intercorrelations. The verbal and reasoning tests in one battery and the spatial tests in the other have the lowest intercorrelations.

Table 5. Intercorrelations of the tests. The 1948 sample (n = 4616) above and the 1953 sample (n = 4048) below the diagonal.

		1	2	3	4	5	6	7
1.	Opposites	—	.55	.41	.64	.61	.32	.50
2.	Number series	.56	—	.46	.65	.56	.39	.46
3.	Metal folding	.44	.46	—	.42	.38	.46	.53
4.	Instructions	.66	.64	.44	—	.71	.47	.57
5.	Concepts	.62	.59	.42	.76	—	.46	.54
6.	Form—board	.35	.40	.47	.50	.50	—	.48
7.	Mech. compreh.	.46	.42	.55	.56	.51	.47	—

7.1.4 Combination of scores of the initial and final subtests

As mentioned earlier, the two test batteries measure the different abilities in different ways and the subscales of the two batteries are not comparable. The initial test battery gives about the same weight to verbal, reasoning and spatial ability. In the final battery, spatial/technical ability is relatively stronger.

In Härnqvist's analysis (chapter 4), the scores of the two sets of subscales were made comparable by means of canonical correlation analysis. The subscales were combined in order to obtain the highest possible correlation between the factors common to the two test batteries (Härnqvist, 1968; Cooley and Lohnes, 1971).

In Table 6, the results of the canonical analysis are presented. The figures for the 1948 sample are taken from Härnqvist (1968) and the ones for the 1953 sample are calculated in the same way. In the table, the signs of the coefficients for the second component are reversed for the 1948 sample compared with Härnqvist (1968). This is done in order to make this factor positive in the verbal end and negative in the spatial one, thus being exactly comparable with the corresponding factor in the 1953 sample.

A third factor appears in both analyses but since this has a low correlation (.14 and .10 respectively) between occasions it is not used in any further analysis.

The patterns shown by the weight coefficients are similar for the two samples - exactly the same order of coefficients is shown within each battery and for each of the two components.

Table 6. Canonical analysis. Components, weight coefficients and canonical correlations for the two samples.

	First component		Second component	
	1948	1953	1948	1953
Opposites	.71	.53	.38	.49
Number series	.63	.44	.29	.39
Metal folding	.31	.24	-.88	-1.14
Instructions	.74	.53	.49	.66
Concepts	.40	.35	.38	.44
Form-board	.09	.06	-.55	-.64
Mechanical comprehension	.37	.21	-.60	-.88
Canonical correlation	.78	.76	.38	.41

There is also congruence between samples as regards the canonical correlations. For the first component, the correlation of the second sample is .02 units higher than the one of the first sample and for the second component there is a reversed difference of .03 units.

Table 7. Correlations between original variables and canonical components. The 1953 sample.

	First component	Second component
Opposites	.88	.21
Number series	.85	.15
Metal folding	.67	-.74
Instructions	.95	.17
Concepts	.89	.16
Form-board	.61	-.49
Mechanical comprehension	.72	-.57
Canonical correlation	.76	.41

Further data of the canonical analysis in the 1953 sample are presented in Table 7. The first canonical correlation coefficient is .76, which implies that the two sets of canonical factors (one for initial and one for final tests) have 58 per cent of their variances in common. The corresponding figure of the second coefficient is 17 per cent.

65 per cent of the variance in the initial and 65 per cent in the final battery is explained by the first component. (For calculation procedure see chapter 4 and Cooley and Lohnes, 1971). Of the remaining variance, 20 per cent in the first battery and 16 per cent in the second is explained by the second component.

These percentages imply that the two components together explain 72 per cent of the variance in the initial and 70 per cent in the final battery.

The correlations between the original variables and the first component are all positive and vary between .61 and .95. They can be divided into two groups where the first one includes inductive and verbal tests and the second consists of spatial and technical tests. This factor is referred to in the following as the general intelligence *(g)* factor.

The correlations of the second component describe the bipolarity of that factor with verbal/reasoning tests on the positive side and spatial/technical tests on the negative. The bipolarity does not seem to be quite uniform since the correlations of spatial/technical tests dominate. In the present investigation this factor is referred to as the *v-s* factor.

7.1.5 The ability factors

The means and standard deviations of the factors on the two occasions are shown in Table 8. As mentioned earlier, the second factor in the 1948 sample is positively loaded for spatial/technical ability and negatively loaded for verbal/reasoning while the opposite is true for the factor in the 1953 sample. In all tables, however, the signs of the figures for the 1948 sample will be reversed.

The values in Table 8 are not of any primary interest since they are based upon arbitrarily chosen statistics of the composite scores. The values are shown only in order to present the basis of the results to be given later. The range of the possible scores is covered by at least three standard deviations from each composite mean. The scores of the *g* factor are all positive while those of the *v-s* factor can be positive as well as negative.

When the changes in ability are discussed in the following chapters the values are expressed as percentages of a standard deviation to make the results comparable for the two groups.

Table 8. Means and standard deviations of the two factors for the 1948 and 1953 samples.

	Initial				Final			
	1948		1953		1948		1953	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
g factor	34.77	10.10	36.43	10.00	42.26	8.37	47.79	10.00
v-s factor	5.09	5.86	6.67	5.00	4.50	4.79	3.95	5.00

7.2 The inventories

As mentioned earlier, the initial tests were placed in the same booklet as the questionnaire items. All the answers were written directly in the forms.

The topics of the inventories are the same on both occasions, but there are several differences at the item level and in response procedure. The changes made before the collection of information from the 1953 group were intended to increase the reliability of the questionnaire dealing with attitude to school, to make the questions more up to date, to make the information more comprehensive, and to obtain more alternatives for statistical treatment.

For information about the principles of construction as well as more a detailed description of the questionnaires, the reader is referred to Svensson (1964), Rovio-Johansson (1972), and Härnqvist and Svensson (1973).

7.2.1 The inventory for the 1948 cohort

The first inventory, given to the 1948 sample in 1961 is divided into four parts:

Spare time interests consists of 12 questions about interests and activities. For every item, one of five alternatives concerning the frequency of the activity is to be marked. The five-point scale is transformed to a three-point scale (under average, average, and above average) and all items are included in the multiple regression analyses (Balke-Aurell, 1973).

Spare time activities includes 20 items, each forming a triad of activities among which the individual has to choose the most and the least preferable. The activities stem from six areas of interests and every area is represented by 10 items. The answers in this questionnaire form an ipsative scale where the scores are mutually dependent. Independent measurements for the areas are impossible to obtain and, because of this, no items in this questionnaire are used in the multiple analyses.

Plans for future education and occupation includes 9 questions of which 4 concern study plans for the next year and 3 concern occupational plans. The 2 remaining questions deal with how many years the individual intends to attend formal education and if he intends to graduate from upper secondary school.

The plans for the next year are too short-range in relation to the purpose of this investigation and are excluded from further treatment. So are the items about occupational plans but the reason for this is not that the questions deal with matters lacking in interest in this study - on the contrary - but that the answers in general are not sufficiently distinct. The occupations mentioned are often vague, many boys have given two or more answers and several have not answered the question at all.

Of the two remaining items, both measuring study aspiration, the one concerning graduation from upper secondary school is the one which best takes educational aspiration into account and this is the only item in this questionnaire which is included in the analyses.

School: interests and attitudes consists of 30 statements concerning adjustment to school. For each item the individual has to choose between »yes» and »no». The items in this questionnaire were derived from five aspects of interest in school work and attitudes towards school. The 30 items were then brought together into five areas (scales): Contact between child and parents (8 items); Parents' attitude towards further education (6 items); Feeling of security at school (5 items); Interest in school work (5 items); Contact with classmates (5 items). One question (Have you a room of your own at home?) is not included in any scale. Of these five scales the third one is not discriminating enough to be used in further analyses.

7.2.2 The inventory for the 1953 cohort

This inventory includes the same areas as the inventory used in the 1948 cohort. The contents of the questionnaires are, however, different in certain aspects.

Spare time interests (»After school») has 8 items of which 6 are identical - partly or totally - with the earlier version. The items removed from the former questionnaire were those with low discriminative power. The 2 new items concern time spent for homework and sex of best friends. As in the earlier version, a transformation of the answers to a three-point scale is made. All items, except the last one mentioned, are included in the initial stages of the LISREL analyses.

Spare time activities in the new questionnaire gives independent measurements of each activity area. Each area (verbal, technical, outdoor, clerical, and domestic) is represented by ten activities and for every item the individual has to mark whether he finds the activity very interesting, interesting, dull or very dull. The results of all areas are included in the initial stages of the LISREL analyses.

Plans for future education and occupation is partly equivalent to the former »plans». The items about educational and occupational plans are the same in both questionnaires, but some follow-up questions are brought into the latter one. Only one item from this questionnaire is used in the present investigation. This item concerns - as in the questionnaire five years earlier - aspirations for advanced education. The formulation of the questions differs a little between occasions: instead of asking about intention to graduate from upper secondary school the item in the latter questionnaire deals with the intention of attending upper secondary school.

School: interests and attitudes includes, as was the case five years earlier, 30 items to be answered »yes» or »no». The items stem from three areas of interest and attitude (instead of five as before) and each area is represented by 10 items. These three areas (scales) are the same as the second, third, and fourth, five years earlier: Parents' attitudes towards further education; Feeling of security at school; Interest in school work. The three scales are used in the initial stages of the LISREL analyses.

7.2.3 Reliability

Estimates of reliability are calculated for School in both inventories and for Spare time activities in the second one. Svensson (1964, 1971) gives a detailed description of the estimates. The calculations are based on subsamples (3% of totals). Summarizing the results it can be concluded that reliability is fairly low in the School questionnaire 1961 ($r_{K\text{-}R20}$ calculated for boys and girls together varies between .34 and .50) but rises in the one in 1966 ($r_{K\text{-}R20}$: .65 - .75, boys only). The estimates of reliability in the 1966 Spare time activity is somewhat higher ($r_{split\text{-}half}$: .74 - .82, boys only) but, as Svensson concludes, none of the estimates is particularly high which implies that caution must be exercised in drawing conclusions about these variables.

7.3 Other initial variables

School marks. In elementary school, the subject Swedish was divided in two subjects: reading and writing. The marks in these subjects are, together with the marks in mathematics, used in the analyses of the two samples, i.e. the multiple analyses for the 1948 sample and LISREL analyses for the 1953 sample. Since English became a mandatory subject in the new school system, the marks in this subject are also used in the last type of analyses.

The marks in the old school system, and in the 9-year experimental school formed a seven-point scale. In the new school system the grading is made on a five-point scale. In the analyses, all marks are converted into a three-point scale: below average, average, and above average mark.

Social class. Originally this variable was divided into five groups according the father's education and occupation. The coding is the same for both cohorts.

In the multiple analyses of the 1948 sample the codes were converted into a three-point scale (Balke-Aurell, 1973). The transformation was based on as equal frequencies as possible in the three categories giving different classifications for the student and the worker groups. (The account of the categorization of the samples in the student and worker groups is given in chapter 8). In the first group, the social classes are: manual workers; lower and intermediate level employees and farmers; higher level employees and university graduates. In the second group the farmers constitute the second class and all employees are placed in the third social class.

In the LISREL analyses of the 1953 sample the intention is to arrive at a uniform base for both the student and the worker groups. Because of this, the classification is made on a four-point scale where all the categories of the first sample are taken in consideration: manual workers; farmers; lower and intermediate level employees; higher level employees and university graduates.

Attention should be given to the ranking of the transformed codes: the lower the occupational status the lower the code number.

Parents' education. This variable was not included in the multiple analyses of the first sample. In the LISREL analyses of the last sample, education is classified in three groups: elementary and vocational school; lower secondary school; upper secondary school and above.

Municipality. The basis of this variable is the kind of education that is available in or in the neighborhood of the place of residence. In the analyses, this variable is classified in two groups according to whether or not upper secondary school is available.

8 CATEGORIZATION IN EDUCATIONAL AND OCCUPATIONAL GROUPS

Since the main purpose of the present investigation is to analyze the effect of experience on verbal/reasoning and spatial/technical intelligence, the treatment variable must reflect verbal and spatial/technical experience. Because of this, categorizations of study lines and occupations are made on the basis of the emphasis on and training within these domains. As a result of these categorizations, the individuals are classified in verbal and spatial/technical groups which, in the following, are designated as educational and occupational structure groups.

Before the categorization of structure groups is made, the classification of educational levels will be reported.

This grouping is necessary when *g* factor changes are analyzed. The levels will, however, be retained when *v-s* changes are studied. The reason for retaining the categorization of levels in the *v-s* analyses is that the type of verbal - spatial/technical treatment differ between levels. The teaching of engineering in a vocational school is, for instance, more practically oriented compared to that of technology in upper secondary school. This is also indicated in Härnqvist's (1968) analysis as reported in chapter 4.

The request that regression analysis should be based on homogeneous groups given by Lord (1963) and also emphasized by Cronbach et al (1977) is another reason, related to the first one, for retaining the educational levels when the *v-s* factor is analyzed. Thus, the regression analyses of this factor will be made foı each educational level and, consequently, the *v-s* deviations for structure groups will then be calculated for each level separately.

8.1 Educational levels

The grouping in educational levels is the same as Härnqvist (1968) used in his analysis of the change in the *g* factor in the 1948 sample and is in turn derived from the classification developed by the National Institute of Military Psychology. The classification code consists of four digits, the first two of which refer to general educational level and the last two to educational lines. Altogether, 21 level codes were represented when the men in the 1948 cohort were 18 years old, i.e. in 1966. Five years later, when the men in the second group had reached this age, only 14 level codes were used. This decrease in the number of codes is due to the change in the school system mentioned earlier, a change which had almost been completed in 1971. Beside this, some codes which stand for about the same educational level in 1966 were brought together in the coding in 1971.

In the analysis of the *g* factor as well as in the main analysis in this investigation, i.e. in the study of the *v-s* factor, the investigation is based on four main educational levels. The principal reason for this more concentrated classification is that the frequencies must be large enough to provide for additional grouping along a horizontal axis, i.e. to provide for division into structure groups. One more reason for basing the analysis on the four main educational levels is to facilitate comparisons between the two samples. It is difficult to find comparable minor levels but a division into the main levels will make the two cohorts comparable.

Thus, the individuals in the two samples are classified in the four main educational levels:

Level 1: Compulsory school only

Level 2: Practical-vocational education

Level 3: Shorter theoretical and theoretical-practical education

Level 4: Advanced theoretical education

Due to the change in the school system there are some differences in the composition of the main levels. The lower secondary school (level 3) is, for instance, hardly represented in the last group.

In Table 9 the numbers in the 1948 group are based on Härnqvist's analysis. The numbers in the 1953 group are based on the information of the first two digits in the educational code only and this means that the two samples are directly comparable in this respect. In the analyses based also on study line codes, the numbers diminish in both samples.

The greatest differences between the samples are at levels 2 and 3. For the 1948 sample these groups are of the same size. Five years later, level 3 is about half the size of level 2. This reduction in level 3 is due to the discontinuation of the lower secondary school. In the 1948 sample more than 400 (9%) men finished school after this level of education. In the 1953 sample, the number is 57 (1%).

Table 9. Distribution of the samples - 18 years old - over the four main educational levels.

Level	1948 sample No	1948 sample %	1953 sample No	1953 sample %
4	1194	26	1159	29
3	958	21	549	14
2	946	20	1131	28
1	1518	33	1182	29
Total	4616	100	4021	100

The 1948 men in the 9-year experimental school attended different lines in the last three grades (chapter 6). These lines, indicated by the last two digits in the educational code were, however, not available when the first analysis of the *g* factor was made. Because of this, all, including those in theoretically oriented lines, who finished school after the experimental school, were placed at the first main level.

The men in the 1948 cohort who finished school in theoretical lines in the 9-year experimental school constitute about 1% of the totals. The corresponding figure for the 1953 group, i.e. the number in theoretical lines in the comprehensive school, is 12%. This last figure is, as will be seen later, not exactly comparable to the first one and is also somewhat diffuse.

These percentages can be transferred to the third level since this type of education replaced the lower secondary school. This transfer results in 32% (1948) and 17% (1953) at level 1 and 22% (1948) and 26% (1953) at level 3. The analysis of the *g* factor in the 1953 cohort could then be based on these numbers instead of those given in Table 9.

One reason for maintaining the basis given in Table 9 is already mentioned - the comparability of the analyses. This reason is, however, not a strong one since the differences between the actual and corrected figures in the 1948 sample are small and probably of no consequence for the results. After consideration, however, other arguments appeared:

- The last two digits in the educational code are often not found in the code list for the experimental and comprehensive schools but in those for vocational education. This implies that the boys, after studies in one of these schools (unknown line) took a vocational - and from a military point of view more interesting - course.

- Some of the theoretical lines are less academically oriented compared with others. The theoretical line which is designed to prepare for studies at the upper secondary school is, according to the codes, represented by 2.5% of the 1953 sample. This number is comparable to that of the 1948 men at the theoretical line in the 9-year experimental school who were placed in level 1 in the first analysis of the *g* factor.

Because of this, the 1948 basis of grouping is retained but it should be remembered that a greater number of men in the 1953 sample at level 1 are more theoretically educated compared with the 1948 sample.

The vocational school was expanded between 1966 and 1971 which explains the greater number of the students at this level in 1971. The continuation school of the theoretical and practical type at level 3 was also being expanded during this time which is indicated by the numbers of students at this school - 2% 1966 and 11% 1977.

The greater number of students at the highest educational level is partly an effect of the non-segregated compulsory school after which the students, when they are 16, choose upper secondary school. In the old segregated school system a theoretical choice (and a selection) prior to that had to be made at about 13 years of age (chapter 6). The fact mentioned earlier (chapter 5) that the dropouts in the 1948 sample were greater for the men at the fourth level than the other levels probably affects the percentage to some extent as well.

8.2 The student group and the worker group

As mentioned in chapter 5, the 1948 sample consists of 4443 men with complete educational and occupational codes. Among these, 1876 (42%) were still attending school at the age of 18. The comparable figures of the 1953 sample are 3847 and 1211 (31%). The discrepany in the proportions of the student groups in the samples is probably a result of the reorganization of the school system including the expansion of the vocational lines. This type of education, which is usually completed one or two years after comprehensive school, has increased its number of students. The extension of the period in 1971 of military enrollment probably resulted in a decrease in the number of men attending school at this time as well.

In this type of investigation it is appropriate to keep the men who are still in school separated from those who have started their working life. The men in the student group are probably more oriented towards theoretical matters and this whole group is assumed to be more at the verbal/reasoning end of the *v-s* factor than the men in the worker group.

The division of individuals into the student and worker groups (designed as Students and Workers) is made on the basis of the occupational code which includes a special section for those who attend some education at the time of enrollment.

Some difficulties in making the grouping in the same way for the two samples also appeared in this categorization. In the 1948 cohort, the occupational codes separate those who are attending some sort of education from those who have an occupation. The coding instruction in 1971 was somewhat different since those who, at the time of enrollment, were attending upper secondary school and had definite plans for vocational education at university level were assigned the vocational code and not the actual educational one. Those who had already started that type of education were, however, assigned an appropriate educational code.

The actual occupational codes are based on the area of work and not on the required education (level and line). This fact implies, together with the coding instruction mentioned above, that a student who, at the time of enrollment, is attending the upper secondary school and intends to study electro-engineering at an institute of technology will be assigned the same code as those who have finished school after a lower degree in this special education and are working in this occupation.

Some occupational codes are evidently codes of future professions, like physician, dentist and lawyer, but these include rather few individuals (less than 1% of the total). Among other codes at educational level 4 there is no possibility of discriminating between those who intend to acquire vocational education and those who already are working in the profession. An estimate of the number of the workers erroneously coded in this way shows, however, that they are rather few - around 2.5% of the total - but this difference between the samples must be considered.

In the analyses of the *v-s* factor, Students and Workers are kept apart for the same reason as the separation in main educational levels, i.e. the necessity of making the investigation groups as homogeneous as possible.

8.3 Structure groups

The next step in the formation of investigation groups is the classification as regards the main treatment variable, i.e. according to type of study and working experience.

This categorization results in the treatment variable when the *v-s* analyses are considered. The groups, homogeneous in level of education and in accordance with the way the experience is acquired (at school or at work), are divided on the basis of the type of the training or experience.

8.3.1 Educational structure groups

For categorization of study experience the curricula are analyzed in respect of verbal or spatial/technical emphasis. Three categories are formed - one with verbal emphasis, one with spatial/technical emphasis and one with neither verbal nor technical emphasis. An attempt to divide the verbal and technical categories into subcategories had to be abandoned for two reasons. First, the verbal structure groups at the lower educational levels were represented by too few men to make further division possible. Furthermore, the educational codes are not specific enough to divide study lines according to varying degrees of especially spatial/technical orientation.

The result of the categorization according to study experience is, then, three structure groups. Even in this rather rough differentiation, some uncertainty remains mainly because of too broad educational codes. However, in most cases, the forming of the verbal and technical educational groups is simple and the groups are distinctive as to these aspects of experience.

The criteria for the categorization of educational structure groups are:

- ***Verbal domain*** (V): The education is mainly oriented towards verbal subjects.

- ***Technical domain*** (T): The education is mainly oriented towards technical, scientific, mechanical, spatial or manual subjects.

- ***Residual group*** (O): The education has no pronounced orientation towards either verbal or spatial/technical subjects.

In Appendix 2 examples of this categorization are given.

In Table 10, the result of the categorization is shown. In this table, all men in the two samples are categorized. In Table 11, only the Students are reported.

There are some discrepancies between numbers in this table and that based c educational level only (Table 9), mostly due to missing information on study line:

Table 10. Number of men in educational level and structure groups. Total samples.

Educ. level		Educational structure groups V n	V %	O n	O %	T n	T %	Total n	Total %
4	1948	202	18	40	3	906	79	1148	100
	1953	423	37	3	0	732	63	1158	100
3	1948	170	18	268	28	527	55	965	100
	1953	236	43	18	3	295	54	549	100
2	1948	55	6	142	16	714	78	911	100
	1953	122	11	43	4	965	85	1130	100
1	1948	73	5	533	38	813	57	1419	100
	1953	300	25	269	23	613	52	1182	100
Total	1948	500	11	983	22	2960	67	4443	100
	1953	1081	27	333	8	2605	65	4019	100

At level 3 in the 1948 cohort, however, there are more individuals in Table 10 than in Table 9 which is probably due to corrected educational codes in the last stage of the collection of this group (chapter 5).

The greatest difference in the distributions of the two cohorts is that more men in the 1953 sample are categorized in the V groups than in the 1948 sample. This is largely the result of a change in the instruction of coding between the enrollment years. In 1966, a code manual was used where only those lines of education which were of particular military interest were specified. This explains, in the case of the first cohort, the comparatively high frequency in the O groups at the expense of the V groups. The 0 groups are of substantial size only at the first educational level as regards the 1953 group.

This means that the results of the analysis are not exactly comparable between the samples as far as the V and the 0 groups are considered. The T groups, however, had been coded in about the same way in both cohorts which is indicated in the rather congruent proportions. The greatest (and the only noticable) difference in proportions for the T groups is at the fourth level. Of the men born in 1953 a smaller proportion at this level belongs to the T group than is the case in the 1948 cohort. This is due to the fact that there are, compared to the other lines, fewer male students in the technical and natural sciences lines in the upper secondary school around 1970 than five years earlier (Statistical Abstract of Sweden, 1967; 1972). The liberal arts and the social sciences lines have increased their relative numbers of students during this period.

The proportions of the educational structure groups in Table 11 are based only on the men who have been coded as attending school at the time for military enrollment.

Table 11. Students in educational level and structure groups.

		Educational structure groups							
Educ.		V		0		T		Total	
level		n	%	n	%	n	%	n	%
4	1948	199	18	32	3	891	79	1122	100
	1953	252	38	1	0	408	62	661	100
3	1948	48	12	133	34	216	54	397	100
	1953	94	44	10	5	110	51	214	100
2	1948	18	8	23	10	195	83	236	100
	1953	25	17	5	3	120	80	150	100
1	1948	1	1	74	61	46	38	121	100
	1953	66	35	32	17	88	47	186	100
Total	1948	266	14	262	14	1348	72	1876	100
	1953	437	36	48	4	726	60	1211	100

There are surprisingly many Students at the first level in 1971 (the 1953 sample). About 15 per cent of the total student group state that they still attend compulsory school. This is probably due to the fact that, at the time for enrollment, they had started studying again after a break of a couple of years. The opportunities of receiving recurrent education have increased since the middle of the 60's both in formal education and in the informal courses of a shorter duration. The educational code is only designed to provide information on education, but when looking at the numbers of Students at the first level, some doubt about its application arises. Probably, some informal education is coded as well.

The most evident difference between the samples, when comparing Tables 10 and 11, is the great reduction in the number of Students at level 4 in the 1953 sample.

This is confusing even with regard to the extended time for military enrollment for this age group. The explanations for this are the coding instructions regarding future (academic) profession mentioned earlier, but also that there is a certain raise in the number of dropouts among the 1953 students in the upper secondary schools.

8.3.2 Occupational structure groups

It is more difficult to obtain a basis for the categorization of the verbal/reasoning - spatial/technical occupational experience and specialization than it is for education. An occupational code does not express a generally valid and structured content as does an educational code. Furthermore, an occupation requires different tasks depending on working place and sometimes an occupational code has no bearing on the dimension studied here (for instance »managing director»). This last type of code rarely occurs in the samples, however, and the main weakness in occupational codes is the difference in demands between working places for the same occupations.

The occupations are coded according to »Nordisk Yrkesklassificering, NYK» (Nordic Classification of Occupations) which has been developed for the Nordic countries by the labor market authorities in Denmark, Finland, Norway, and Sweden. The code is a five-digit one where the first digit refers to field of occupation, the second to occupational group, the third to occupational subgroup (occupational families) and the last two to individual occupation. The first three digits in the code are constructed in approximately the same way as those in the International Standard Classification of Occupations (ISCO).

In the NYK there are, besides the classification and the code numbers, short descriptions of every individual occupation. These descriptions are used when dividing the occupations into V and T groups. Another source of information is »Svenskt yrkeslexikon, SYL» (Swedish Dictionary of Occupations) developed by the vocational guidance authorities in Sweden and intended as an aid for vocational counsellors. The descriptions of occupations are more comprehensive in SYL than in NYK, where the former is based on the latter. SYL does not, however, include all individual occupations.

A third aid in categorizing is »Yrkesbeskrivningar - Verkstadsindustrin» (Descriptions of Occupations - Engineering Industry) which fits the purpose of this investigation as regards some of the technical and mechanical occupations.

In earlier research including classification of occupations, the groups were formed on the basis of personality traits and intended either for use in vocational guidance (e.g. Super 1957; Vernon, 1962) or to explain differences between persons employed in different occupations and with different responsibilities (e.g. Kohn and Schooler, 1978). These earlier classifications do not fit the present investigation with its special demands on verbal - spatial/technical categorization of individual occupations. One exception to this is the classification made by Holland (1966) who developed a theory about features of personality as related to occupational preferences. The theory includes an assessment of dominating aspects of occupational groups and these aspects have to some extent influenced the categorization of occupations in this investigation.

It was presumed that the categorization of occupations would result in seven groups; three with different degrees of emphasis within the verbal domain, three within the technical domain, and one residual group which should contain occupations where neither verbal nor technical aspects dominated. This grouping was not possible, however, since too few men have occupations in the verbal group to allow further division. This reason is the same as that for not categorizing into educational subgroups. The other reason for not forming educational subgroups - the lack of specificity of the codes - does not apply to the categorization of occupations. The occupational codes are sufficiently specific to be subdivided and in the case of the technical groups the frequencies are sufficient to form three subgroups.

The occupational categorization thus resulted in five groups: one verbal, three technical representing different types of technical/spatial working tasks and one residual group.

In the 1948 sample, 388 occupational codes from 1966 are analyzed according demands in verbal and technical matters. In 1971, i.e. for the 1953 sample, the number of codes rises to 478. The development of new vocational areas as well as the extension of time for military enrollment and the change in coding instruction are factors underlying this increase.

It is impossible to obtain information on how long the men have been working in the profession coded, but very few have worked more than 3 years.

The criteria for the grouping of occupational codes are:

- ***Verbal domain*** (V): The main work assignment requires use of the language in spoken or in written form.

- ***Technical domain, category 1*** (T_1): The work requires good comprehension of spatial tasks. Work with or after drawings.

- ***Technical domain, category 2*** (T_2): The work requires to a certain degree comprehension of technical-mechanical relations. Work with machines.

- ***Technical domain, category 3*** (T_3): The work requires independent decisions concerning technical-mechanical problems.

- ***Residual group*** (O): Occupations for which none of the categories above are valid.

Examples of occupations in the different categories are given in Appendix 2.

The ranking of all the three T-groups is not conceived as an ordinal scale. The two last groups, however, are ordered in such a way that the occupations in T_3 have tasks which put greater demands upon the same ability of the workers than those in T_2 . The T_1 group, however, requires spatial ability but no mechanical comprehension and forms a group distinct from the other two.

Several occupations caused categorization problems. One of the occupations is farm worker. The demands on technical knowledge are extremely varying, depending on the machine equipment in the farms. The explicit occupational requirement is the ability to carry out minor machine repairs. After discussion with vocational counsellors this occupation was placed in the T_2 group.

Another occupation which caused difficulties was shop assistant in hardware and machinery shops. Since the demand on technical knowledge is not explicit for these occupations it was decided to place these, as well as all other service occupations - with one exception - in the V domain. The exception is assistant in petrol stations where the occupational demand is similar to that for the T_2 group. This is in agreement with the analysis by Holland (1966).

In Table 12 the frequencies of the occupational groups are shown. A look at first at the distribution according to educational level shows that, compared with the first sample, there is a considerably larger part of the 1953 worker sample at the highest level. This fact was discussed in the preceding section and depends on changed coding instructions. It was concluded that the analysis of this group would have to be carried out with special caution.

The low frequencies at the highest level in the first cohort result in an exclusion of this group in the analysis of changes in the *v-s* factor.

When looking at the structure groups, it can be concluded that about 2/3 of the 18 year old male workers are occupied in some sort of spatial/technical work, and about 10 per cent have occupations with pronounced verbal tasks. The higher the level the greater is the relative frequency of the V groups and the reverse holds for the T_2 groups.

The two samples are in rather good accordance as regards the distribution of the structure groups. There is, however, one exception to this, namely, the generally lower frequencies in the O groups of the sample 1953. The decrease in these groups is balanced by an increase in the T_3 groups. The reason for this variation is probably the greater opportunities for formal vocational training

Table 12. Number of Workers at educational levels and in occupational structure groups.

Educ. level		Occupational structure groups V n	%	0 n	%	T_1 n	%	T_2 n	%	T_3 n	%	Total n	%
4	1948	3	•	8	•	6	•	8	•	1	•	26	•
	1953	90	24	111	29	25	7	73	19	82	22	381	100
3	1948	122	21	135	24	124	22	132	23	55	10	568	100
	1953	60	19	55	18	23	7	69	22	107	34	314	100
2	1948	37	5	119	18	183	27	171	25	165	24	675	100
	1953	50	5	88	9	267	28	277	29	282	29	964	100
1	1948	72	6	459	35	251	19	397	31	119	9	1298	100
	1953	96	10	233	24	219	22	320	33	109	11	977	100
Total:													
	1948	234	9	721	28	564	22	708	28	340	13	2567	100
	1953	296	11	487	18	534	20	739	28	580	22	2636	100

connected with a greater specialization in occupations which the increasing number of different occupations represented in the samples suggests (338 and 478 respectively). The contribution from the workers at the highest level in the last sample also leads to the general increase in the case of the T_3 group.

8.4 Combination of educational and occupational categories

For the worker groups in the two cohorts the relation between educational and occupational structure groups is shown in Table 13.

There seems to be a considerably larger number of the 1953 Workers who had attended verbally oriented education than the 1948 Workers but this is mainly due to the more comprehensive educational coding routine in 1971 than in 1966 mentioned earlier.

Table 13. Distribution of the Workers in educational and occupational structure groups.

Education		Occupation V	0	T_1	T_2	T_3	Total
V	1948	80	38	17	18	3	156
	1953	188	158	78	119	32	575
0	1948	136	536	306	444	123	1545
	1953	20	79	63	85	31	278
T	1948	18	147	241	246	214	866
	1953	88	250	393	535	517	1783
Total	1948	234	721	564	708	340	2567
	1953	296	487	534	739	580	2636

Most of the »movers» come from verbally oriented education to an occupation with spatial or technical demands (1.5 and 8.7 per cent respectively). There are few »movers» moving from an educational T group to an occupational V group (0.7 and 3.3 per cent respectively).

PART III

RESULTS

9 INTRODUCTORY COMMENTS

9.1 Summary of the preparatory work

The present investigation originates from the Individual Statistics Project (ISP) where ten per cent samples from two birth cohorts (1948 and 1953) are followed. In this investigation the male parts of these samples are investigated twice - at 13 and at 18 years of age.

The data collected on the first occasion comprise results on ability tests and questionnaires together with information about school, marks, social class, and place of residence. The information collected at the second occasion consists of ability test results, education, and, if any, occupation. The ability test battery at 13 is identical for both cohorts as is the test battery at 18. The two batteries are, however, different from each other. The test scores at 13 and 18 years are therefore combined by the method of canonical correlation analysis which results in two common components. The first component is designated as the general *(g)* intelligence factor and the second is a bipolar factor termed the verbal/reasoning versus spatial/technical *(v-s)* intelligence factor.

The main purpose is to study whether verbal/reasoning versus spatial/technical intelligence is influenced by educational and occupational experience within the verbal and technical domains. These analyses are made separately in the two samples, which makes it possible to study the stability of the influence.

As a parallell to the analysis of changes in the general intelligence factor made in the first cohort (Härnqvist, 1968) a replication study is made in the second one in order to examine the stability of these changes as well.

The investigation groups are formed in four steps. In the first step the men are grouped at four levels according to the amount of education: compulsory school (1), practical-vocational education (2), short theoretical (-vocational) education (3), and advanced theoretical education (4). In the second step those who attend some sort of formal education at 18 years of age are separated from those who have started to work in an occupation (Students and Workers).

All the participants are then divided into educational structure groups, verbal (V) and spatial/technical (T), according to type of education. Those for whom the type of education cannot be classified as either V nor T form a residual (0) group.

Finally, the worker group is divided into four occupational structure groups, according to central demands in their occupations. Those with occupations where verbal ability is required are grouped into the V group; where spatial ability is required into the T_1 group; where handling of technical matters is required into the T_2 group; where understanding of technical matters is required into the T_3 group. Here, too, the unplaced occupations form a residual (0) group.

The analyses begin with linear regression where the initial results of the *v-s* and *g* factors, respectively, predict the results at 18 years. The prediction is made for the different educational and occupational structure groups within educational levels where the *v-s* factor is concerned, and for the different educational levels where the *g* factor is concerned. The changes in intelligence are estimated from the differences between the observed and the predicted final results and are analysed according to grouping.

In a following step of analysis, made for the 1948 sample only, the influence of the background predictors on intelligence is examined by means of multiple linear regression.

For further examination of changes, the data from the second sample are analysed by the method of linear structural relations (LISREL). In this method, errors of measurement and multicollinearity are controlled. These analyses result in statements about the relations between the initial variables, the educational and occupational experiences, and the final intelligence scores. In these analyses a model of intelligence other than the hierarchical one *(g* and *v-s* factors) is used. This is a model mainly in accordance with the multiple factor theory and the analyses are based on a verbal factor separated from a technical/spatial factor, both loaded with general ability.

9.2 Comparability between the samples

In describing the verbal/reasoning - spatial/technical *(v-s)* factor, the results are given in standardized units. This is because, as mentioned earlier, the results are not comparable between samples since the canonical weights of initial and final tests show some difference. Furthermore, the preparatory data processing which resulted in the *g* and *v-s* factors is made different for the two samples, mainly in order to get more easily manageable measurements in the second sample. The data processing of the samples is separated by a period of about nine years (1968 and 1977) and new programs, techniques and knowledge have been developed during this time. If a comparison of the results of the samples is to be made the best way is to look at the initial and final tests (chapter 7) which are identical for the two samples.

The main results of this investigation are not the final scores as such - even if these are interesting too - but the deviations between expected and actual scores. The deviations are analysed according to educational level and type of educational or occupational experience. In order to make the results of the samples comparable these are expressed as percentages of actual standard deviation.

The problem that the factors are not built up by exactly the same weights remains, of course, when the results are standardized, but this difference is rather small. If the shifts of the loadings had been great enough to influence the factors themselves this would have jeopardized the comparability, but this is not the case.

10 CHANGES IN THE V-S FACTOR

The verbal/reasoning ability is bipolar to the spatial/technical ability. The higher the result on this factor, the more pronounced is the verbal/reasoning ability compared with the spatial/technical ability, which, in turn, is the more dominating ability the lower the values of the factor are. This means that the results here cannot be described as, for example, »high verbal ability» or »high verbal and spatial ability». The statements must be based on both parts simultaneously and without any separate grading. The only gradings allowed are those based upon comparisons, for example »higher verbal than spatial ability».

This fact must be held in mind when the actual results are discussed. In the analyses of changes in this factor, however, nothing prevents speaking of, for instance, change in the verbal direction, because this sort of conclusion is based upon comparisons between predicted and final results whatever the actual results are.

10.1 Initial results

The initial results of the *v-s* factor for the samples separated according to level and type of education are shown in Table 14. Compared with Härnqvist's (1968) analysis, the factor is reversed (chapter 7) for the 1948 sample in order to make the changes comparable between the cohorts. This alteration does not change anything else except that the *s-v* factor becomes the *v-s* factor.

Later on in this chapter, when the changes in the *v-s* factor are discussed, the initial results are analysed in greater detail. The purpose of the present section is to give a general picture of how ability is ordered according to future level and structure groups and what - if any - differences can be found between the cohorts at this early age.

The results in Table 14 are shown as deviations, expressed as percentages of standard deviation of initial values, from the total mean for the 1948 and the 1953 sample respectively. In this table, as well as in all the other tables in the present investigation, results which are based on less than 15 individuals are omitted.

Table 14. Initial results of the *v-s* factor. Deviations from total mean expressed as percentages of the standard deviation.

Educational level		Educational structure group V	O	T	Total	
4	1948	47	17	7	15	
	1953	32	.	-2	10	
3	1948	22	-6	-1	2	
	1953	20	-9	-8	4	
2	1948	-3	-2	-16	-13	
	1953	32	-6	-18	-12	
1	1948	7	2	-10	-5	
	1953	21	-2	-9	2	
Total	1948	27	0	-5	($\bar{x}$=5.06	s_x=5.80)
	1953	26	-4	-10	($\bar{x}$=6.67	s_x=5.00)

A negative sign in the table above means that the group on the average is more oriented towards spatial/technical ability than the total sample and a positive figure means a deviation in the verbal/reasoning direction. It should also be pointed out that the results presented in Table 14 and further on are relative. This means that if a subgroup is large, the deviation of the mean of this subgroup will be artificially smaller than the deviation of a smaller subgroup.

The *v-s* factor stems from the age of 13 but the educational levels and lines which form the basis for the grouping are entered later in life. Table 14 then describes the initial direction of ability for individuals who years later will form verbal and technical groups at different educational levels.

The most notable difference between the samples is in the V group at level 2. In the description in chapter 6 of the changes in the school system in Sweden during 1960's the broadening of vocational education was mentioned. This resulted in, when verbal education is considered, a greater number of students especially in clerical and commercial vocational education. It seems as if those in this small group in the first cohort who later attended this sort of education were not verbally oriented at 13. In the second cohort, however, this group, which is considerably larger and probably includes many students who earlier would have started working directly after compulsory school or attended education at a higher level, displays distinct orientation towards the verbal part of the factor.

There is also a clear distinction between levels. The group of boys who will later attend education at the highest level is the most verbally oriented and those who will attend education at the second level are the most spatial/technically oriented. This is the same result as shown by Härnqvist (1968).

Even when Table 14 is studied horizontally there is a clear distinction between future groups: those who later choose a verbal education are more verbally oriented than those at the same level who choose a technical education. This result is more evident in the case of the 1953 group than the 1948, except at the highest level.

One reason for dividing the samples into Students and Workers was a hypothesis that those who leave school rather early in life are less verbally oriented than those who stay longer in school (chapter 8). To test if this hypothesis holds true even three years before school leaving age the initial *v-s* results of Students and Workers are compared. This gives deviations for the student groups of 1 (1948) and 6 (1953) per cent of the standard deviation while the figures for the worker groups are -1 (1948) and -3 (1953) per cent. The groups can then be said to be, to a small extent, differentiated according to the hypothesis at the early age of 13. This is more valid for the 1953 than for the 1948 cohort.

10.2 Regression analysis

The question that will be dealt with in this section is whether the development of the verbal/reasoning - spatial/technical factor is influenced by the type of intellectual and practical experience provided at school or work.

As mentioned in chapter 3 the causality expressed in this formulation is somewhat problematic. Competetive explanations for the hypothesized directions of changes can be formulated. One of these is based on self-selection. This implies that the development is determined early in life and that this potential development, expressed in interests and attitudes, will direct the choice of type of study and work as well as the individual differences showing up later in life. The problems involved in ascertaining the causality will be returned to in following sections and summed up in the last chapter.

The different standard deviations of the *v-s* factor in the two samples make direct comparisons between samples impossible. Then, when analysing the changes, these are expressed as percentages of the standard deviation of y scores of the 1948 and 1953 samples respectively.

Before comparing the *v-s* changes in the two cohorts and, in order not to give too many figures at one time, the cohorts are first analysed separately.

10.2.1 The 1948 cohort.

The initial, final and final estimated means of the *v-s* factor in the student group are given in Table 15.

In this table, the actual values, not made comparable to those of the second cohort but reversed to constitute the *v-s* factor, are shown. Standardization is carried out only in comparisons between the cohorts.

The final means are ordered according to the structure groups at each level as well as for the total student group. In Appendix 3:1, the figures are analysed one step further. From this it can be concluded that the common within-group regressions are satisfactory measures of all within-group regressions, i.e. the differences (b_w - b_j) are not significant at any level. In Table 15 these common within-group regressions are corrected for lack of reliability in the initial measures (b_{wc}).

As seen in Appendix 3:1, the initial values in the structure groups are significantly ($p \leq .01$) separated at only one educational level - the fourth - and for the total group. The final and the final adjusted (adjusted by the within-group regressions) are significantly separated in these groups and also at level 2.

The correlation coefficients range from .27 to .47 (Table 15) which corresponds with the result of the canonical analysis presented earlier.

In Table 16 and in Appendix 3:2 the corresponding results of the worker group are shown. As was pointed out earlier (chapter 8), the frequencies at the fourth educational level are too small to base an analysis upon.

Table 15. Regression analyses of the *v–s* factor in the 1948 sample. Students.

	V	O	T		V	O	T
Level 4				**Level 3**			
n	199	32	891	n	48	133	216
$\bar{x}$	7.71	5.97	5.46	$\bar{x}$	5.16	4.43	4.04
$\bar{y}$	6.93	6.10	4.40	$\bar{y}$	5.68	4.68	3.73
$\bar{y}'_c$	5.70	4.94	4.71	$\bar{y}'_c$	4.56	4.32	4.20
$b_w=.36$	$b_{w_c}=.44$	$r_{xy}=.43$		$b_w=.26$	$b_{w_c}=.32$	$r_{xy}=.32$	
Level 2				**Level 1**			
n	18	23	195	n	1	74	46
$\bar{x}$	5.95	2.61	3.52	$\bar{x}$	–	5.01	2.55
$\bar{y}$	8.82	4.16	3.26	$\bar{y}$	–	4.35	2.49
$\bar{y}'_c$	4.42	3.49	3.74	$\bar{y}'_c$	–	4.07	2.94
$b_w=.23$	$b_{w_c}=.28$	$r_{xy}=.27$		$b_w=.37$	$b_{w_c}=.46$	$r_{xy}=.47$	
Total							
n	266	262	1348				
$\bar{x}$	7.10	4.62	4.85				
$\bar{y}$	6.84	4.71	4.06				
$\bar{y}'_c$	5.33	4.34	4.43				
$b_w=.32$	$b_{w_c}=.40$	$r_{xy}=.39$					

The final means are more accurately arranged according to the structure groups than the initial means are. The correlation coefficients vary between .30 and .39 which is a smaller variation than in the student group.

The initial means of the structure groups neither differ at any level nor in the total group (Appendix 3:2). The opposite holds for the final means, significantly

Table 16. Regression analyses of the *v–s* factor in the 1948 sample. Workers.

	V	O	T_1	T_2	T_3	
Level 3						
n	122	135	124	132	55	
$\bar{x}$	6.83	4.99	5.39	5.73	5.89	b_w=.31
$\bar{y}$	6.13	5.54	5.06	4.15	4.35	b_{w_c}=.39
$\bar{y}'$	5.55	4.83	4.99	5.12	5.18	r_{xy}=.40
Level 2						
n	37	119	183	171	165	
$\bar{x}$	4.35	5.41	4.95	4.39	3.70	b_w=.27
$\bar{y}$	4.89	4.78	3.83	4.11	2.90	b_{w_c}=.34
$\bar{y}'$	3.83	4.19	4.03	3.84	3.61	r_{xy}=.33
Level 1						
n	72	459	251	397	119	
$\bar{x}$	5.56	5.19	4.66	4.86	3.64	b_w=.24
$\bar{y}$	5.54	4.92	4.65	3.87	3.79	b_{w_c}=.30
$\bar{y}'$	4.69	4.58	4.42	4.48	4.11	r_{xy}=.32
Total						
n	234	721	564	708	340	
$\bar{x}$	6.10	5.20	4.94	4.92	4.06	b_w=.27
$\bar{y}$	5.72	5.03	4.47	4.00	3.43	b_{w_c}=.33
$\bar{y}'$	4.84	4.54	4.46	4.45	4.16	r_{xy}=.35

differing at every level as well as in the total group. The final adjusted means do not differ at level 3 but in all other groups.

The common within-group regressions are, according to Appendix 3:2, adequate measures of the within-group regressions.

10.2.2 The 1953 cohort.

The initial values of the *v-s* factor in the student group of the 1953 cohort are clearly ordered with the men in the V groups as the most verbally oriented and those in the T groups as the most spatial/technically oriented (Table 17). The actual final scores are ordered in the same way as the initial scores except at level 1 and for totals where the 0 and the T groups change positions. The total 0 group consists mainly of the boys in the 0 group at level 1 which means that it is the result of the last group mentioned that appears twice.

The data in Table 17 are further analysed in Appendix 3:3. From this it can be stated that the common within-group regressions are adequate measures of the group regressions. It is also shown that there are significant differences between structure groups in initial means at levels 3 and 4 as regards the total student group. The 0 groups at level 2 and 3 are very small and it would perhaps have been more proper to omit them in the analyses at these levels (this was, of course, done at level 4 with only one individual in the 0 group). But as one purpose of this investigation is to compare the 1948 and 1953 cohorts, the exclusion of the 0 groups of one sample must, for comparability, be followed by exclusion of those groups of the other sample. In the 1948 sample, however, the 0 groups are rather large owing to the more »neutral» study lines as well as the rougher coding than is the case in the 1953 sample (chapter 8). In the 1948 sample there are probably many boys in the 0 groups who would have been placed in one of the real structure groups if the more exact coding used for the 1953 cohort had been applied. Removing the boys in the 0 groups would change the picture of the levels in the 1948 cohort and make a proper comparison between cohorts impossible. Because of this, the small 0 groups in the 1953 sample are retained and the loss of df with attendant loss of some significances is compensated for by sample comparability as well as the possibility of making interpretations of differences in structure groups.

The final means of the structure groups are significantly different at each level except the first. The adjusted final means are markedly different at level 4 and 2 and in the total student group. This result is exactly the same as in the 1948 cohort.

Table 17. Regression analyses of the *v-s* factor in the 1953 sample. Students.

	V	O	T		V	O	T
Level 4				Level 3			
n	252	1	408	n	94	10	110
$\bar{x}$	8.24	.	6.61	$\bar{x}$	8.11	.	5.83
$\bar{y}$	5.62	.	3.77	$\bar{y}$	5.96	.	3.40
$\bar{y}'_c$	4.99	.	4.18	$\bar{y}'_c$	5.14	.	4.09
$b_w=.40$	$b_{w_c}=.50$	$r_{xy}=.41$		$b_w=.36$	$b_{w_c}=.46$	$r_{xy}=.40$	
Level 2				Level 1			
n	25	5	120	n	66	32	88
$\bar{x}$	8.35	.	6.34	$\bar{x}$	7.35	6.89	5.88
$\bar{y}$	7.03	.	2.98	$\bar{y}$	5.26	3.02	3.42
$\bar{y}'_c$	4.60	.	3.47	$\bar{y}'_c$	4.43	4.18	3.65
$b_w=.45$	$b_{w_c}=.56$	$r_{xy}=.50$		$b_w=.43$	$b_{w_c}=.53$	$r_{xy}=.46$	
Total							
n	437	48	726				
$\bar{x}$	8.08	6.66	6.36				
$\bar{y}$	5.72	3.28	3.54				
$\bar{y}'_c$	4.88	4.16	4.00				
$b_w=.41$	$b_{w_c}=.51$	$r_{xy}=.43$					

The final means of the 1953 worker group show, as they do in the case of the 1948's, a more accurate order according to structure groups than the initial means (Table 18). The initial mean scores do not differ significantly between the

Table 18. Regression analyses of the *v-s* factor in the 1953 sample. Workers.

	V	O	T_1	T_2	T_3	
Level 4						
n	90	111	25	73	82	
$\bar{x}$	8.81	7.45	6.86	6.57	4.93	b_w=.50
$\bar{y}$	6.78	4.01	5.55	3.98	2.38	b_{w_c}=.63
$\bar{y}'_c$	5.54	4.68	4.31	4.13	3.10	r_{xy}=.49
Level 3						
n	60	55	23	69	107	
$\bar{x}$	8.26	6.66	6.73	7.57	5.95	b_w=.42
$\bar{y}$	5.97	5.08	3.34	4.59	3.17	b_{w_c}=.51
$\bar{y}'_c$	5.04	4.23	4.26	4.69	3.86	r_{xy}=.43
Level 2						
n	50	88	267	277	282	
$\bar{x}$	7.92	6.47	5.80	5.84	5.62	b_w=.32
$\bar{y}$	7.41	3.65	3.21	2.69	2.50	b_{w_c}=.40
$\bar{y}'_c$	3.91	3.33	3.06	3.08	2.99	r_{xy}=.36
Level 1						
n	96	233	219	320	109	
$\bar{x}$	7.61	7.05	6.45	6.73	5.78	b_w=.38
$\bar{y}$	4.16	4.40	3.91	3.71	2.57	b_{w_c}=.47
$\bar{y}'_c$	4.26	3.99	3.71	3.84	3.40	r_{xy}=.37
Total						
n	296	487	534	739	580	
$\bar{x}$	8.16	6.99	6.15	6.46	5.61	b_w=.37
$\bar{y}$	5.87	4.25	3.61	3.43	2.62	b_{w_c}=.46
$\bar{y}_c$	4.47	3,94	3.55	3.69	3.30	r_{xy}=.40

structure groups at the first three levels (Appendix 3:4). At level 4 and for the total worker group, however, they are markedly separated. The final mean scores and the adjusted final means also differ significantly in these two groups as well as at level 2.

From Appendix 3:4 it can also be concluded that the common within-group regressions are adequate as common slopes.

A comparison between the student and worker groups of the two cohorts (Tables 15-18) reveal that there is a wider separation between the results at each level for the Workers than for the Students which can be due to the more detailed grading for the Workers. This explanation is, however, rejected when the initial results are considered, since the verbal groups - equally graded for Students and Workers - of the Workers are more verbally oriented which was the main cause of the greater V-T separation. This stronger verbal accentuation for the Workers V groups shows up only at the fourth level (1953) in the final results.

10.2.3 Estimated changes.

As mentioned earlier (chapters 4 and 9), the change in intelligence is estimated from the difference between predicted result, corrected for unreliability in initial scores, ($\bar{y}'_c$) and final result ($\bar{y}$). In Table 19 the changes in the *v-s* factor, expressed as percentages of the standard deviation at each level, are summarized for the two student cohorts.

A consistent order of the changes is shown in Table 19. Except at level 1 in the 1953 cohort the changes are at every level and for each cohort arranged from the most positive, i.e. most verbal, in the V groups to the most negative, i.e. most spatial/technical in the T groups.

At level 1 (1953) the 0 and T groups change position. This is also the result for the total 1953 student group, but due to low frequencies in the 0 groups at level 2-4 the result of the total 0 group is dominated by the 0 group at level 1 - the frequency in this group is 67% of the frequency in the total 0 group.

The relative number of individuals at each of the four educational levels is approximately the same in the two cohorts. For the analysis of the *g* factor (chapter 10) which is based on educational level only, it is then concluded that each level has the same influence on the total regression line in both samples which, in turn, makes a comparison of changes between cohorts possible. In the case of the *v-s* factor however, attention must be paid to the diversity in relative size of the corresponding structure groups in the two cohorts.

Table 19. Estimated changes (per cent of S_y) in the *v-s* factor for educational structure groups. Students in the 1948 and 1953 samples.

Educ. level		Educational structure group V	O	T	$b_{w_c}(\frac{s_x}{s_y})$	p≤.01
4	1948	25.1	23.7	-6.3	.51	sign.
	n	199	32	891		
	1953	12.6	–	-8.2	.49	sign.
	n	252	1	408		
3	1948	24.0	7.7	-10.1	.39	–
	n	48	133	216		
	1953	16.0	–	-13.5	.48	–
	n	94	10	110		
2	1948	82.6	12.6	-9.0	.30	sign.
	n	18	23	195		
	1953	47.9	–	-9.7	.55	sign.
	n	25	5	120		
1	1948	–	5.8	-9.4	.55	–
	n	1	74	46		
	1953	16.5	-23.1	-4.6	.56	–
	n	66	32	88		
Total	1948	30.7	7.5	-7.5	.47	sign.
	n	266	262	1348		
	1953	16.7	-17.5	-9.1	.51	sign.
	n	437	48	726		

For the student group at level 3, for example, the number in the V group is 12% of the total number at that level in the 1948 cohort and 44% in the 1953 cohort. The influence of the 1948 V group on the total regression line (at level 3) is then much smaller than the corresponding influence of the 1953 V group. This problem can be viewed in two ways. On the one hand the 1948 V group at level 3 can be assumed to be more specialized in the verbal direction than the 1953 V group. Then the calculated changes correctly describe the difference between samples - the V group in the first sample is more verbally oriented than the corresponding group in the second sample.

On the other hand, the real changes in the two V groups can be assumed to be the same. Since the small V group of 1948 does not have the same influence on its total regression line as the large V group of 1953 has, the 1948 regression line will be at a greater distance from its V group than the 1953 line. This, in turn, makes the *v-s* change in the first V group artifically greater.

As mentioned in chapter 6, the change in the school system in Sweden during the period 1966 to 1971 included an expansion of the vocational lines, verbal as well as technical. A greater proportion of the second cohort in the structure groups V and T is then logical.

In chapter 8 it was mentioned that the coding of education is more detailed on the second occasion. This means that some types of education were zero coded in the first sample but specifically coded in the second. These coding differences mostly refer to lines less interesting from a military point of view, i.e. especially the verbal ones.

Because of these two facts - the reformed school and the reformed coding - it is impossible to determine to what extent the two corresponding V groups are alike in educational experience and to what extent they differ.

The standardized within-group regression coefficients in Table 19 are at levels 2 and 3, i.e. at those levels where most of the new study lines were introduced, markedly lower in the 1948 than in the 1953 cohort. At level 1 and 4 as well as for the total student group the standardized b_{w_c} are about the same for the two samples.

In trying to combine the regression heterogeneity with the assumption about a more specialized V group in the 1948 cohort some observations can be made. When the corresponding standardized b_{w_c} are the same in the two samples a greater change in one structure group of one cohort can be said to be caused by more specialized training, compared with the same group in the other cohort. This seems to be true in the case of the V groups at level 4 and for the total V groups.

If, on the other hand, one sample shows a completely different regression than the other, this implies that the distance $(\bar{y}-\bar{y}_c')$ for one group in that sample will differ from $(\bar{y}-\bar{y}_c')$ in the corresponding group in the second sample even if the two groups have the same initial and final mean scores. The differences between the estimated *v-s* changes are then due to the different relative sizes of the structure groups in the two cohorts. This seems to be valid for the groups at levels 2 and 3.

To sum up this discussion, it can first be concluded that the size of the changes in the *v-s* factor is not exactly comparable between the cohorts, due to the variation of the relative frequencies in corresponding structure groups. A second conclusion is that the differences in changes between samples are too large, especially for the V groups of the middle levels, but to what extent the changes must be corrected is impossible to say. This gives the last conclusion that the comparison of size of the *v-s* factor development between cohorts must be made with great caution.

Even if the comparison of the size of the changes between samples is hard to make, the possibility of exposing each change to a significance test will give some information about conformity/discrepancy between the samples. The bases of the significance test are shown in Appendix 4:1.

As mentioned in Appendix 4:1, the significant deviations are marked in the tables. A mark within brackets implies a deviation close to the significance limit.

All the marks in Table 20 indicate a difference in expected direction, i.e. the V groups are in the verbal and the T groups in the spatial/technical direction of the *v-s* factor.

The conformity between cohorts is evident. Every mark in one sample is accompanied by a mark in the other. At level 4, there are pronounced *v-s* changes in both structure groups in both cohorts. No final mean of the structure groups at level 3 or 1 is significantly different from the $\bar{y}'_{cj}$ but at level 2 those of the verbal group are. The final means of the structure groups for the total student group are significantly separated from $\bar{y}'_{cj}$. Out of 19 real structure groups, 10 are marked in Table 20. Among the non-marked ones those at level 1 were expected to give small differences. This was due partly to uncertainty about whether the men at this level really attend school at 18 and partly because of the low study specialization at this level (chapter 8).

At level 3 and - with the development of the vocational school in mind - level 2 for the 1953 T group the nonsignificant results are surprising. According to the significance tests there seems to be no changes in these groups. As mentioned earlier, however, the orders of the changes (Table 19) are strictly as expected within each cohort at both these levels. Later on, after the corresponding results of the worker group have been shown, these results will be returned to.

The estimated changes in the *v-s* factor of the two cohorts for the Workers are given in Table 21. As before, the changes are standardized according to the standard deviation in y scores.

Table 20. Final v-s means outside 95 per cent confidence intervals of $\bar{y}'_{c_j}$. Students.

Educ. level		Educational structure group V	O	T
4	1948	$*_v$	–	$*_{s/t}$
	1953	$*_v$	.	$(*_{s/t})$
3	1948	–	–	–
	1953	–	.	–
2	1948	$*_v$	–	–
	1953	$*_v$	.	–
1	1948	.	–	–
	1953	–	–	–
Total	1948	$*_v$	–	$*_{s/t}$
	1953	$*_v$	–	$*_{s/t}$

Since the estimated changes in Table 21 are not arranged in the same proper order as those for the Students were, one conclusion can be that working experience does not influence the *v-s* development to the same degree as educational experience. The incongruent order may, however, be due to the more detailed subdivision of the Workers resulting in smaller subgroups, to less work than study experience and also to variation between working places as regards demands on skill in identical occupations.

The short time to settle down in an occupation seems to be influential to a certain degree. This is supported by the orders of the *v-s* changes at different levels. At the two highest levels the period of work experience is very short and, where the fourth level is concerned some doubts about what the occupational codes stand for - present or future occupation - were expressed in chapter 8.

Table 21. Estimated changes (per cent of s_y) in the *v-s* factor for occupational structure groups. Workers in the 1948 and 1953 samples.

Educ. level		Occupational structure group					$b_{w_c}(\frac{s_x}{s_y})$	$p \leq .01$
		V	O	T_1	T_2	T_3		
4	1948	.	.	.	.	.	.	—
	n	.	.	.	.	.	.	—
	1953	23.9	-12.9	23.9	-2.9	-13.9	.57	sign.
	n	90	111	25	73	82		
3	1948	12.1	14.8	1.5	-20.2	-17.4	.50	sign.
	n	122	135	124	132	55		
	1953	17.7	16.2	-17.5	-1.9	-13.1	.51	—
	n	60	55	23	69	107		
2	1948	22.4	12.4	-4.4	5.7	-15.2	.40	—
	n	37	119	183	171	165		
	1953	72.6	6.6	3.1	-8.1	-10.2	.43	sign.
	n	50	88	267	277	282		
1	1948	18.4	7.4	5.1	-13.0	-7.1	.38	sign.
	n	72	459	251	397	119		
	1953	-2.1	8.5	4.1	-2.7	-17.1	.48	—
	n	96	233	219	320	109		
Total	1948	18.6	10.4	.2	-9.5	-15.5	.42	sign.
	n	234	721	564	708	340		
	1953	28.2	6.3	1.2	-5.2	-13.7	.47	sign.
	n	296	487	534	739	580		

At the two lowest levels, on the other hand, the period of work experience is about 2 - 3 years and at these levels the deviations are more regularly ordered. But even here there are some reversals of deviation orders. The greatest reversal is found at the 1953 level 1 where the V group is placed between the T_1 and T_2 groups. As regards the working period of two years for the men at these levels, no information exists, however, about how long the periods of the occupations actually coded are. One assumption is that those at the lowest level are less stationary in occupations than those at level 2. In the total groups of Workers the estimated changes are, however, ordered as expected.

In these comments on the *v-s* changes, the words »as expected» are used which, however, may not be quite correct. When the classification in structure groups was described, (chapter 8), it was pointed out that the T_1 , T_2 , and T_3 groups were not supposed to form a one-dimensional spatial/technical grading of work specialization. The T_1 group contains occupations characterized by drawings and other markedly spatial tasks. The men in the T_2 group handle machines and technical tasks and those in the T_3 group are capable of constructing and repairing. This makes higher demands on technical knowledge in the T_3 group than in the T_2 which brings these groups into the same continuum. The T_1 group, however, belongs to a somewhat separate spatial dimension which, according to the weight coefficients in the canonical analyses (chapter 7), has about the same weight as the technical dimension in the final scores. It is therefore not granted that the T_1 group will be expected to have the smallest *v-s* change as the subscript may imply.

The within-group regressions, corrected and standardized, are, at each level, more alike between the worker groups than the corresponding regressions of the student groups are (Table 19). The only noticeable difference in the case of the Workers is at level 1 where the 1953 regression is .10 units higher than the regression in the 1948 sample.

The relative frequencies in the structure groups also correspond more between samples in the case of the Workers than in the case of the Students. The only marked difference is in the T_3 groups at level 3 (10 and 34 per cent of totals in 1948 and 1953 respectively). This higher degree of correspondance, discussed in chapter 8, was expected because neither the labor market, nor the occupational coding have undergone such changes as have the school system and coding of education.

This, together with the regression conformity, makes a comparison between samples possible. The most prominent result of this comparison is that men born in 1953 with shorter vocational education (level 2) show a more salient change in *v-s* ability compared to those at the same level, born in 1948. This is probably an indirect effect of types of vocational education since this has been specialized between data collections. Vocational education leads to an occupation in a more direct way than education at the other levels.

In Appendix 5:2, the confidence intervals of $\bar{y}_{c_j}'$ are shown. The results of the comparisons between intervals and final means are given in Table 22.

Table 22. Final *v-s* means outside 95 per cent confidence intervals of $\bar{y}_{c_j}'$. Workers.

Educ. level		Occupational structure group V	O	T_1	T_2	T_3
4	1948	.	.	.	.	.
	1953	$*_v$	–	–	–	–
3	1948	–	–	–	$*_{s/t}$	–
	1953	–	–	–	–	–
2	1948	–	–	–	–	$*_{s/t}$
	1953	$*_v$	–	–	–	$(*_{s/t})$
1	1948	–	–	–	$*_{s/t}$	–
	1953	–	–	–	–	$(*_{s/t})$
Total	1948	$*_v$	$*_v$	–	$*_{s/t}$	$*_{s/t}$
	1953	$*_v$	–	–	–	$*_{s/t}$

As for the Students, a mark within brackets implies a final mean close to the interval limit, $\pm\ t_{.10} \cdot s_{\bar{y}_j'}$ (Appendix 4:1).

Neither in this analysis do the structure groups at level 3 show significant changes except in the 1948 T_2 group.

At level 2, both T_3 groups show marked changes. As may be remembered, it was only the V groups at this level that showed significant changes in the student group. The 1953 V group for the Workers also shows such a change.

At this level, the connection between educational line and occupation should be the strongest and the result of the 1953 V group reinforces the assumption made earlier that the greater differentiation in educational lines for the last cohort may give more distinct *v-s* changes.

Among the structure groups T_3 has 5 out of 9 marked changes (brackets included). They are follwed by the V and the T_2 groups. For the T_1 groups, where the occupational influences are assumed to occur along a continuum somewhat different from that for the T_2 and T_3 groups, no significant changes appear even for the total T_1 group. For the zero-structure groups one change in the verbal direction is found.

In Table 22, the non-significant results are more frequent than the significant ones. Most of the changes among the Workers are found at the two lowest levels and in the case of the total group (which up to 75 per cent consists of men at level 1 and 2). This is in congruence with the hypothesis expressed earlier that the longer the occupational experience, the more distinct the *v-s* change in accordance with type of experience.

10.3 Multiple regression analysis

In Balke-Aurell (1973) multiple analyses of the *v-s* changes in the first cohort are reported. A summary of this investigation will be given in the present section.

In these multiple analyses the independent variables are the actual variables in the first data collection which means that the ability tests and not the initial *v-s* factor are used together with other variables described in chapter 7.

The independent variables can be arranged in the following categories:

- ability (tests)
- school achievement (marks)
- background (social class; municipality)
- interest and aspiration (questionnaires)
- social relations (questionnaires)

As pointed out in chapter 4 the errors of measurement in these analyses must be remembered. The independent variables do - except for the ability tests - have rather low reliability.

Table 23. Changes (per cent of s_y) in the *v-s* factor estimated by multiple regression analyses of educational structure groups in the 1948 sample. Students.

Educ. level		Educational structure group V	O	T	R^2	$\bar{R}^2$
4	Change ($\% \cdot s_y$)	23.3*	20.8	-7.3*	.22	.21
	n	199	32	891		
3	Change ($\% \cdot s_y$)	25.1*	3.4	-8.4*	.19	.18
	n	48	133	216		
2	Change ($\% \cdot s_y$)	71.5*	26.8	-8.4*	.22	.19
	n	18	23	195		
1	Change ($\% \cdot s_y$)	•	1.0	-.4	.40	.37
	n	1	74	46		
Total	Change ($\% \cdot s_y$)	34.3*	1.6	-4.9*	.17	.17
	n	266	262	1348		

In Table 23, the significant changes ($p \leq .05$) for Students are marked. The bases for the calculation of significance are given in Appendix 4:2.

All the V and T groups, except those at level 1, show significant changes in the expected direction. In the simple regression analysis level 4 (V and T) and level 2 (V) display such changes (Table 20). The changes estimated by these multiple regression analyses are, however, on the whole similar to those estimated by simple regression analyses (Table 19). At level 1, however, the small changes observed in the regression analysis, vanish in the multiple analyses i.e. when other, non-intellectual, variables enter the equation. As will be seen later on, there are different variables which enter the equations of the four levels. This means that the changes and explained variances are not quite comparable between levels since these are not calculated from the same variables. The base of the variables, i.e. the tests and questionnaires is, however, the same for all levels.

The corrected explained variances ($\bar{R}^2$) show some improvement in the multiple analyses. Compared with the explained variances in the simple regression analyses, the improvement is on the average 10 per cent (Table 24).

Table 24 Comparisons of changes (per cent of s_y) and explained variance in the *v-s* factor obtained by simple and multiple regression analyses in the 1948 sample. Students.

Educ. level		Educational structure group V	O	T	Explained variance
4	simple	25.1	23.7	-6.3	.18
	multiple	23.3	20.8	-7.3	.21
3	simple	24.0	7.7	-10.1	.10
	multiple	25.1	3.4	-8.4	.18
2	simple	82.6	12.6	-9.0	.07
	multiple	71.5	26.8	-8.4	.19
1	simple	.	5.8	-9.4	.22
	multiple	.	1.0	-.4	.37
Total	simple	30.7	7.5	-7.5	.15
	multiple	34.3	1.6	-4.9	.17

The range of improvement varies from 3 per cent (level 4) to 15 per cent (level 1). The lower the education the greater the influence of the non-intellectual variables on the estimated changes in the *v-s* factor.

As mentioned earlier (chapter 4), there is a risk of overestimating the importance of the specific variables which enter a multiple regression. This is partly due to the fact that the entering of one variable depends on the presence of another variable, highly correlated with the first, which may outrival the new one. Another difficulty in the interpretation of entering variables is the obvious fact that only the available ones can enter. The interpretation of important variables must be then made with the available group of variables in mind, i.e. the interpretation must be relative.

The independent variables were earlier grouped in five categories. Of the first group of variables (ability), only the metal folding test has a great influence and is the only variable which enters all the regression equations. This is quite natural since this test dominates the *v-s* factor at 13 years.

School achievement and municipality, where the coding of the last variable is based on educational facilities, form the second group of predictive variables of the *v-s* ability for the Students. A third group consists of the two other tests, interests and Parents' attitude towards higher education.

Among the independent variables at the different levels, the ability and social relations variables enter the equations at levels 3 and 4 somewhat more often than at the other levels. The opposite holds for interest variables.

In Table 25, the results of the multiple analyses of the *v-s* factor for the Workers are given. The explained variance is lower for the Workers than for the Students at level 1 but about the same at levels 2 and 3 as well as in the total group. This result corresponds on the whole with that of the simple regression analyses.

As before, significant ($p \leq .05$) changes are marked in Table 25. The differences between the results of the simple (Table 22) and multiple regressions in this aspect are at level 3 where the V and 0 groups show significant changes in the multiple analysis but not in the simple one.

The orders of the changes are more in conformity with expectations in the multiple regressions than in the simple (Table 26), and only at one place is the order V, O, T_1 , T_2 , and T_3 broken (level 2, T_1 and T_2).

The average increase of explained variances in the multiple analyses is 5 per cent for the Workers, i.e. less than the gain for the Students (Table 26).

In summing up the more detailed analysis in Balke-Aurell (1973) it can be concluded that Metal folding is the strongest predictor for the worker group and school achievement (marks) comes second. This result corresponds with that of the Students. The remaining variables are of small importance and municipality, social relations, and, especially, reading interest are weaker for Workers than for Students.

Table 25. Changes (per cent of s_y) in the *v-s* factor estimated by multiple regression analyses of occupational structure groups in the 1948 sample. Workers.

Educ. level		Occupational structure group V	O	T_1	T_2	T_3	R^2	$\bar{R}^2$
3	change ($\% \cdot s_y$)	14.8*	11.9*	-.4	-16.3*	-20.0	.22	.21
	n	122	135	124	132	55		
2	change ($\% \cdot s_y$)	22.8	13.1	-3.4	6.5	-12.7	.16	.16
	n	37	119	183	171	165		
1	change ($\% \cdot s_y$)	17.2	2.1	1.7	-9.5*	-12.3	.14	.14
	n	72	459	251	397	119		
Total	change ($\% \cdot s_y$)	24.2*	9.1*	1.3	-4.7	-14.2*	.14	.14
	n	234	721	564	708	340		

Table 26. Comparisons of changes (per cent of s_y) and explained variance in the *v-s* factor obtained by simple and multiple regression analyses in the 1948 sample. Workers.

Educ. level		Occupational structure group V	O	T_1	T_2	T_3	Explained variance
3	simple	12.1	14.8	1.5	-20.2	-17.5	.16
	multiple	14.8	11.9	-.4	-16.3	-20.0	.21
2	simple	22.4	12.4	-4.4	5.7	-15.2	.11
	multiple	22.8	13.1	-3.4	6.5	-12.7	.16
1	simple	18.4	7.4	5.1	-13.0	-7.1	.10
	multiple	17.2	2.1	1.7	-9.5	-12.3	.14
Total	simple	18.6	10.4	.2	-9.5	-15.5	.12
	multiple	24.2	9.1	1.3	-4.7	-14.2	.14

11 CHANGES IN THE G FACTOR

Härnqvist's (1968) analysis concerns the relative changes in the *g* factor for different educational levels in the 1948 cohort. In order to study the constancy of the changes and the effect of the new school system, the same analysis is carried out for the 1953 cohort.

As mentioned earlier, about 70% of the boys born in 1948 were attending the old, segregated school in 1961 and 30% were attending the (experimental) comprehensive school. Five years later, when the boys born in 1953 were at the same age, i.e. 13 years old, the proportions were about 20% and 80% respectively (chapter 5).

11.1 Regression analysis of the *g* factor in the 1953 cohort

The order of both initial and final means of the *g* factor at the four levels is shown in Table 27. The common within-group regression is, as in the regression analysis of the *v-s* factor, corrected for lack of reliability in the initial variable.

The within-group regression coefficients of the four levels (b_j) show that the lower educational groups have steeper regressions. Härnqvist (1968) reports the same finding and refers to two explanations. The first one is that individuals in the lower educational groups are more heterogeneous in study activities during leisure time than individuals in higher educational groups and that these activities affect the intellectual level. The other explanation is that the higher educational groups are initially more intellectually homogeneous than the lower ones. This results in a greater influence from other, non-intellectual factors, uncorrelated with initial intellectual level, in the higher educated groups in creating the final intellectual level. The difference between the slopes will be returned to in chapter 14.

In Table 28, the analysis of the final adjusted means of the *g* factor are presented. The significance of the F between groups implies that the final adjusted means of the four educational levels are clearly separated ($p \leq .01$). The t values range from 5.11 to 20.54.

The significance of the differences between average within-group regression and each of the within-group regressions ($b_w - b_j$) indicates that b_w is not a fully acceptable basis for measuring deviations of estimated and attained scores for the four educational levels together ($p < .01$). In spite of this, this is done in the next section because b_w describes the best (or the least bad) common regression

Table 27. Means, standard deviations, and regressions of the *g* factor in the 1953 sample.

Educ. level	n	$\bar{x}$	s_x	$\bar{y}$	s_y	b_j
4	1159	44.57	7.31	56.14	7.25	.50
3	549	37.95	7.24	50.31	6.25	.46
2	1131	32.63	8.26	44.32	8.08	.66
1	1182	31.35	9.36	41.74	9.39	.73
Total	4021	36.43	10.00	47.79	10.00	
b_w=.63	b_{w_c}=.68	r_{xy}=.76				

Table 28. Analysis of final adjusted values.

	df	MS	F
Between	3	5782	153*
Within	4016	38	
Total	4019	42	
Within:			
$b_w - b_j$	3	1001	27*
$y_{ij} - b_j$	4013	37	

line. Nor was the average within-group regression in the analysis of the 1948 sample a fully acceptable measure.

11.1.1 Estimated changes

With the restriction of the b_w in mind the changes in the *g* factor for both cohorts are shown in Table 29.

To make the deviations comparable between the cohorts the changes in the *g* factor are expressed as percentages of the standard deviation of y scores in the 1948 and 1953 cohort respectively.

In Table 29, the original within-groups regression coefficients in the 1948 sample are given together with the standardized ($b \cdot \frac{s_x}{s_y}$) coefficients in order to make the regressions comparable between samples. (In the 1953 sample these are standardized from the beginning.)

Table 29. Changes in the *g* factor estimated by regression analysis for educational levels in the 1948 and 1953 samples.

Educ. level	n 1948	n 1953		Regressions (b_j) 1948 orig.	1948 stand.	1953		Changes ($\% \cdot s_y$) 1948	1953
4	1194	1159		.40	.48	.50		32.7	28.2
3	958	549		.44	.53	.46		12.4	14.9
2	946	1131		.56	.67	.66		-8.2	-8.8
1	1518	1182		.59	.71	.73		-28.6	-25.9
			b_{w_c}	.56	.68	.68	s_x	10.10	10.00
							s_y	8.37	10.00

The results of the cohorts are strikingly similar. There are very small differences between group regressions (b_j) when adjustment is made for the smaller standard deviation in the y scores in the 1948 sample compared to the 1953's. The corrected common within-group regressions (b_{w_c}) are exactly the same.

The deviations are also approximately the same, but some difference is discernible: The extreme levels deviate less in the last cohort. The men at the lowest level in the 1953 cohort do not seem to lose as much as those born five years earlier did. The explanation for this is probably the change in the school system in the meantime. Most of the boys born in 1953 attended a reorganized and unified compulsory school where some had a program similar to that of the lower part of grammar school in the old system.

At level 4 the difference in change is rather large. In chapter 5 it was mentioned that the 1948 dropout groups probably are more frequent at level 4 than at levels 1-3, but there is no reason to believe that these individuals differ from the participants in respect of intelligence change. In the case of the last cohort, the reason that broader admission to the upper secondary school may result in a lower average ability than earlier does not seem to be valid - no indication of that is found in the test results. In chapter 15, the difference between the samples will be returned to.

It must be remembered that the figures given in Table 29 are not absolute. The changes in each cohort are related to the total means which, in turn, are not exactly comparable between cohorts. The changes are expressed in standard deviation units but this allows us only to compare the relative size of deviations from each of the total means. The question of whether the second cohort has a higher or lower value than the first one is not answered in Table 29.

To return to the discussion about regression heterogeneity, it can be established that the ranking of group regression coefficients is more regular in the 1948 sample than in the 1953. The difference between the highest and the lowest coefficient is, however, greater in the 1953 sample.

11.2 Multiple regression analysis

In order to study which of the initial variables, besides ability, that predicts the future *g* level, the 1948 cohort is studied by the method of multiple regression analysis in Balke-Aurell (1973). The independent variables in this (stepwise) analysis consist of all the variables collected in 1961. As in the multiple regression analyses of the *v-s* factor reported in the preceding chapter, the initial tests, not the combined *g* factor score at 13, are used as predictors.

Since this analysis is made in connection with the analyses of the *v-s* factor, the basis is the third collection of information on the 1948 sample (chapters 5 and 8). This results in some changes in the numbers of men at the educational levels compared with the regression analysis presented in the preceding section which is based on the second data collection.

Table 30 Changes in the *g* factor estimated by multiple regression analysis for educational levels in the 1948 sample.

Educ. level	n	y	y'	Changes (%·s_y)
4	1148	49.87	48.72	13.7
3	965	44.39	43.96	5.1
2	911	39.31	39.09	2.6
1	1419	36.42	37.56	-13.6

R^2=.64 $\bar{R}^2$=.64 s_y=8.37

The estimation of final scores (highly significant between levels) is in this multiple analysis more uncertain than that based upon the simple regression analysis because of the rather low reliabilities in the independent variables which are not taken into consideration in the multiple analysis (chapter 4). The errors of measurement are thus large which makes the estimated changes uncertain. The estimated changes in the simple regression and in the multiple regression analyses are then not comparable and the proportion of explained variance is only a few per cent higher - from 61 to 64.

The main aim of this analysis is, however, to find out which of the variables have predictive power. These are in sequence Opposites, Number series, Metal folding, marks, Parents' attitude towards higher education (scale 2) and municipality.

In Balke-Aurell (1973), multiple analyses of the 1948 sample divided into structure groups of Students and Workers are presented. The V groups of the Students are analysed according to educational level; a new analysis is made for the 0 groups of the Students; and so on. This basis (which can be called vertical) of the analysis is a reversal of the analyses of the *v-s* factor where the regression equations are calculated from each educational level and the deviations of the structure groups are studied. (This basis can be called horizontal).

A short summary of the findings of these separate multiple analyses of the *g* factor shows that the proportions of explained variance range from 50 to 59 per cent in the ten analyses (three for Students, five for Workers and totals for both). The strongest predictive variables are, for both Students and Workers, the ability tests. For the Students, however, marks and leisure time activities are more prominent than Metal folding. Another discrepancy between the groups is a greater dominance of background variables (social class, municipality) in the worker group than in the student group. The contrary is valid for relation variables (Parents' attitude towards higher education, Contact with friends).

The order of deviations between educational levels is still very regular in these multiple analyses within each structure group.

12 LATENT ANALYSIS OF INTELLIGENCE CHANGE

In connection with the multiple analyses of the *v-s* factor (chapter 10) and of the *g* factor (chapter 11) it was pointed out that the errors of measurement in the independent variables made the estimations uncertain. In these analyses, it was also concluded that the stepwise multiple regression analysis used does not allow more than one variable from one factor to enter the equations.

In the simple and multiple regression analyses of the *v-s* factor the difficulty in interpreting the changes, i.e. if a change is to be viewed as a gain in one part of the factor or a loss in another, was discussed.

Level and type of education are looked upon as treatment variables mediating the change between the first and the second occasion (chapter 4). They are conceived as being influenced by ability, achievement, interests and social factors at early age and are, in turn, assumed to influence ability after completed schooling. The results presented so far indicate an influence from educational levels on general ability and an influence on *v-s* ability from type of education at high educational levels and from type of occupation (and vocaional education) at lower educational levels. These results are based upon separate analyses designated as vertical and horizontal and conclusions about the combined effect of level and type of education are not possible. These four problems - measurement errors, the possible exclusion of significant variables, bipolarity of the *v-s* factor and separate analyses of level and type - are the reasons for using the LISREL (LInear Structure RELations) method to analyse the 1953 cohort. A further reason for using this method is to test the method itself.

One shortcoming in the data may, however, jeopardize the results of the LISREL analyses. This shortcoming, which stems from the assumption of normally distributed variables, is not fulfilled in regard to the treatment variables. After the description of the LISREL analyses in the present investigation, this assumption will be returned to.

12.1 The LISREL method

LISREL was introduced by Jöreskog (1973) and is fully described in Jöreskog (1977). In Jöreskog and Sörbom (1978), a description of the method together with a computer program is presented. LISREL is briefly discussed in chapter 3 where further references are given.

The LISREL method deals with relations between dependent and independent latent variables, estimated by several combined observed variables. The relations can be analysed in several groups simultaneously. The measurement errors of the observed variables are corrected for by estimates of error variances.

The analysis requires two steps where the first deals with estimates of latent variables from the observed (measurement model). The second step implies a determination of the inter- and intrarelations between the independent and dependent variables (structural equation model).

How the model fits the data is assessed in an observed chi-square value. Chi-square is susceptible to deviation from normality and also to sample size of which it is a direct function. The df is dependent on number of observed independent (q) and dependent (p) variables as well as number of estimated parameters (t):

$$df = .5(p + q)(p + q + 1) - t$$

In the LISREL notation a system of Roman and Greek letters is used - Roman for the observed variables and lower-case Greek for latent variables, measurement errors, residuals and relations. In order to avoid confusion these symbols are used here together with verbal translations.

12.2 LISREL path analyses

In trying to combine the former separate regression analyses of the *g* and *v-s* factors a LISREL analysis of the total group is undertaken. The dependent variables in this analysis are the *g* and the *v-s* factors at 18 originating from the canonical analysis and used in the investigation.

In this first analysis, the level and structure of education are included among variables. These variables are defined as intervening ones (chapter 4) influenced by personal factors on the first occasion but, in turn, influencing the ability at the second occasion. The intervening positions of these variables are taken into account in the path analyses presented.

In a second analysis, the final tests as such and not the canonical factors are the dependent variables in the model. The four final tests results in two latent variables, one verbally dominated (V) and one technical/spatial (T/S). Both latent variables also include a general ability factor, but this is not isolated in a separate factor since the main interest of the study is the verbal and technical/spatial domains separately. Also, this second analysis is formed as a path analysis with the level and structure of education as intervening variables.

In a third step, the model from the second analysis is transferred to the subgroups of the sample - Students and Workers. These groups also form the bases of the earlier regression analyses. Because of low frequencies level 1 for Students and level 4 for Workers are omitted in the analyses.

Earlier, it was mentioned that a shortcoming of the data which may jeopardize the LISREL analyses is the prerequisite of normally distributed variables. The observed independent and dependent variables can be looked upon as approximately normally distributed - which is the case in the regression analyses made earlier.

As far as the invervening variables are concerned, this assumption is not valid at all. In addition, educational level is an ordinal variable describing amount of education together with amount of theoretical emphasis in education. Educational structure is not even measured on an ordinal scale - it is a nominal variable including three categories: verbally, technically, and neither verbally nor technically dominated education. Furthermore, each of the structure groups varies between levels as regards type of subjects and orientation (theoretical or practical).

These two shortcomings - non-normal distribution and measurements on ordinal and nominal scales - raise doubts about making this type of LISREL analysis at all. If these analyses were the only ones applied to the data, these doubts would have resulted in another model where the measurements of the invervening variables would have been treated as in the regression analyses, i.e. as separate groups.

In this investigation, however, these LISREL analyses are looked upon as a way of checking the results of the regression analyses and their interpretation.

Because of this, educational experience (level and type) is included as intervening variables in these LISREL analyses, although they do not fulfill the assumption given. Consequently, the interpretations to be made are uncertain, especially where the educational structure is concerned. »Interpretations» includes both the implications of a given effect as well as those of a non-effect of a variable. The latter type of implications is probably more frequent than the former because the crude measurement of the intervening variables hides an effect more often than it produces a false one.

The LISREL path analyses are seen as an attempt to shed more light on the causality between educational experience and change in intelligence. Because of this, both level and type of education must be analysed simultaneously.

When the LISREL path analyses were concluded, the suggestion of making analyses of covariance withing the LISREL program was given in Sörbom (1978) and Sörbom and Jöreskog (1981). In this way, the educational level and the educational and occupational structure may be, as in the regression analyses, looked upon as classification variables. The advantages of LISREL, i.e. the treatment of multicollinearity and errors of measurement will, of course, remain.

Thus, the LISREL analysis of covariance seems to be a valuable method by which the earlier results can be tested. However, the fact that the paths, i.e. the relations between the intervening variables and the initial and final ones, cannot be made explicit in the analyses of covariance does not make the path analyses redundant.

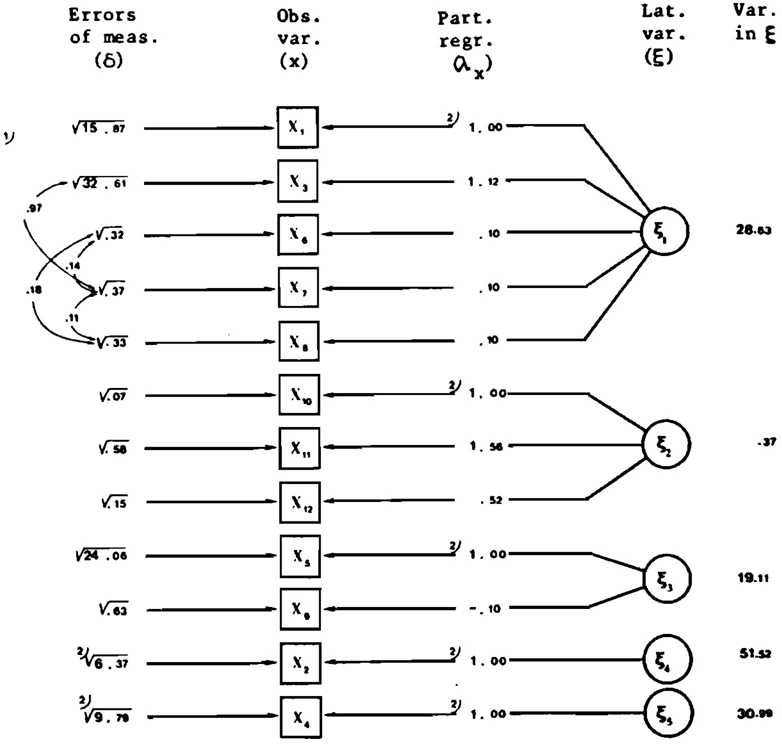
In the final section of this chapter the results of the analysis of covariance with latent initial variables and multiple latent dependent variables (V and T/S factors) are given.

12.3 Path analyses

12.3.1 Total group; canonical g and v-s factors as dependent variables

The measurement model of the independent variables is given in Figure 2. This model is the basis of every LISREL analysis in the sense that the observed and latent independent variables are the same. The differences that later will appear refer to the loadings of parameters.

The original items which are the basis of the observed variables are described in chapter 7. The chi-square given in Figure 2 indicates a poor fit of the model, but



χ^2 = 494 df = 42 prob. = .00

Sample size: 4019

1) Covariance
2) Fixed parameter

x_1 Opposite test	x_{11} Social class
x_3 Number series test	x_{12} Mother's education
x_6 Grade in Swedish	x_5 Verbal spare time activity
x_7 Grade in mathematics	x_9 Book reading frequency
x_8 Grade in English	x_2 Metal folding test
x_{10} Father's education	x_4 Technical spare time activity

Figure 2. Measurement model of independent variables for the total 1953 sample.

as mentioned earlier, chi-square is a direct function of sample size which in this analysis is 4019. This implies that even a very small difference will become significant. Munck (1979) avoids this problem, which appears when she compares the IEA-countries with varying sizes of investigation groups, by calculating a chi-square based upon a fictitious (and lower) frequency. This fictitious chi-square is, however, as Munck points out not chi-square distributed.

This type of fictitious chi-square is not calculated in the present investigation because the model presented in Figure 2 is the best possible fit, significant or not. In Jöreskog and Sörbom (1980) a similar decision of ignoring a significant chi-square value is made on the basis of large sample size which in their case is 773.

The statement that the model presented is the best one is based upon several try-outs preceding the solution in Figure 2. In the first attempts, a considerably larger number of observed variables were included which resulted in further latent variables. Those models had, however, an extremely poor fit with $\chi^2 > 1000$ and the variables were excluded in a stepwise manner from the analyses. These »pre-models» also included unsuccessful attempts to separate the first factor into Verbal ability and School achievement.

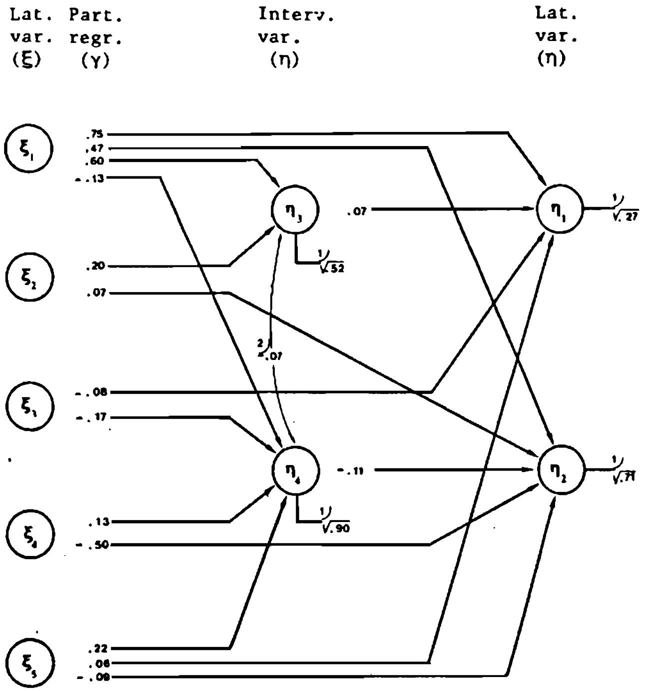
For each latent variable, one of the observed variables must be fixed in order to determine the scale of the latent variable. The fixed parameters are marked in Figure 2. Two of the latent variables (ξ_4 and ξ_5) are built up by only one observed variable. This requires a fixed measurement error and means that all the true variance in the observed variable is included in the latent variables. All errors are calculated from estimates of reliability (Härnqvist, 1968 and Rovio-Johansson, 1972).

The correlations between measurement errors are marked with curved arrows in Figure 2 and imply that the observed variables have some common variance, unique for these variables.

The resulting independent latent factors can be described as

- ξ_1 : Verbal ability and scholastic achievement (Verbal-scholastic ability);
- ξ_2 : Social background;
- ξ_3 : Verbal interest;
- ξ_4 : Spatial ability;
- ξ_5 : Technical interest.

The weights of the observed variables, i.e. the standardized partial regression coefficients, are given in Appendix 6.



$\chi^2 = 795$ df = 70   prob. = 0

Sample size: 4019

1) Residuals
2) Correlation

ξ_1 Verbal-scholastic ability	η_1 *g* score
ξ_2 Social background	η_2 *v-s* score
ξ_3 Verbal interest	η_3 Educ.level
ξ_4 Spatial ability	η_4 Educ.structure
ξ_5 Technical interest	

Figure 3. Path analysis (standardized LISREL estimates) of total group with the *g* and *v-s* factors as dependent variables.

In Figure 3 the result of the complete LISREL analysis is shown. In this figure, as well as in all the other figures which show the structural relations, only significant ($t \geq 2.6$) path coefficients are given and marked with arrows.

The explained variance in the *g* factor is 73 per cent (100 (1-.27)) which is an increase of 15 per cent compared with the explained variance in the simple regression analysis in the 1953 cohort. Though not based on the same sample, the increase compared with the multiple regression analysis (total group) can be estimated to nearly 10 per cent.

In the case of the *v-s* factor the increase in explained variance is about 10 per cent in the LISREL analysis compared to the two other types of analyses. The comparisons are based on the 1953 and 1948 total student groups, respectively.

The higher percentages of explained variances in the LISREL analyses are mainly due to on the inclusion of level and structure of education as intervening variables. In the two types of regression analyses of the *g* factor, the level is a classification variable and the structure is ignored. The opposite is true for to the regression analyses of the *v-s* factor.

The increases in explained variance in the LISREL analyses are also due to the use of latent instead of observed variables. These explain half of the variance in educational level and 10 per cent of the variance in educational structure.

Educational level (η_3) is dependent on Verbal-scholastic ability and Social background. None of the interest variables is of any importance here. Type of education (η_4) depends on Spatial ability and Verbal and Technical interest.

The interests and Verbal-scholastic ability variables predict the final *g* factor. The strongest prediction stems from the ability variable. Social background is not significant for the *g* factor but is of importance in predicting educational level which in turn predicts this factor. The *v-s* factor is, however, directly predicted by Social background and this is a positive prediction, i.e. directed towards the verbal part of the factor.

The final *v-s* result also depends on ability variables and structure of education where a verbal type of education predicts in the verbal direction and a technical type in the spatial/technical direction. None of the interest variables predict this factor directly.

One coefficient in Figure 3 is difficult to explain. This is the negative relation between Verbal interest and the *g* factor. This latent interest variable is built up from Verbal spare time activity and Reading books. The book-reading variable gave some trouble when the measurement model was constructed. Evidently this observed variable indicates some unexplained factor which in turn influences the following calculations.

12.3.2 Total group; latent V and T/S factors as dependent variables

In the second analysis a complete LISREL model is used, i.e. the observed y variables also enter, via a measurement model, the structural equation model. The latent dependent variables are constructed here as separate verbal (V) and technical/spatial (T/S) factors. With these two factors kept separate, conclusions can be made about the rival assumptions concerning the source of *v-s* change, i.e. whether this implies a rise in one part or a decrease in the other or simultaneous changes in both parts. The two factors are, of course, not directly comparable to the bipolar factor since the latter is not loaded with general ability, but some conclusions about what kind of development underlies a change may be made.

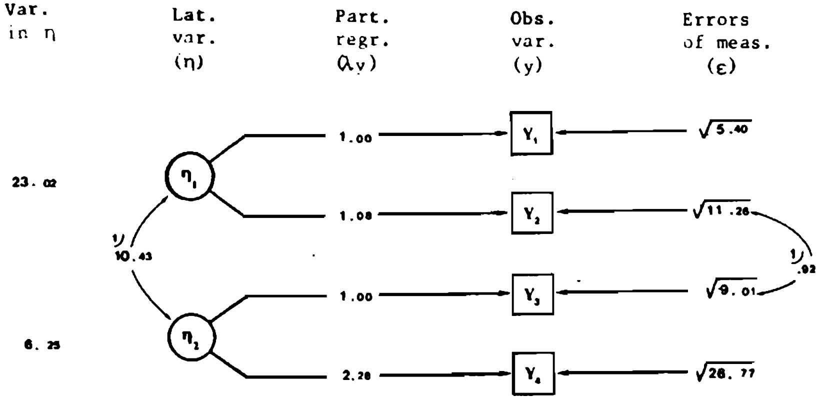
The measurement model for the dependent variables in the total group is shown in Figure 4. The first latent factor (η_1) is equally influenced by Instructions and Concepts and is a verbally loaded factor. The second latent variable is also equally loaded by its two observed variables, Form-board and Mechanical comprehension (see Appendix 6). In the following, these factors are named V and T/S respectively but attention must be paid to the fact that both are, to a great extent, loaded by general ability. An estimate based on the canonical analysis (chapter 7) of these loadings points to the fact that the first latent factor (V) is more *g* loaded than the second (T/S).

The path analysis based on these dependent variables is shown in Figure 5. The measurement model for the independent variables is the same as described earlier in Figure 3. The explained variance in the V factor is 88 per cent and in the T/S factor 78 per cent. As before, only significant ($t \geq 2.6$) coefficients are given.

The former path analysis, with the *g* and *v-s* factors as dependent variables (Figure 3), gave the result that the *g* level at 18 years was dependent on Verbal-scholastic ability together with interests at 13 years but that this factor was also dependent on the level of education reached in the meantime. For the *v-s* factor the conclusions were ambiguous because of the bipolarity of the factor.

The analysis reported in Figure 5 indicates an interesting result in the V dependent variable. This variable is significantly regressed on Verbal-scholastic ability and Verbal interest, where the regression on the latter one is, as for the *g* factor, negative. Neither any of the other independent variables, nor educational level or structure seem to be of any importance here.

The T/S ability, however, is influenced by several factors such as interests, Social background, educational level and structure in addition to the ability factors, which in turn dominate the regression.



χ^2 = 11.67 df = 1 prob. = .0006

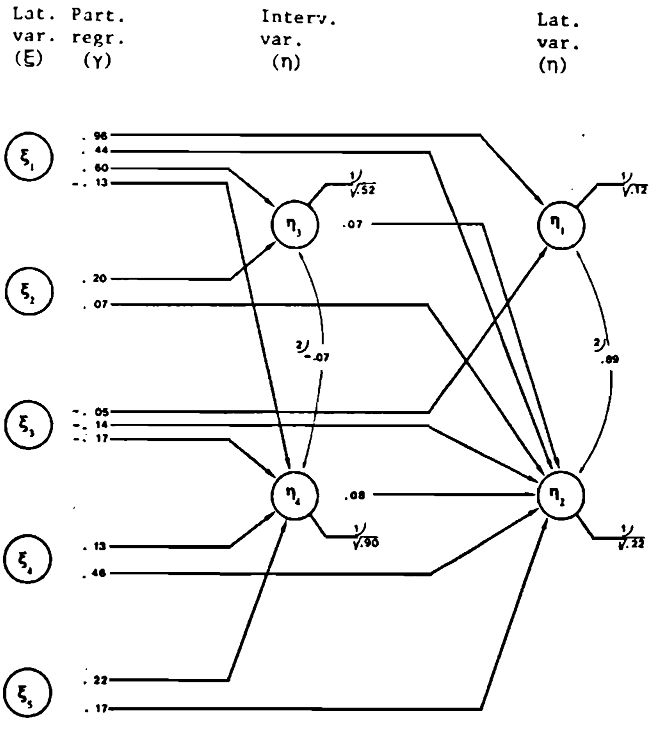
Sample size: 4019

1) Covariance

Y_1 Instructions Y_3 Form-board

Y_2 Concepts Y_4 Mechanical comprehension

Figure 4. Measurement model of dependent variables for the total 1953 sample.



$\chi^2 = 933$ df = 95 prob. = 0

Sample size: 4019

1) Residuals
2) Correlation

ξ_1 Verbal-scholastic ability
ξ_2 Social background
ξ_3 Verbal interest
ξ_4 Spatial ability
ξ_5 Technical interest

η_1 V score
η_2 T/S score
η_3 Educ.level
η_4 Educ.structure

Figure 5. Path analysis (standardized LISREL estimates) of total group with verbal and technical/spatial ability as latent dependent variables.

The T/S ability has a positive regression on the Verbal-scholastic ability probably because of a common *g* factor loading and also because of the influence from scholastic achievement on this variable.

The T/S ability is negatively regressed on Verbal interest which implies an anti-verbal influence on this ability. This interest variable resulted in, however, some strange regressions earlier which makes an interpretation of this variable dubious.

The independent variables, which influence the educational level and structure, are the same as in the former analysis.

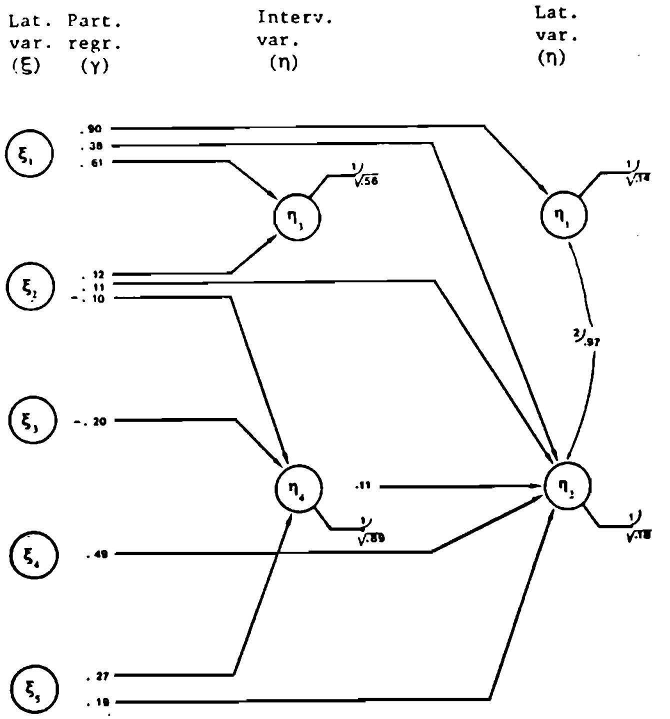
12.3.3 Students and Workers; latent V and T/S factors as dependent variables

The model for the total group unfortunately does not work when the group is subdivided into Students and Workers.

Because of this, reanalyses are made for each subgroup. Measurement models for the independent as well as for the dependent variables for these groups are based upon the same observed variables but some variation among parameters occurs. Earlier the non-suitability of the educational structure variable to LISREL analysis was pointed out. This weakness will probably be even greater when the occupational structure with its two additional categories is considered. Because of this and also because the handling of all variables - observed and latent, independent, intervening, and dependent - is quite difficult, it was decided to use type of education with its three gradings as the intervening structure variable for the Workers as well as for the Students.

The standardized partial regressions and the measurement models of the independent and dependent variables for the student and worker groups are shown in Appendices 6 and 7. The errors of measurement are constantly lower probably due to restriction of range. Mark in Swedish (x_6) and Book reading frequency (x_9) have some unique covariance which was not the case when the total group was analysed. This also holds for Social class (x_{11}) and Mother's education (x_{12}).

The path analysis of the student group is shown in Figure 6. The educational level is, as regards totals, predicted by the first two latent variables, i.e. Verbal-scholastic ability and Social background. The structure of education is predicted by Technical interest (positively), Verbal interest (negatively) and Social background (negatively), i.e. of all the non-ability variables. Evidently the Students had reached such a high level in the ability factors at 13 years that these variables do not discriminate between types of education.



χ^2 = 400   df = 95   prob. = 0

Sample size: 1211

1) Residuals
2) Correlation

ξ_1	Verbal-scholastic ability	η_1	V score
ξ_2	Social background	η_2	T/S score
ξ_3	Verbal interest	η_3	Educ.level
ξ_4	Spatial ability	η_4	Educ.structure
ξ_5	Technical interest		

Figure 6. Path analysis (standardized LISREL estimates) of the student group with Verbal and Technical/spatial ability as latent independent variables.

The two dependent variables are regressed on in the same way for the Students as for the total group, except that the influence from Verbal interest on the V factor and the educational level on the T/S factor are not significant in the student group. Educational level is, for Students, unimportant in both predictions, which is a result of restriction of range of this variable.

From the measurement models for the worker group (Appendices 7:3 and 7:4), it can be seen that the covariances between errors of measurement in the ability and school variables are greater for Workers than for Students but lesser in two of the social variables - Social class and Mother's education.

When the variances in the latent independent variables for the student and worker groups are compared it can be noticed that the two factors loaded with ability are relatively alike. Social background has a considerably lower variance in the worker group and, to a certain extent, this also holds for Technical interest. A considerably higher variation in the worker group is, however, shown by the Verbal interest variable.

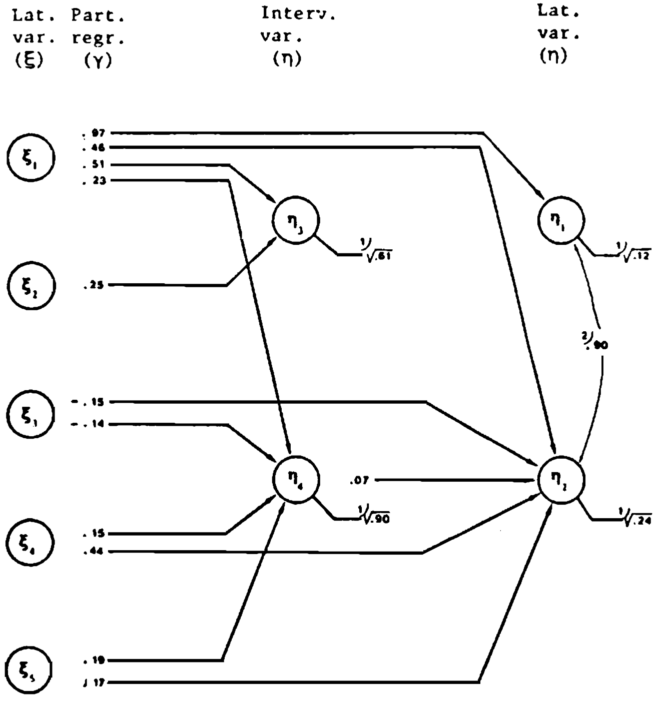
The path diagram resulting from the structural equation in the worker group (Figure 7) is, on the whole, comparable to that for the total group (Figure 5).

The educational level is, as in both former analyses, predicted by Verbal-scholastic ability and Social background. The latter variable has, in this group, compared to Students and totals, lost its importance both in predicting educational structure and T/S ability. The educational structure is, as regards totals, predicted by ability and interest variables and, for the dependent variables, the same paths as those for totals are also shown.

To sum up the main results of the LISREL analyses made up to now, some notations are made:

- the final ***general intelligence*** factor is predicted by initial Verbal-scholatic ability and by level of education. Regarding the influence from the educational level, this is the same as that given by the regression analysis in the 1953 cohort as well as by both types of regression analysis, i.e. simple and multiple, in the 1948 cohort (chapter 10). In the last type of analysis mentioned, the initial tests and marks appeared as predictors. In the LISREL analyses Verbal (uncertain) and Technical interests also seem to be important in determining the final *g* factor.

- the final ***verbal/reasoning - spatial/technical intelligence*** factor is predicted by type of education. This result is also similar to that given by regression analysis of the 1953 cohort and by the two types of analyses in the 1948 cohort (chapter 9). The final *v-s* result is also predicted by ability (Verbal-scholastic and Spatial) variables and by Technical interest and Social background.



1) Residuals
2) Correlation

$\chi^2 = 577$ df = 95 prob. = 0

Sample size: 2636

ξ_1 Verbal-scholastic ability

ξ_2 Social background

ξ_3 Verbal interest

ξ_4 Spatial ability

ξ_5 Technical interest

η_1 V score

η_2 T/S score

η_3 Educ.level

η_4 Educ.structure

Figure 7. Path analysis (standardized LISREL estimates) of the worker group with verbal and technical/ spatial ability as latent dependent variables.

Though not directly comparable, the initial tests and school achievement also predict the final *v-s* ability in the multiple regression analyses of the 1948 cohort.

- The final ***verbal ability (V)***, loaded with general ability, is predicted only by Verbal-scholastic ability and (uncertain) Verbal interest. The level of education is not important.

- The final ***technical/spatial ability (T/S)***, also loaded with general ability, is predicted by all the independent (ability, interest, and Social background) variables as well as by level and type of education. When the total group is divided into Students and Workers, the level of education loses its significance, probably due to restrictions of range.

- ***Level of education*** is predicted by Verbal-scholastic ability and Social background. Interests and Spatial ability seem to be unimportant.

- ***Type of education*** is predicted by all the independent variables when the total group is analysed. In the student group, the ability variables lose their importance but in the worker group, only Social background does. These results may depend on restrictions of range.

- ***Social background*** has its main importance in predicting level of education. When the analysis is based on the hierarchical structure of intelligence, i.e. when the *g* factor is isolated, Social background predicts educational level and the *v-s* factor, but not the *g* factor. In the multiple factor structure the T/S ability but not the V ability is predicted by this variable.

- ***Technical and Verbal interests*** mainly predict type of education. To some extent they also predict final intelligence factors in both types of structure of intelligence. Most important is Technical interest as a predictor of T/S ability.

12.4 Analysis of covariance

Within the LISREL IV program some arrangements can be made in order to perform an analysis of covariance for several treatment groups (Sörbom, 1978; Gustafsson and Lindström, 1979). Recently, an application of the method is given by Sörbom and Jöreskog (1981). In the present investigation, this type of analysis is made for both treatment variables. In this section, only the results of the analyses of covariance are presented, which means that the measurement and structural equation models are excluded.

Some remarks about the models, which are built up in about the same way as those used in about the previous LISREL analyses, must be made, however. First, the tests of significance gave, as earlier, mostly probabilities close to zero but in the analyses based on groups with small frequencies (around 200) the probabilities rise. For example, in the V-T comparison of Students at level 3 shown later (Table 32) the fit of the structural equation model is non-significant (chi-square = 234, df = 189).

Secondly, the within-group regressions are heterogeneous - a result similar to that of the regression analyses of the *g* factor for both cohorts (chapter 10). Despite this, the groups are analysed on the basis of common within-group regressions.

Thirdly, in the previous LISREL analyses some problems were caused by the latent variable Verbal interest. In these later analyses, the book-reading variable, one of the two observed variables which composed the latent variable, was excluded. This means that the latent Verbal interest variable is the same as the observed Verbal spare time activity and also that, out of five latent initial variables, three (Spatial ability, Verbal interest, and Technical interest) are identical with observed variables.

12.4.1 Structure groups; deviations in V and T/S factors

As mentioned earlier, both treatment variables are studied by analysis of covariance with latent multiple independent and dependent variables.

Educational structure is analysed in the total group (Table 31) and in the student group (Table 32). In the tables the V and T group differences of the initial and final adjusted means respectively are given in t vales. The analyses are based on the results of the V groups within each level and in the tables the deviations of the corresponding T groups are given.

Only significant ($p \leq .05$) deviations are shown in this table as well as in the successive (32-35) ones.

When the independent variables are considered, there is a pronounced differentiation in both interest and ability as regards future type of education. This conclusion holds for levels 1, 2, and 4. At level 3, only the variables within the technical domain appear as significant.

At the two lowest levels, the Verbal-scholastic ability is weaker for the future T groups compared with the V ones, but at level 4 the opposite difference appears.

Table 31. Significant differences (t values) between educational T and V groups in latent variables. The total 1953 sample.

Educ. level	n_T	n_V	Latent initial variables: Verbal-schol. ability	Social back-ground	Verbal inter.	Spatial ability	Techn. inter.	Latent final variables: V	T/S
4 (T-V)	732	423	4.17	-2.62	-3.36	6.67	7.53	–	4.00
3 (T-V)	295	236	–	–	–	3.82	5.63	–	–
2 (T-V)	965	122	-3.78	–	-3.96	3.82	2.16	–	4.25
1 (T-V)	613	300	-10.82	-2.54	-6.16	–	4.13	–	–

The results of the interest variables are ordered in accordance to future type of education with a significantly greater Verbal interest for the V groups and a significantly greater Technical interest for the T groups. Also, Spatial ability is positively differentiated in the T groups at levels 2-4.

As regards the adjusted final means of the latent dependent variables only the T/S ability at levels 2 and 4 deviates more than expected. The men in these T groups seem to have been influenced by the type of education obtained. This result is not valid for any V group as regards Verbal ability.

In the analysis of the student group (Table 32), levels 1 and 2 are excluded because of small frequencies but also because most of the men at these levels have not attended school continuously up to the time of the final testing.

The results of the student group are similar to those of the totals with the exception that Verbal-scholastic ability is significantly greater in the T than in the V groups at both levels. This variable, composed of Verbal ability and Scholastic achievement (marks), is then more developed for those who will later be educated in technical and natural sciences lines than for those with a corresponding verbal education. Because the sample investigated consists of men only, this is probably a result of the stronger selection to the lines within the T groups than to the lines within the V groups.

Table 32. Significant differences (t values) between educational V and ? groups in latent variables. The 1953 student group.

Educ. level	n_T	n_V	Latent initial variables: Verbal-schol. ability	Social back-ground	Verbal inter.	Spatial ability	Techn. inter.	Latent final variables: V	T/S
4 (T-V)	408	252	2.93	-2.99	-2.09	5.49	4.82	–	3.64
3 (T-V)	110	94	2.33	–	–	4.09	3.99	–	–

In the worker group, differences between the V groups, and each of the T group within levels are given in Table 33. The bases are as before the results of the V groups.

All the T groups at levels 1 and 2 differ significantly negatively from the V groups when Verbal-scholastic ability at 13 is considered. This means that those who will have an occupation (and mostly an education too) where technical matters are treated in a practical way have a lower result on Verbal-scholastic ability compared to those who will have an occupation within the verbal domain.

There are considerably more significant differences between the V group and each of the T groups in the latent initial variables at the first level than at the others. Only Spatial ability does not show up in any of the three comparisons at this level. Spatial ability is, in fact, only significantly greater for the T_3 group than the V group at level 3. The non-significance of this variable in the worker group is a result quite contrary to that of the student (and total) group i.e. when educational and not occupational structure was analysed.

Again, the T/S ability is the only latent dependent variable that shows a significant change. This result appears in all the T groups at level 2 and the order of the t-values is the same as that of the T groups.

'able 33. Significant differences (t values) between occupational T_1, T_2, T_3, respectively, and V groups in latent variables. The 1953 worker group.

Educ. level			n	Latent initial variables: Verbal-schol. ability	Social back-ground	Verbal inter.	Spatial ability	Techn. inter.	Latent final variables: V	T/S
	(T_1-V)	23	60	–	–	–	–	1.99	–	–
3	(T_2-V)	69	60	–	–	–	–	2.95	–	–
	(T_3-V)	107	60	–	–	–	2.72	3.62	–	–
	(T_1-V)	267	50	-4.49	–	–	–	–	–	2.35
2	(T_2-V)	277	50	-4.14	–	–	–	2.79	–	3.01
	(T_3-V)	282	50	-2.70	–	–	–	3.39	–	3.68
	(T_1-V)	219	96	-3.88	-1.98	-2.12	–	–	–	–
1	(T_2-V)	320	96	-3.43	-1.99	-3.62	–	2.46	–	–
	(T_3-V)	109	96	-2.31	–	-4.13	–	2.86	–	–

12.4.2 Educational levels; deviations in V and T/S factors

In the next two tables, the results of the analysis of covariance between levels and within educational total V and T structure groups are given. The bases of these comparisons are the means of the V and T group respectively at level 1.

Table 34. Significant differences (t values) between educational levels 4, 3, 2, respectively, and 1 in latent variables within the verbal educational structure groups.

			Latent initial variables					Latent final variables	
Compared educ. levels		n	Verbal-schol. ability	Social back-ground	Verbal inter.	Spatial ability	Techn. inter.	V	T/S
4-1	423	300	10.35	8.17	2.42	3.71	-2.06	–	–
3-1	236	300	–	–	–	–	–	2.60	–
2-1	122	300	-3.74	–	–	-2.57	–	2.57	–

As in Table 31 in the »horizontal» analysis, the significant results at the third level are fewer than at the other levels. As regards the »vertical» analysis (Table 34) this means that the V group at level 3 does not differ from the V group at level 1 in any of the initial variables.

There are negative differences in the initial ability variables at level 2 compared with level 1. This may be a result of the inclusion of the Students attending the theoretically oriented line in compulsory school at level 1. This group was, as mentioned in chapter 8, brought to the V group at this level.

The differences in interests at 13 years are only pronounced between levels 1 and 4 where those who later will go on to higher education show a higher verbal and lower technical interest than those who will finish school early.

For all the V groups, the V factor, but not the T/S factor, seems to be influenced by higher education. The non-significance of the V factor at level 4 may be due to the ceiling effect since the observed final means of Instructions and Concepts (which form this latent variable) in this group deviate 2/3 of a standard deviation from total means.

Table 35 Significant differences (t values) between educational levels 4, 3, 2, respectively, and 1 in latent variables within the technical educational structure groups.

Compared educ. levels	n		Latent initial variables: Verbal-schol. ability	Social back-ground	Verbal inter.	Spatial ability	Techn. inter.	Latent final variables: V	T/S
4-1	732	613	26.61	11.74	8.66	14.25	–	–	3.30
3-1	295	613	15.52	4.28	3.94	6.38	2.89	2.19	3.19
2-1	965	613	3.90	–	2.54	3.45	2.32	3.12	5.16

For the T groups at all levels, the means of the initial variables differ significantly from those at level 1 except Social background at level 2 and Technical interest at level 4. The t values are strictly ordered in levels.

Both the dependent variables deviate more than expected at every level from those at level 1. The t values at level 2 are the greatest. The non-significance of the V factor at level 4 is again probably due to the ceiling effect - the means of the observed variables deviate about 4/5 of a standard deviation from the means of the total group.

In the following summary, the results of the analyses of covariance are connected to the previous results in the path analyses:

- ***Type of education*** influences final Technical/Spatial ability in vocational and secondary education. Probably, »type of education» can be specified as a technical type of education, assuming that this influence is positive, i.e. an emphasis on technical subjects in education is related to a higher T/S score. The Verbal (V) factor is not influenced by type of education. Thus, the influence from type of education on T/S ability but not on V ability can be explained by the fact that all education is verbal. The education at the lines within the V groups is more homogeneously oriented to verbal subjects, but the education at the lines within the T groups also put great demands on verbal ability. This last fact is more valid the higher the educational level. Beside the handling of verbally loaded tasks within education, there is also a technical orientation of the education at the lines which constitute the T groups. This special orientation results in a significant influence on T/S ability from the type of education. As regards the influence on V ability, there is no difference between the influence from lines within the V and T groups.

- ***Type of occupation*** also seems to influence T/S ability. This holds for occupations within the technical field and for which vocational education is demanded. In fact, this result may be in line with that given above, i.e. that the special handling of technical matters within vocational education produces a positive T/S change.

- ***Level of education*** displays changes in the V intelligence factor for those who have been given a verbal type of education. The T/S factor deviates no more than expected in this type of education. Level of education influences, however, both V and T/S intelligence within the technically educated group. This corresponds with the earlier comment about technically ***and*** verbally oriented education at the study lines within the T groups.

  In the path analysis of the total group, the T/S factor, but not V factor, was predicted by the educational level. When the group was divided into Students and Workers the prediction of the T/S ability was also non-significant.

  Obviously, when groups are homogeneous with regard to verbal or technical type of education, as in the analyses of covariance, the analyses display influences by the level of education on V and T/S ability. When the groups are heterogeneous in this aspect, as in the path analyses, the influence of level does not show up when V and T/S factors are predicted. However, when general ability is predicted the educational level becomes a predictor in the heterogeneous group.

- Among the ***initial variables,*** those within the technical field, especially Technical interest, are most discriminating with regard to future type of education. Verbal-scholastic ability has a two-fold influence: those at lower educational levels who will attend a verbal type of education have a higher result than those who will attend a technical type, while the opposite holds for those at higher educational levels. These contradictory results may depend on the fact that different parts of the Verbal-scholastic ability variable work at different educational levels. At (future) lower educational levels the scholastic part (marks) of the factor is equally low for both the (future) V and T structure groups, which means that the verbal ability part is the discriminating one. At (future) higher and more theoretically oriented levels of education, the verbal ability part of the variable does not discriminate between those who will attend a verbal type of education and those who will attend a technical type of education but, remembering that only boys are investigated, the scholastic part of the variable may. Thus, the stronger selection to the future »T» lines is evident at the age of 13.

PART IV

DISCUSSION AND CONCLUSIONS

13 BASES OF THE INVESTIGATION

13.1 Samples

The groups investigated are sampled from total populations. Both samples are thus heterogeneous, which gives an emphasis of the general intelligence *(g)* factor (Vernon, 1969; Cooley, 1976). If any restriction of populations were made, for instance with regard to educational level, the importance of the *g* factor would decrease.

Only males are, studied, and in this respect the samples are, however, homogeneous. It is impossible to state what effect this restriction may have on the appearance of the intelligence factors resulting from the canonical analysis. The *g* factor would probably have been stronger, but the greatest difference would have occurred in the second factor, i.e. the verbal/reasoning - spatial/technical *(v-s)* one. Inclusion of the more verbally oriented girls would have resulted in a stronger emphasize on the verbal part of the *v-s* factor as well as a more distinctive V factor. Also, the number of individuals attaining verbal types of education would, of course, have increased as would have the average of Verbal interest.

13.2 Tests

The intelligence tests which form the bases of all analyses in the present investigation were all carefully examined and checked before application and all are group tests with written instructions. The spatial and technical tests are thus not pure tests of spatial and technical ability, partly because the mode of instruction and partly because of the artificial type of tasks with, for instance, drawn metal pieces.

The situations in which the two test batteries were given differ to some extent. The first battery was administered in school where those included in the sample were brought together on one single occasion. At the time of the second collection the men were in a strange environment and the importance of the event (military enrollment) may have caused some tension. It is impossible to state what effect this difference between the test situations has had, but for some, for instance those who are easily influenced by stress situations, it will have caused a lowered correlation between the results of the two test batteries.

In relation to the test situations, it must also be pointed out that there is a risk that a desire to be given a certain military assignment could influence the way of answering the test. This risk is, however, rather small because the pattern of test results congruent with a person's wishes is difficult to discover for a person who has never seen the tests before.

Another shortcoming of tests used in investigations like the present one is that only the scores of the subtests are analyzed and not the answers to the individual items. Eysenck (1967) points this out, noting that different items require different mental processes for their solutions. Going one step further, it can be pointed out that a certain item may be correctly solved by different mental processes by different individuals. This fact is an important one, but to analyze this a quite different approach compared to that used in the present investigation is required. Returning to Eysenck's remark it can be mentioned that the tests used here were analyzed in detail in the construction process in order to make them uniform (Svensson, 1964; Johansson, 1965; Ståhlberg, 1971). It may also be mentioned that the tests were always taken in the same order.

13.3 Intelligence factors

The *g* and *v-s* components found by the method of canonical correlation analysis are orthogonal in the total samples and an underlying assumption is that this orthogonality remains when the samples are subdivided. This is a necessary assumption in order to make meaningful comparisons and is checked and found to be valid in the major subgroups (Students and Workers).

The hierarchical model of abilities is mainly used in the present investigation, and, with its emphasis upon the *g* factor, it is a necessary approach when the effect of amount of schooling upon intelligence is analyzed (cf Cooley, 1976). The multiple factor model and the method of analysis used here improves the understanding of the results given by the analyses stemming from the hierarchical model.

The intelligence factors are broad concepts and, as Humphreys (1976) states, single tests will never cover the whole domain. This is an obvious fact but it has to be kept in mind when results and their implications are discussed in terms o general, verbal, spatial, and technical intelligence.

13.4 Methodology

The corrections for unreliability made in the regression analysis, are based on reliability estimates on the total 1948 sample (Härnqvist, 1968). The estimates are then directly transferred to the second sample which may lead to erroneous corrections for this sample. There is, however, no indication that these estimates differ between the two cohorts.

Another assumption regarding the corrections for unreliability is that the reliability is the same for all subgroups. Due to restriction of range the reliability in the independent variable will probably be somewhat lower in the subgroups compared with the total group.

Errors of measurement in the independent variables are not handled in multiple regression analysis. Furthermore, the multicollinearity gives a complexity of relations between variables which is hard to interpret (cf Cochran, 1968; Pedhazur, 1975). Attempts at interpretation, using standardized regression coefficients, are therefore based on groups of variables and not on single ones.

The results of the multiple analyses, as well as those of earlier research, were used as bases for the measurement model in the LISREL analyses carried out on the 1953 sample. There were, however, some changes in the inventories used for the two cohorts. The inventory Spare time activities is, in the 1948 cohort, scaled in a manner which made it impossible to study separate activities. In the corresponding inventory of the 1953 sample the activities measured could be analyzed one at a time. In addition, the scales concerning the child's and the parent's attitude to and interest in school were improved in the second collection. The other two inventories (Spare time interests and Plans for future education and occupation) are more similar for the two cohorts.

All the independent variables, such as test results, marks, spare time activities (verbal, technical, outdoor, clerical, and domestic), Scale 1-3, questions concerning verbal and social interests in Spare time interests, Plans for higher education (one question only), Social class, Parents' education, and municipality were brought into equations in order to form a measurement model of independent variables in the LISREL analyses. These attempts were, however, not successful and the variables were, one at a time, removed. The only items, stemming from the inventories and included in the measurement model of the independent variables, are Verbal spare time activities, Technical spare time activities, and Book-reading frequency (from Spare time interests). This result is disappointing since the expectation was that aspirations, attitude and interests concerning school and other activities like clerical and outdoors ones ought to also give some information and perhaps reduce the predictiveness of the complex variables like Parents' education and Social class (cf Wolf, 1966). Instead, both of these produced an evident latent variable at an early stage of the work with the measurement model.

The tests of how well the measurement model describes the data indicated significant deviations in all stages of the work with the model of the independent variables. This is true also for the measurement model finally used in the structural equations. The goodness-of-fit measure is, however, directly dependent on the sample size, which is large in the present investigation and gives significance even to a small deviation. The significant value leads, however, to uncertainty in the interpretation of the result. In the LISREL analyses, corrections for unreliability are made. Also the direct and indirect influence upon intelligence from the predictive variables are handled as well as the multicollinearity.

Two types of LISREL analysis are carried out. The first one results in path analyses where educational level (1-4) and structure (V, O, and T) are used as intervening variables. With this, an assumption within the method is violated, namely that of normal distribution. The intervening variables cannot be considered as normally distributed and educational structure in particular forms a very weak measurement scale.

The reasons for still including the educational variables in the path analyses are to examine if the influences of independent variables on final intelligence, which were found in the regression analyses, could be explained as direct or indirect influences. Furthermore, the paths also make it possible to establish whether the effects of education on intelligence, found in earlier analyses, could be considered valid.

The other type of analysis used within the LISREL method is analysis of covariance where the intelligence changes for level and type of education as well as type of occupation are studied. In applying this method the treatment variables (education and occupation) are, as in the regression analyses, considered as classification variables.

14 EDUCATION AND INTELLIGENCE CHANGE

14.1 Verbal/reasoning - spatial/technical intelligence

The order of deviations in the student group, based on regression analysis, is shown in Table 36. In this group most of the men at levels 3 and 4 have participated in education up to the time of final testing. Those at level 1 and 2 have been out of school for a couple of years.

As seen in the table, the changes ($\bar{y}$-$\bar{y}_c'$) at levels 2-4 are ordered strictly in accordance with educational experience with a change toward the verbal end of the scale for those who have studied in verbally oriented lines and toward the spatial/technical end for those who have studied in technically oriented lines.

The changes at level 3 and, for the T groups, at level 2 fall, however, within the confidence limits calculated earlier from the corrected expected final result for each group.

The deviations within the worker group (Table 37) are not as consistently ordered as in the student group. This is partly due to the finer grading of the structure groups for the Workers and partly to the greater uncertainty in the classifications. But it may also constitute a result in itself - occupational experience in this respect has not, at the time of 18 years, influenced ability to the same degree as educational experience has.

That the first explanation seems to hold to a certain extent is shown in Table 37 where the ranks 3 through 5, in seven cases out of nine, fall within the T groups. In addition, the groups which mostly distort the regular pattern are the T_1 occupations.

In the multiple analyses of the *v-s* factor, the explained variance increases, compared with that of the simple analyses, with only a few per cent for the total student and worker groups.

In these multiple analyses, the explained variance is based on several variables while in the simple analyses it is based on only one. This may result in expectations of a larger increase of explained variance in the multiple analyses than just a few per cent. However, in groups, heterogeneous in educational levels passed, the

Table 36. Orders of *v–s* changes within educational levels in the student groups of the 1948 and 1953 samples.

Educ. level		Educational structure group V	O	T
4	1948	①	2	③
	1953	①	.	②
3	1948	1	2	3
	1953	1	.	2
2	1948	①	2	3
	1953	①		2
1	1948	.	1	2
	1953	1	3	2
Total	1948	①	2	③
	1953	①	3	②

Significant changes within circles.

different nonintellectual variables have less chance of entering the multiple equation if they turn out to be of importance at only one or two levels, even if this importance is great. The only independent variables of significance are the ability tests at 13 years which also form the basis of the ability factors calculated. Because of this, the variances explained by the two types of analyses are about the same for both the total student and worker groups. This remark is in line with the statements reported earlier (chapter 2) concerning homogeneous and heterogeneous populations and the possibilities of investigating different mental abilities and one single general ability (cf Vernon, 1969; Cooley 1976). Also Lord's (1963) recommendation that regression analyses ought to be based on homogeneous subgroups is in line with this remark.

Table 37. Orders of *v-s* changes within educational levels in the worker groups of the 1948 and 1953 samples.

Educ. level		Occupational structure group				
		V	O	T_1	T_2	T_3
4	1948	.	.	.	.	.
	1953	(1,5)	4	1,5	3	5
3	1948	2	1	3	(5)	4
	1953	1	2	5	3	4
2	1948	1	2	4	3	(5)
	1953	(1)	2	3	4	(5)
1	1948	1	2	3	(5)	4
	1953	3	1	2	4	(5)
Total	1948	(1)	(2)	3	(4)	(5)
	1953	(1)	2	3	(4)	(5)

Significant changes within circles.

The improvement with regard to the explained variance in the multiple regression analyses becomes, in accordance with the statements above, greater when each level is analyzed separately. In the student group, the improvement becomes greater the lower the level and in the worker group the greatest improvement is achieved at level 2, i.e. for those who have attended vocational education.

The orders of the *v-s* deviations, estimated by the multiple regression analysis (the 1948 cohort only), are shown in Table 38.

The orders of the *v-s* changes in the student group are the same as in the simple regression analyses, i.e. strictly as expected. In the worker group, the orders become more regular in the multiple analyses than in the simple ones.

Table 38. Orders of *v–s* changes, based on multiple regression analy within educational levels in the student and worker group the 1948 sample.

Educational level	Students – Educational structure group V	O	T
4	(1)	2	(3)
3	(1)	2	(3)
2	(1)	2	(3)
1	.	1	2
Total	(1)	2	(3)

	Workers – Occupational structure group V	O	T_1	T_2	T_3
4	.	.	.	.	.
3	(1)	(2)	3	(4)	5
2	1	2	4	3	5
1	1	2	3	(4)	5
Total	(1)	(2)	3	4	(5)

Significant changes within circles.

Thus, the introduction of non-intellectual variables in the regressions results in better agreement with the hypotheses when the worker group is considered.

In the first LISREL analysis (the 1953 cohort only), educational structure predicts significantly the final *v-s* result. Educational level does not show any relation with this result. The explained variance in the final *v-s* result increases in the LISREL analyses by about 10 per cent compared with the regression analyses.

To sum up the three types of analyses of the *v-s* changes, it can be concluded that verbal and technical types of education are clearly related to changes in this factor. When it comes to type of occupation (regression analysis only), the conclusion is more vague. There seems to be a relation here too, but it is doubtful whether this relation stems from the type of education underlying vocational choice or the type of occupation per se.

The *v-s* changes are, however, ordered according to types of experience both in the worker group and especially in the student group. As a result of the multiple regression analyses, the portion of explained variance increases and the orders of the changes in the worker group form a more salient pattern. Thus, other variables besides intelligence predict the final *v-s* results better for those educated at low levels than at high ones. Furthermore, an improvement in regularity results from the multiple analyses in the worker group. A corresponding improvement in the student group is not possible since the *v-s* changes are already regular in the simple regression analyses.

14.2 General intelligence

When *g* factor changes between 13 and 18 years of age are considered, the results show a striking conformity between cohorts. Those educated at the highest educational level, i.e. at the upper secondary school and above, display a much higher final mean than expected and those at the second highest level, i.e. with lower secondary school, show an increase of about half of that size. The changes at the lowest level (compulsory school only) are of about the same size as those at the highest one but negative. The changes at the second level (vocational education) are also negative but the decrease is only one third of the deviation at the lowest level.

The conformity between the cohorts is also true for regression coefficients. The higher within-group regression coefficients at the lowest level compared with the other levels have been discussed earlier. One explanation for this is that some of those who finished school as early as possible had high ambitions within other domains than the educational one and fulfilled these ambitions which, in turn, stimulated their intelligence development. This suggestion may be connected to Kohn's (1969) suggestions about different ambitions in different social classes.

The result of the multiple analysis in the 1948 cohort is similar to that of the simple analysis when considering intelligence changes in relation to educational level. The explained variance in the multiple analysis is about three per cent higher compared with the simple analysis, i.e. a rather small increase. The changes are, however, smaller in the multiple analysis which is due to errors in the measurement of the independent variables and also to the fact that the predictor variables used here predict the treatment variable, i.e. the educational level. In the multiple analysis all the effects of initial variables on the *g* factor development are stated as direct and the indirect effects of the variables are hidden within these direct effects. This explanation is, to a certain extent, confirmed in the LISREL analyses.

In the first LISREL analysis, where the canonical *g* and *v-s* factors are dependent variables, the effect of educational level upon general intelligence is still evident when the direct and indirect effects of the independent variables are partialled out. The explained variance in the *g* factor is, in the LISREL analyses, 10 to 15 per cent higher than in the regression analyses.

14.3 Verbal intelligence and Technical/spatial intelligence

In the LISREL analyses of the 1953 cohort the dependent variables are also defined according to the multiple factor theory, i.e. verbal (V) and Technical/spatial (T/S) abilities, where both are loaded with the *g* factor and thus correlated. Only the T/S variable is predicted by educational level and educational structure group. This result is not in agreement with the results of the regression analyses of the *v-s* factor even if a strict comparison can not be made because of the different constructions of the dependent variables.

The non-predictiveness of type of education on Verbal ability is an unexpected result. This is especially true in the case of the student group since the structure variable used in the LISREL analyses is based upon type of education and not occupation and therefore not so relevant in the worker group as it should be in the student group.

One reason for this unexpected result may be that the two final tests which form the V factor are highly loaded with general ability as shown in the canonical correlations. In this connection, the greater influence of the spatial/technical part of the final *v-s* factor compared with the initial one was also mentioned. This leads to the conclusion that the *v-s* changes reported earlier may in fact be negative or positive changes in spatial/technical ability and not changes in verbal ability. However, this conclusion is not unambiguous because it is rather unlikely that negative changes in the spatial/technical factor would be ordered as consistently as they are, which is especially valid for the student group.

Earlier, the restrictions of the intervening variables according to distribution and scale of measurement were pointed out. It was suggested that these restrictions were more severe in regard to educational structure than to educational level. Each type of structure group differs between levels as to type and amount of the education which forms the groups. Though heterogeneous in this aspect, the T groups are assumed to be more uniform than the V groups. The T groups comprise more practically oriented education at the lower levels, but in the same area as in education at the higher levels. The V groups differ more as between, for instance, classics lines in upper secondary school (level 4) and vocational clerical education (level 2). This means that the spatial/technical area is more specific than the verbal one. When analyzing the structure groups over all four levels at the same time, as is done in the LISREL analyses, the risk that such diversity obscures the effect of verbal type of education is great. Added to this, the fact that all education is more or less verbal, even at the lines within the T groups, makes the verbal area even more comprehensive.

The LISREL analyses of covariance are carried out on a vertical (structure groups within levels) and a horizontal basis (levels within structure groups). Only the »real» structure groups, i.e. not the residual ones, are included in the analyses.

The changes in the V and T/S factors are estimated in this way. When first considering the horizontal analyses, those educated at the fourth and the second level display significant changes in the T/S factor. Education and, to a certain extent, occupation within the technical area produce significant changes in the T/S ability.

A corresponding change in the V factor for those educated or occupied in verbally oriented lines or tasks compared to those in the technical domain does not show up. This is the same result as obtained from the LISREL path analyses where educational structure does not predict the V factor. The explanation of this last result was that the structure groups do not differ in verbal orientation in the same sense as in technical orientation.

In the vertical analyses, the estimated means of the V factor are, at level 2 and 3, significantly different from the means at level 1. This is valid in both vertical analyses, i.e. in the analysis of educational level in the V groups as well as that in the T groups. Verbal-scholastic ability is the only variable that predicts the final V score and the means of this initial variable are much higher for those who will attend advanced education than for those who will finish school early. The selectivity of Verbal-scholastic ability is stronger in the T domain than in the V domain.

In the analysis of the educational level in the T domain, significant differences in estimated T/S ability also appeared.

The deviations in V ability between educational levels for both verbally and technically oriented education are in line with the observation made earlier that all education is verbal. Furthermore, the fact that significant deviations in T/S ability only appear in the T domain, support the conclusion that technically oriented education is more restricted than verbally oriented education.

A final observation which concerns the interpretation of the V factor development, as well as Verbal interest, is related to the restriction of the groups investigated. If girls were included in the samples another pattern of these variables would probably have appeared (cf Anastasi, 1958; Vernon, 1950).

14.4 Conclusions regarding intelligence change

The relative changes in the *g* factor between 13 and 18 years of age are consistently ordered as to educational level. It is impossible to state the size of these changes in relation to the total development. According to Bloom (1964), only ten per cent of the development occurs between these ages. It seems difficult to accept this low percentage in the light of the present results. The changes may be proportionally rather small, but, since the initial and final tests, i.e. the basis of the *g* factor, cover only a restricted domain of general intelligence, it does not seem likely that these would have hit the remaining part of the development so successfully.

The theory proposed by Cattell, dividing general intelligence into fluid and crystallized intelligence can also be connected to the results. The crystallized part is assumed to develop at grown-up ages and is also assumed to be influenced by environment while the fluid part is predominantly inherited. In addition, Horn's (1968) analysis of the tests for Gf and Gc indicates that the tests in the present investigation measure both types. From this point of view the changes shown can be assumed to be changes in Gc. However, as Undheim (1980b) suggests, Gf may also be influenced by experience.

Since education is not completed for all individuals at the time of the final testing, the changes are probably underestimated (cf Svensson, 1962).

The initial results of the *v-s* factor show that 13 years old boys differ in *v-s* ability in relation to future type of education. According to Vernon (1965), the *k:m* (practical-mechanical-spatial-physical) ability is developed during the teens, while the development of the verbal ability starts earlier. These results are confirmed in most studies which are based on the hierarchical structure of abilities and may also serve as an explanation for the present results. However, evidence of true positive changes in verbal ability for those educated in verbally oriented lines is shown by the strict order of *v-s* changes. If no change according to education had occurred, the *v-s* changes in the V groups would not have differed from those in the O groups.

Thus, a differentiation in abilities occurs earlier than at the age of 13 which is confirmed in the present investigation. It seems, however, that this development continues, especially as far as the spatial/technical intelligence is concerned. This conclusion is based on the analyses of both types of intelligence models. In this connection the verbal influence on all types of education must be pointed out again. In this study it is shown that educational level is related to changes in Verbal ability in both the V and T groups.

It was earlier pointed out that many investigations have shown that students in technical lines improve in Technical/spatial ability. This is in line with the present investigation. The investigations referred to are mostly concerned with either only technical students or technical students in contrast to students in classics lines. The present investigation comprises all types of education. The T groups of the Students include students of, for instance, technology, science and chemistry and the changes occurring in this rather heterogeneous group should be more limited than would have been the case if only technical education had been included.

In relation to this, the duration of the verbal and spatial/technical experience must be pointed out. Several of the boys in the 1948 cohort and the main part of the 1953 cohort, made their choices of study line at the age of 15. Between 13 and 15 years the boys attend the same type of education except as regards the choice of courses in some subjects (chapter 6). This means that the duration of experience of verbal and spatial/technical education and occupation is mostly not five years but two or three and, furthermore, that this experience occurs in the last part of the period investigated.

Ferguson (1956) pointed out that ability is clearly affected by training and Dubois (1962), in examining the transfer theory in a technical student group, concludes that technical education ought to be general and not specific. This suggestion is not fully supported in the present investigation. At level 4, the technical education can be classified as general and at this level significant changes in *v-s* (and T/S) intelligence show up. But at level 2, even more distinctive changes occur according to type of education and occupation. At this level, education can be classified as specific or practical.

15 INTELLIGENCE CHANGE IN RELATION TO CHANGES IN THE SCHOOL SYSTEM

15.1 General intelligence

The men born in 1953 and educated at the highest level do not show as great a relative gain as the corresponding group of men born in 1948. At the lowest level, those born in 1953 deviate less from the average scores than those born in 1948. Thus, those educated at the extreme educational levels in the new comprehensive school system deviate less from each other in final intelligence than those at the corresponding levels in the old, segregated school system.

This result may be a consequence of sample differences. In a first step to check this, the dropouts will be discussed and compared.

As mentioned in chapter 5, the largest dropout group in the 1948 sample is found at the highest educational level. The effect of the dropouts upon the within-group regression may be a lowering of that regression with concomitant greater deviations for both the extreme levels. This kind of data defect cannot, however, be an explanation for the greater deviations in the 1948 sample - on the contrary. Besides, this dropout group is small and probably of no effect at all.

The dropouts in the second sample can be divided into two groups: (1) loss of the military enrollment records in some minor districts, and (2) loss of the occupational codes for some highly educated men. The first group cannot be assumed to be concentrated to any specific educational level and the second group does not concern educational level at all.

One further difference between the data of the two samples is the extended enrollment time for the second cohort, 10 months compared to 2 for the 1948 cohort. A consequence of this is that the deviations should be larger in the last cohort which does not serve as an explanation of the differences in deviations in the two cohorts.

Thus, the different dropout groups cannot explain the smaller range of the *g* factor changes in the 1953 cohort.

There is, however, another difference between the cohorts that may serve as an explanation of the smaller deviation at the lowest level as regards the second cohort. This explanation refers to the non-segregation itself. Since the lower secondary school at level 3 was not available for most of the 1953 boys and was substituted by the comprehensive school (level 1), those who would have attended the lower secondary school attend a theoretical line in the comprehensive school included in level 1 (chapter 8). The lesser deviation at level 1 in the 1953 cohort would then be due to the inclusion of this group at level 1 in the 1953 cohort. A further explanation of the difference between cohorts is that almost all at level 1 in the last cohort have attended school for 9 years, while many at level 1 in the first cohort have left school after 7 or 8 years.

To sum up the differences between the samples it can be concluded that the longer time of compulsory school attendance of the last cohort seems to be the reason for the less negative change in general intelligence at level 1 of this cohort. Consequently, this gives a smaller positive change at the highest level of this cohort compared to the highest level of the 1948 cohort.

15.2 Verbal/reasoning-spatial/technical intelligence

In the student group the relative deviation in the *v-s* ability is greater in the 1948 than in the 1953 cohort. As mentioned earlier, this may, however, be an artificial result of the great differences in numbers in the comparable structure groups of the two samples. One attempt at controlling these differences consists of the confidence intervals calculated for each group. The number of significant deviations does not differ between cohorts. Similary, no evidence of differences in *v-s* changes between cohorts is found for the worker group.

Earlier, when the classification of individuals according to type of education and occupation was discussed, the larger numbers of individuals in the V and T groups of the last sample were observed. This is the result of the more differentiated coding as well as the greater number of possible educational lines available to the last cohort.

This means that although a greater number is exposed to differentiated education in the new school system, the differentiation in ability remains the same as in the old school system.

In summarizing the differences between the two cohorts as regards intelligence changes, it can be suggested that the new comprehensive system of schooling results in a smaller variation in adult general intelligence. It also seems as if an expansion of verbally and technically oriented educational lines enables more individuals to become differentiated in the dimension from verbal/reasoning to spatial/technical ability.

It must be pointed out that the conclusions above are vague and must be viewed more as suggestions for further research than as definite results of this investigation. Research aimed at penetrating the question about the effects of different school systems on intelligence changes must, more firmly, control for different educational groupings and cohort homogeneity with regard to education than is the case in the present investigation.

16 PREDICTORS

16.1 General intelligence factor

Among the significant predictors for the *g* factor in the multiple regression analysis (Balke-Aurell, 1973) Parents' attitude towards higher education (as perceived by the boy) and municipality are those which, besides more conventional predictors like initial test scores and school achievement, show up when the total sample is analyzed. In the investigation, the analysis is also made of the student and worker group separately. There, in addition to tests and marks, leisure time activities and relations with schoolmates more often show up as predictors in the student than in the worker group. The contrary holds for social class and municipality.

As mentioned earlier, there is a risk that the variables, which are shown to be important predictors in the multiple analysis, in fact predict the treatment variable which in turn predicts the final *g* factor. This means that the indirect influence of a variable is not separated from the direct influence in this multiple regression analysis.

In the LISREL analysis of the *g* and *v-s* factors, the indirect influence of Social background on the *g* factor is evident. This variable predicts educational level in this analysis, as well as in all the other LISREL analyses made, but does not show any direct relation to the *g* factor. General intelligence is predicted by, in addition to educational level, Verbal-scholastic ability in the LISREL analyses. This is in congruence with the results of the multiple analyses.

The interest measures used in the LISREL analyses were not available in the 1948 data which form the basis of the multiple regressions. These variables also predict general intelligence, but some doubts as to the measurement of Verbal interest must be mentioned once again.

As far as comparisons can be made, the difference between the results of multiple and LISREL analyses of the *g* factor is the non-predictiveness of Spatial ability shown in the LISREL analysis.

Thus, the influence of socioeconomic factors on educational choice which has been shown in many previous investigations (e.g. Coleman, 1966; Jencks, 1972;

Husén, 1972; Härnqvist, 1978), is also evident in the present investigation. The hope of finding underlying variables which would constitute a substitute for the complex socio-economic status, were not realized. Parents' attitude towards higher education shows up but only in the multiple analyses of the 1948 cohort. In the LISREL analyses, this variable failed to enter any of the latent variables. Thus the suggestions given by, for instance, Lynn (1959) and Wolf (1966), concerning variables measuring stimulation and aspiration from parents, cannot be tested in the present investigation.

The direct influence of Verbal interest and Technical interest on general intelligence has not been established in previous research. The definition of the concept of interest is also, as Lavin (1965) observes, diffuse. In this investigation, interests are measured by rating of given activities, where the ratings are based on the attractiveness of activity.

Educational outcome is mostly measured by achievement in school subjects and not in general intelligence. The importance of this last factor as an outcome variable is shown in the present investigation. The impossibility of separating educational achievement from Verbal ability in the LISREL measurement model is one evidence of the importance of Verbal-scholastic ability. The fact that educational achievement predicts general intelligence in the multiple analyses is an additional proof of this importance. In the LISREL analyses, the influence of this factor on general intelligence can be described as both indirect and direct in the sense that both the educational level and the final *g* factor are predicted.

16.2 Verbal and spatial/technical group factors

In the multiple analyses of the *v-s* factor the prediction of the treatment variable by the independent variables is probably less strong than in the multiple analysis of the *g* factor. This is partly due to restriction of range since the factor is analyzed at one educational level at a time, and partly due to the fact that most of the variables (social class, municipality, school marks, school adjustment, plans for higher certificate examination) predict general intelligence more than verbal-spatial/technical.

Another type of scaling of social class and municipality might have improved the prediction of the *v-s* factor, namely, if these had been classified according to V-T structure. This would be worth trying in another study.

Educational achievement predicts *v-s* ability in most of the multiple analyses of both Students and Workers. In the student group, interests (from Spare time interests inventory), and Parents' attitude toward higher education show some predictiveness too.

In the LISREL analyses of the *v-s* factor, the predictive variables are, in addition to educational structure group, Verbal-scholastic ability, Spatial ability, Social background, and Technical interest. All these variables, except Social background, also show an indirect influence, which means that they also predict the type of education. For Verbal interest this indirect relation is the only one when final *v-s* ability is considered.

The type of education, verbal or technical, is thus predicted by ability, educational achievement, Social background, and Technical and Verbal interests. The direct influence of technical interest on spatial-technical test scores reported by Blade and Watson (1955) and Bloom (1964) corresponds with the findings in this investigation but here a consistent indirect influence of interests is also found (cf Vernon, 1953; Härnqvist, 1978).

The indirect influence of interests on ability was found in the LISREL analysis, both of the *g* and *v-s* factors and of the V and T/S factors, when the total group was analyzed. This is due to the fact that the same measurement model of independent variables is being used in both analyses.

This model did not, however, hold when the subgroups (Students and Workers) were analyzed. Two different measurement models were constructed, one for the student group and one for the worker group. The structural equations are also quite different in the two groups. The predictors of type of education differ to some extent between Students and Workers. Thus, the significant predictors of type of education are, for the student group, the Verbal interest and Social background variables which predict verbal type of education, and the Technical interest variable, which predicts technical type of education. In the worker group the interest and ability variables show up as predictors. The indirect influence of interests on change in ability (*v-s* and T/S) is thus sustained.

17 CAUSALITY

In the present investigation, it is shown that the higher the educational level, the more positive are the changes in general intelligence. It is also shown that ability group factors, verbal/reasoning and spatial/technical, are developed in accordance with verbal and technical types of education and, to some extent, also with type of occupation. This is more valid for the spatial/technical than for the verbal/reasoning ability and it is more evident within the educational than within the occupational domain.

Thus, there are consistent relations between level and type of education and changes in corresponding abilities. A direct causal interpretation of these relations, that education affects general intelligence as well as verbal and spatial/technical intelligence, is, however, hard to make.

In the outline of the research problem, different views concerning the development of group factors were mentioned. These opinions were also transferred to apply to the development of the *g* factor.

One view concerns a predetermined development and differentiation of intelligence regardless of the growing-up environment. The changes in the *g* factor as related to educational level as well as the changes in the *v-s* factor as related to the type of education and occupation would not, if this interpretation is correct, have shown such salient patterns in both cohorts as they in fact do.

Another interpretation refers to an early development and differentiation and suggests that no changes occur after 13 years. It was pointed out earlier that the development of the general and group factors investigated, especially the verbal factor, is probably most rapid before the age of 13. However, it seems as if development also continues during the teens. Since the collection of data was made only at 13 and 18 years, no conclusion about different rates of development during the period can be drawn. According to previous research, the verbal ability starts developing earlier than the spatial/technical one. If this is the case, the measurement of development based on verbal ability as contrasted to spatial/technical ability, would mean that the development of the latter ability may dominate the relation. If a collection had also been made when the individuals were, for example, 15 years of age, some difficulties in the interpretation of *v-s* changes could have been avoided.

A third interpretation of development and differentiation of intelligence is that every individual has a predetermined potential intelligence which guides the educational and occupational choices. This interpretation was earlier referred to as self-selective assignments. An individual knows his potential and will make choices in accordance with it. This will result in relations, but not causal ones, between education and changes in intelligence. This opinion is the same as that expressed by, for instance, Anastasi (1958), Lord (1963), Campbell (1963), and Cronbach et al (1977) : Self-selection with regard to educational choice must be controlled before any statement on educational influence on intelligence can be made.

Nonrandom assignment can, however, be of two different kinds (Cronbach and Furby, 1970; Cronbach et al, 1977). In one case, the assignment is based on the same variable as the initial measurement, for instance, the school admittance test where the test scores are the bases of the decisions that determine the type of education assigned and, at the same time, serve as the independent variable in the treatment effect study. The pupil's and the teacher's knowledge of the test scores may also disturb the measurement of treatment effects (Cronbach and Furby, 1970).

In another case, the assignment of treatment is independent of the result of the initial variable as, for example, test scores are not made public and, furthermore, have no effect on educational choice or assignment. The effect of the nonrandom assignment in the latter case must be much weaker than in the former. The conditions of this study correspond to the second case.

In the present study, the hypothesis of selfselection is examined by the inclusion of non-intellectual variables in the multiple regression and LISREL analyses. After the inclusion of these variables, however, distinct relations with educational (and occupational) experience and changes in ability still appear.

PART V

SUMMARY

18 SUMMARY

18.1 Purpose and theoretical background

The purpose of this investigation is to study whether changes in ability are influenced by certain types of educational and occupational experience between 13 and 18 years of age.

The basis of the investigation is the hierarchical structure of intelligence where the general intelligence factor holds the position of the primary factor and the group factors are the secondary factors. An alternative analysis proceeds from the multiple factor theory, where the group factors are handled as the primary factors.

The tests used in this investigation cover parts of the factors mentioned above. In the case of the hierarchical theory, the factors used in this investigation are designated as the general intelligence (*g*) factor and the *v-s* factor where verbal/reasoning ability is contrasted with spatial/technical ability. In the analyses based on the multiple factor theory, changes in a Verbal ability (V) factor and in a Technical/Spatial (T/S) factor are investigated.

In order to study the influence of education and occupation on changes in these ability factors the education and occupations are classified into verbal and spatial/technical domains. The changes in the *v-s* factor and in the V and T/S factors are then analyzed according to these classifications, designated as structure groups. The research question is whether the individuals who, during the period of five years, have attended a verbal type of education or occupation will display a change in the verbal direction while those who have attended a spatial/technical type of education or occupation change more in the spatial/technical direction.

When the *g* factor is considered, the question is whether changes in this factor are influenced by level of education passed. This part of the investigation is a replication of Härnqvists's (1968) analysis.

The different theories concerning the intelligence factors and their development and differentiation are discussed. It is stated that the opinions about the age of development and differentiation differ mainly due to which theory of structure of abilities the investigations are based on, but also due to investigation design (longitudinal or cross-sectional) and methodology.

The question of whether a change in the assumed direction may be interpreted as having been *caused* by the environment is also discussed. The competetive explanation is self-selection and implies that the development of a certain pattern of abilities in accordance with the education depends on a potential ability pattern which has governed the educational choice. This results in a relation between experience and intelligence development which is not a causal one.

An additional purpose of this investigation arises from the reorganization of the Swedish school system (from a selective to a comprehensive school) that occurred between the schooling of the two groups investigated.

18.2 Design

18.2.1 Samples

The groups investigated are two ten per cent random samples of males born in 1948 and in 1953 and followed from 13 to 18 years of age. The drop-out groups are rather small and mostly random and the samples are judged as being representative of the populations from which they are drawn.

18.2.2 Data collections

Initial information about the individuals (ability tests and questionnaires) was collected in 1961 and 1966, respectively. The second collections of data (ability tests and information on education passed and, occupation held) were made in connection with the enrollment in military service in 1966 and 1971 respectively.

The ability tests at the first collection are the same for both cohorts, as are the military enrollment tests. The test batteries differ, not in the abilities measured, but in test format and abilities emphasized.

Other information at 13 years of age comprises school marks, preferred and actual leisure-time activities, the boy's and his parents' attitude toward school, and future plans for education and occupation.

18.2.3 Classification in subgroups

Since the main purpose is to study the relation between verbal or spatial/technical experience in education and occupation and relative changes in the *v-s* factor, a categorization of the 18 year old men according to type of experience is made. Before this, a grouping based on where the experience was gained - at school or at work - is carried out. The two groups Students and Workers are formed as a result of this last categorization.

The categorization of type of experience results in three educational structure groups: individuals who have attended study lines dominated by verbal subjects (V); by spatial/technical subjects (T); by neither verbal nor spatial/technical subjects (O). The classification of the experience of the Workers results in five occupational structure groups: individuals working in occupations with mostly verbal tasks (V); with spatially oriented tasks (T_1); with demands on comprehension of technical-mechanical matters (T_2); with demands on independent decisions concerning technical-mechanical problems (T_3); with none of the previous demands mentioned (O).

The higher the educational level, the more theoretically oriented is the education. Therefore, the samples are also grouped in four educational levels: compulsory school only (1); vocational education (2); lower secondary education (3); higher secondary education and above (4). This last grouping also forms the basis of the analysis of relative changes in the *g* factor.

18.3 Methodology

18.3.1 Comparability between the test batteries

The initial test battery consists of three tests: Opposites (verbal), Number series (reasoning), and Metal folding (spatial). The final test battery comprises the four tests Instructions (verbal), Concepts (verbal and reasoning), Form-board (spatial), and Mechanical comprehension (technical-mechanical).

Since the initial and final test battery are not directly comparable, the actual scores at 13 years of age cannot be compared with the actual scores at 18 years of age. To overcome this, Härnqvist (1968), in his analysis of *g* factor changes in the

1948 cohort, used the method of canonical correlation analysis from which components common to the two batteries are derived. In the present investigation, the 1953 cohort is analyzed by the same method.

The results of these analyses are strikingly similar for the two cohorts. As previously mentioned, two common components are found - the first designated as a general intelligence factor and the second as a bipolar factor measuring verbal/reasoning ability at one end and spatial/technical at the other. The two factors are uncorrelated.

18.3.2 Analysis of change

In this investigation the primary method of measuring relative changes in intelligence is simple regression analysis. The changes are defined as the differences between the predicted and the attained final scores. The predicted scores are based on the common within-group regression, corrected for unreliability in initial scores.

In the analyses of changes in the *v-s* factor, the treatment variable is the type of educational and occupational experience. The changes are then analyzed for the educational (Students) and occupational (Workers) structure groups within each educational level and for total groups of students and workers as well.

The relative changes in the *g* factor are analyzed according to educational level which, in this analysis, constitutes the treatment variable.

In order partly to isolate the effect of the treatment variables and partly to find out which other initial variables predict the final *g* and *v-s* scores, multiple regression analyses were made in the 1948 cohort by Balke-Aurell (1973). The bases of these analyses, i.e. structure groups and educational levels, are the same as in the simple regression analyses. This investigation (Balke-Aurell, 1973) is summarized in the present study.

The unreliability in initial scores is not handled in the multiple regression analyses. In addition, the problem of multicollinearity as well as the fact that the inclusion of one variable in the regression equation prevents other variables, correlated with the first, from entering, make the results from the multiple regression analyses difficult to interpret.

These problems, unreliability, multicollinearity, and restrained variables are handled by the method of analysis of linear structural relationships (LISREL) used in the 1953 cohort.

In the first step of the LISREL analysis, latent variables, independent and dependent, are derived from the observed variables, thus forming the measurements models. In the second step the two sets of latent variables are related. This results in the structural equation model.

The LISREL analyses are presented in two ways. The first is in path analyses where the educational level and structure are included as intervening variables. This step is regarded as an attempt to isolate the effect of treatment variables as well as to find out the latent independent variables which are related to final intelligence scores. These relations can be either indirect (mediated by educational level or structure) or direct.

In the first of these path analyses the *g* and *v-s* factors act as dependent variables. In the other path analyses the observed final test scores are combined to two separate latent group factors, one verbal (V) and one technical/spatial (T/S). This structure is used in order to further explain the changes in the *v-s* factor given by the regression analyses. The bipolarity of the *v-s* factor is inconvenient when statements of the changes in the separate abilities are to be made. It must be pointed out, however, that the two sets of factors, *v-s* at one side and V and T/S at the other, are not equivalent since both of the factors in the last set are loaded with general intelligence and thus correlated.

The last mentioned path analyses, i.e. with the V and T/S factors as latent dependent variables, comprise analyses of the Students, the Workers, and the total 1953 sample separately. The structure variable in all these analyses as well as in the first path analysis is the educational (V, O, and T) structure groups.

In addition to the path analyses, an analysis of covariance is made using the LISREL method. The results obtained in these analyses are the differences between the groups in initial means and in final adjusted means. The final variables are the V and T/S factors. The group comparisons made here are horizontal (between structure groups, within educational levels) and vertical (between educational levels, within structure groups).

18.4 Results

18.4.1 The verbal/reasoning - spatial/technical factor

The results of the *v-s* factor at 13 years display a clear order of *v-s* ability according to the future educational structure groups. The individuals who will later attend a verbal education at a certain educational level are, at 13 years, more oriented toward the verbal part of the factor than those who will attend a technical education at the same level who, in turn, are more spatial/technically oriented.

As regards the four educational levels, those who will later attend education at the highest level are most verbally oriented and those who will attend education at the second level (vocational education) are most spatial/technically oriented at 13 years. In all these results, there is a considerable conformity between the two cohorts.

In the regression analyses in the student group, the orders of *v-s* changes are consistently as expected for both cohorts. At each level, those who have been educated in verbally oriented lines have changed more than expected in the verbal direction compared with those educated in spatial/technically oriented lines who, in turn, have changed most in the spatial/technical direction. The estimated *v-s* changes of those in the residual groups fall in between the other groups.

These consistent orders of *v-s* changes are evident at each educational level and in both cohorts. One exception to this is found at level 1 in the 1953 cohort, where the residual and technical group change positions. There are, however, some doubts about those at level 1 which are classified as Students - they were probably out of work at the time for military enrollment or had taken up studies after a period of employment.

The results of the regression analyses of the 1948 and 1953 Workers, where the changes in the *v-s* factor are related to the types of occupational experience, also reveal a regularity of change in congruence with hypotheses, but not to the same extent as the results of the Students do. The occupational V groups in most cases show the greatest change in the verbal direction, while the T groups (T_1 , T_2 , and T_3) display final results more in the spatial/technical direction than expected. These results are most evident at the lower levels which is quite as expected since the men at these levels have been working in an occupation for a longer period than the men at the higher educational levels.

However, no information is available about the duration of the working period in the occupation coded and it is suggested that if such had been used, more pronounced deviations would have appeared. Furthermore, the study lines which precede the occupations held are not controlled either. The transfer from one educational domain to another occupational domain is, however, rather small, especially from an educational T group to an occupational V group.

In the multiple regression analyses, where the non-intellectual variables are included in the estimation of final intelligence, the prediction is improved to some extent. The results in the simple regression are, however, still valid: type of education and occupation is related to change in ability.

In the student group, the relative changes in the *v-s* factor that appear in the multiple analyses display the same order as in the simple regression analyses, i.e. strictly as expected. In the worker group, the orders are improved by the multiple procedure. The orders of *v-s* changes are V, O,T_1 ,T_2 , and T_3 except at level 2, where the T_1 and T_2 groups change positions.

Predictors that show up for the Students are the ability tests, especially the spatial one (Metal folding), school achievement (marks), municipality (coded in respect to accessibility of education at different levels), interests, and Parents' attitude toward higher education (from a questionnaire, answered by the boys). In the case of the Workers, ability tests (especially Metal folding) and school achievement are the predictors that most consistently show up in the analyses.

18.4.2 The general intelligence factor

The means of the initial *g* factor are, for the 1953 cohort, ordered in accordance to future educational level. This is the same result as that obtained in Härnqvist's (1968) analysis of the 1948 cohort.

Also in the regression analysis of the *g* factor, the similarity between cohorts is evident. Those educated at the highest level have a higher final mean than expected while those who left school at the lowest level get a lower mean than expected. The changes at the third and second levels are positive and negative, respectively, but less pronounced than those at the extreme levels. All the changes are significantly separated between levels.

The resemblance between the results of the two cohorts is striking. One difference can, however, be discerned. The changes at the extreme levels are somewhat smaller in the 1953 cohort than in the 1948, but since the estimated changes are relative and not expressed in absolute scores no definite statement can be based on this result.

The *g* factor changes estimated by multiple regression analysis in the 1948 cohort (Balke-Aurell, 1973) are somewhat smaller, but still pronounced, than those estimated by simple regression. The explained variance is improved by only a few per cent. The initial variables, apart from the ability tests, which predict the final *g* factor score, are Parents' attitude toward higher education and municipality.

18.4.3 Latent analysis

The LISREL analyses are made for the 1953 cohort. The measurement model of the initial variables contains five latent variables: Verbal-scholastic ability (loaded by Opposites, Number series, and school marks); Social background (Parents' education and Father's occupation); Verbal interest (the verbal domain in the questionnaire measuring preferred leisure time activity and the reading item from a questionnaire concerning actual activity); Technical interest (the technical domain in the preferred leisure time activity questionnaire); and Spatial ability (Metal folding).

The measurement model of the initial variables is the same in all LISREL analyses. The loadings differ, however, in the analyses of the different groups Totals, Students, and Workers.

In the path analyses, where the educational level and educational structure groups are handled as treatment variables, the results of the regression analyses are reinforced.

Thus, significant relationships are found between educational structure group and final *v-s* score as well as between educational level and final *g* score.

All the initial latent variables also predict the final *v-s* score. Where the prediction of the final *g* factor is concerned, the most remarkable result is that Social background does not show up as a significant predictor. Its effect on general intelligence is only an indirect one, mediated by the educational level.

In the path analyses where the latent dependent variables are the separate V and T/S factors, the influence from both educational level and structure on scores on the T/S factor are significant when the total group is analyzed. The influence of educational level is, however, nonsignificant in the separate analyses of the Students and the Workers. The V factor is predicted by Verbal-scholastic ability and Verbal interest in the analyses of the totals and the Students and only by ability in the analysis of the Workers.

The conclusions drawn from these results are that the influence of educational structure on the *v-s* factor found earlier is mainly an influence on the *s* part of this factor. The previous conclusions concerning the influence of a verbal type of education on verbal ability cannot, however, be disregarded. By this is meant that the clear orders of *v-s* changes between the verbal and residual educational groups would not have appeared either if the *v* part of the *v-s* factor had not been influenced. In addition, the results of the analysis of covariance indicate a change in Verbal ability in both the V and T groups.

The results of the analyses of covariance agree with the path analyses based on the same latent dependent variables, i.e. the V and T/S factors.

Consequently, the T/S factor is the one which displays most significant changes both for structure groups and for levels. In the analyses within levels and between educational (Students) and occupational (Workers) structure groups, there are significant deviations in the T/S factor for the educational T groups at level 4 (Students) and for the three occupational T groups at level 2 (Workers) compared with each of the V groups. In the analyses within structure groups and between levels, both the V and the T/S factor deviate in the total T group while only the V factor deviates where the total V group is concerned. These observations are interpreted as all education being verbal, both at the study lines which constitute the V groups and in the lines which constitute the T groups. The demand of verbal ability is higher the higher the educational level. Furthermore, since only men are investigated, the selectivity of the lines within the T groups is stronger, which results in greater demands on both V and T/S ability for this group.

18.5 Conclusions

18.5.1 Changes in intelligence

In this investigation it is shown that type of educational (verbal versus spatial/technical) experience is related to changes in the bipolar ability factor measuring verbal/reasoning versus spatial/technical ability. It is also suggested that corresponding types of occupational experience are related to changes in this ability factor. This conclusion is, however, more vague than the former one, partly because a less salient pattern of ability changes is shown in these analyses, and partly because the education which precedes the occupation is not under control. In relation to educational level, positive changes in Verbal ability seem to occur in both the V and T educational groups, while positive changes in the Technical/spatial ability is observed only in the T groups.

In the analysis of general intelligence a strict order of changes is found: the higher the educational level passed, the more positive are the changes in general intelligence.

18.5.2 Intelligence changes related to school reorganization

All the results mentioned in the previous section are similar for the two cohorts investigated. There are, however, some aspects of the results which can be related to the reorganization of the Swedish school system made in the period between the schooling of the two cohorts. The design of this investigation is, however, made with the intention of studying individual differences and, consequently, conclusions about these differences from a comparative point of view are only tentative.

The numbers in the educational structure groups differ between the cohorts. There are more of the men born in 1953 who belong to the V and T groups, especially the V group, than there are in the 1948 cohort. Despite this, the changes in the *v-s* factor seem to be the same for both cohorts. The conclusion drawn here may be that the expansion of verbally and technically oriented education enables more individuals to differentiate in the dimension of verbal/reasoning versus spatial/technical ability.

At the extreme educational levels, the general intelligence factor does not change as much as it does in the 1948 cohort. The explanation suggested is the longer time of compulsory school attendance and the non-segregation of the comprehensive school.

18.5.3 Causality

In the outline of the research problem, different opinions concerning the development and differentiation of intelligence factors as well as environmental influence on this development were discussed. There are two main explanations of the significant relationship between type of experience and intelligence development - the causal and the »self-selective». In this investigation, attempts are made to control for self-selection in educational and occupational choices. It is shown that interests, school marks, and background variables contribute to the prediction of final intelligence, but they are not able to explain the relation between experience and intelligence change. Therefore, it is concluded that educational and occupational experience affects the development of the general intelligence factor as well as the group factors between 13 and 18 years of age.

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APPENDICES

APPENDIX 1

School terms in English and Swedish

Classics line	Latinlinje; Humanistisk linje
Continuation school	Fackskola
Folk high school	Folkhögskola
Higher certificate examination	Studentexamen
Integrated upper secondary school	Gymnasieskola
Lower certificate examination	Realexamen
Lower secondary school	Realskola
the National Board of Education	Skolöverstyrelsen
Natural sciences line	Reallinje; Naturvetenskaplig linje
9-year compulsory school	Grundskola
9-year experimental school	Enhetsskola
Primary school	Folkskola
Upper secondary school	Gymnasium
Vocational school	Yrkesskola

APPENDIX 2

Appendix 2:1. Examples of categorization in educational structure groups.

Educations classified as V:

Studies in law and behavioral science, classics line, modern linguistic line, lower secondary school, distribution and clerical line.

Educations classified as T:

Studies at institute of technology, technology line, natural sciences line, agricultural line, forestry line, school of navigation.

Educations classified as 0:

Unspecified education; restaurant and catering branch (except for specialized education of waiters which is placed in the V group).

Appendix 2:2. Examples of categorization in occupational structure groups.

Occupations classified as V:

Service occupations (except for assistant in petrol stations which is placed in T_2), journalist, office employee.

Occupations classified as T_1 :

Cartographer, carpenter, welder, brick-layer, architect.

Occupations classified as T_2 :

Lathe operator, engineering worker, farm worker, forestry worker, petrol station worker, driver.

Occupations classified as T_3 :

Mechanic, engineer, watchmaker.

Occupations classified as 0:

Mailman, musician, baker, storeman.

APPENDIX 3

Appendix 3:1. Analyses of the *v-s* factor for the student group in the 1948 sample.

	Initial			Final		Final adjusted		
	df	MS	F	MS	F	df	MS	F
Level 4								
Between	2	412	13.29*	543	23.50*	2	259	13.51*
Within	1119	31		23		1118	19	
b_w-b_j						2	14	.73
$y_{ij}-b_j$						1116	19	
Level 3								
Between	2	26	.84	90	4.21	2	67	3.46
Within	394	31		21		393	19	
b_w-b_j						2	.2	.01
$y_{ij}-b_j$						391	19	
Level 2								
Between	2	62	2.02	257	9.73*	2	209	8.39*
Within	233	30		26		232	25	
b_w-b_j						2	18	.74
$y_{ij}-b_j$						230	25	
Level 1								
Between	1	171	5.26	98	4.36	1	24	1.35
Within	118	33		22		117	18	
b_w-b_j						1	74	4.17
$y_{ij}-b_j$						116	18	
Total								
Between	2	601	18.82*	860	36.88*	2	475	23.78*
Within	1873	32		23		1872	20	
b_w-b_j						2	4	.22
$y_{ij}-b_j$						1870	20	

Appendix 3:2. Analyses of the *v-s* factor for the worker group in the 1948 sample.

	Initial			Final		Final adjusted		
	df	MS	F	MS	F	df	MS	F
Level 3								
Between	4	59	1.57	76	3.37*	4	68	3.59*
Within	563	38		23		562	19	
$b_w - b_j$						4	19	1.01
$y_{ij} - b_j$						558	19	
Level 2								
Between	4	61	1.94	76	3.45*	4	51	2.60
Within	670	31		22		669	20	
$b_w - b_j$						4	16	.80
$y_{ij} - b_j$						665	20	
Level 1								
Between	4	68	1.94	96	4.48*	4	74	3.82*
Within	1293	35		21		1292	19	
$b_w - b_j$						4	11	.56
$y_{ij} - b_j$						1288	19	
Total								
Between	4	156	4.49	278	12.73*	4	186	9.60*
Within	2562	35		22		2561	19	
$b_w - b_j$						4	17	.85
$y_{ij} - b_j$						2557	19	

Appendix 3:3 Analyses of the *v-s* factor for the student group in the 1953 sample.

	Initial			Final		Final adjusted		
	df	MS	F	MS	F	df	MS	F
Level 4								
Between	1	412	17.96*	535	22.11*	1	218	10.62*
Within	658	23		24		657	21	
$b_w - b_j$						1	85	4.15
$y_{ij} - b_j$						656	20	
Level 3								
Between	2	146	5.62*	170	7.08*	2	74	3.46
Within	211	26		24		210	21	
$b_w - b_j$						2	19	.89
$y_{ij} - b_j$						208	21	
Level 2								
Between	2	51	2.08	171	7.21*	2	100	5.28*
Within	147	25		24		146	19	
$b_w - b_j$						2	67	3.70
$y_{ij} - b_j$						144	18	
Level 1								
Between	2	43	1.55	83	3.37	2	52	2.64
Within	183	28		25		182	19	
$b_w - b_j$						2	8	.42
$y_{ij} - b_j$						180	20	
Total								
Between	2	407	16.69*	676	27.91*	2	312	15.43*
Within	1208	24		24		1207	20	
$b_w - b_j$						2	33	1.63
$y_{ij} - b_j$						1205	20	

Appendix 3:4. Analyses of the *v-s* factor for the worker group in the 1953 sample.

	Initial			Final		Final adjusted		
	df	MS	F	MS	F	df	MS	F
Level 4								
Between	4	171	8.37*	227	9.19*	4	85	4.33*
Within	376	20		25		375	20	
b_w-b_j						4	29	1.47
$y_{ij}-b_j$						371	20	
Level 3								
Between	4	61	2.24	91	3.39*	4	47	2.12
Within	309	27		27		308	22	
b_w-b_j						4	19	.85
$y_{ij}-b_j$						304	22	
Level 2								
Between	4	64	2.55	276	12.47*	4	198	10.15*
Within	959	25		22		958	20	
b_w-b_j						4	36	1.84
$y_{ij}-b_j$						954	19	
Level 1								
Between	4	53	2.18	66	2.84	4	38	1.87
Within	972	25		23		971	20	
b_w-b_j						4	12	.61
$y_{ij}-b_j$						967	20	
Total								
Between	4	363	14.78	569	23.93*	4	282	13.84*
Within	2631	25		24		2630	20	
b_w-b_j						4	36	1.79
$y_{ij}-b_j$						2626	20	

APPENDIX 4

Appendix 4:1. Significance test of *v-s* changes estimated by simple regression analysis.

The basis of the significance test is the distribution of $\bar{y}'_j$, i.e. the expected mean of each subgroup (j) given a certain $\bar{x}_j$. The estimate of the square of standard error of an adjusted mean is

$$s^2_{\bar{y}'_j} = MS'_{error} \left\{ \frac{1}{n_j} + \frac{(\bar{x}_j - \bar{x})^2}{E_{xx}} \right\} \qquad \text{(Winer, 1971, 777-781)}$$

$$MS'_{error} = \frac{\Sigma\Sigma(y_{ij} - \bar{y}_j)^2}{\{\Sigma(nj-1)-1\}}$$

n_j: group size

$$E_{xx} = \Sigma\Sigma(x_{ij} - \bar{x}_j)^2$$

This may also be written as

$$s^2_{\bar{y}'_j} = \frac{MS'_{error}}{n_j} + (\bar{x}_j - \bar{x})^2 \cdot \frac{MS'_{error}}{\Sigma\Sigma(x_{ij} - \bar{x}_j)^2}$$

where the last expression constitutes the squared standard error of the common within-group regression.

The assumption behind this expression is that each structure group at each level constitutes a separate sample at that level. This means that the variance is calculated around the total mean for the level (denoted above as $\bar{x}$) and that the actual $\bar{y}'_j$ is an estimate on that regression line. Following this, all expressions above are based on within-group parameters.

If $\bar{x}_j = \bar{x}$, the second part to the right is zero, which means that the variance gets its minimum. The variance then becomes greater as the distance ($\bar{x}_j$ - $\bar{x}$) grows. This holds true when group size is constant. If this is not the fact, a distant group with large n may show a lesser variance than a central group.

The estimation of the standard error above is the base of the confidence interval of $\bar{y}'_j$. The expected group means are in this investigation changed as a result of corrected average within-group regressions which, in turn, depend on errors of measurement in x. These corrected values ($\bar{y}'_{cj}$) are the basis of the confidence intervals given in Appendix 5:1. The $s_{\bar{y}'_j}$ is based, as seen above, on the uncorrected regressions which results in a certain underestimation of the variance. The difference between $s_{\bar{y}'_j}$ and $s_{\bar{y}'_{cj}}$ can, however, be ignored as far as this study is concerned.

The final means attained, which are placed outside the 95 per cent confidence interval

$$\bar{y}'_{cj} \pm t_{.05} \cdot s_{\bar{y}'_j}$$

are marked in the tables. If the actual mean is placed in the interval but near the limit, i.e. within $\pm\, t_{.10} \cdot s_{\bar{y}'_j}$ a mark is put in brackets.

Appendix 4:2. Significance test of *v-s* changes estimated by multiple regression analysis.

The standard error on which this testing is based is for group j

$$s_{\bar{y}'_j \cdot x_1 x_2 \ldots x_k'} \sqrt{\frac{N-1}{N-k} \cdot \frac{N-n_j}{N \cdot n_j}}$$

where $\sqrt{\frac{N-1}{N-k}}$: is the correction for sampling error, and

$\sqrt{\frac{N-n_j}{N \cdot n_j}}$: is the correction for relative size of subroup j.

This significance test is not exactly the same as that of the changes estimated by simple regression analysis since neither the deviations ($\bar{x}_j$ - $\bar{x}$), nor the variances of regression coefficients are included.

APPENDIX 5

Appendix 5:1. Confidence interval $(\bar{y}'_{ij} \pm t_{.05} (s_{\bar{y}'_{ij}}))$ of the *v-s* factor. Students.

Educ. level		Educational structure group V	O	T
4	1948	5.70±1.96(.31)	4.94±2.04(.77)	4.71±1.96(.15)
	$\bar{y}$	6.93	6.10	4.40
	1953	4.99±1.96(.29)	–	4.18±1.96(.23)
	$\bar{y}$	5.62	–	3.77
3	1948	4.56±2.00(.64)	4.32±1.96(.38)	4.20±1.96(.30)
	$\bar{y}$	5.68	4.68	3.73
	1953	5.14±1.98(.48)	–	4.09±1.98(.44)
	$\bar{y}$	5.96	–	3.40
2	1948	4.42±2.12(1.18)	3.49±2.08(1.04)	3.74±1.96(.36)
	$\bar{y}$	8.82	4.16	3.26
	1953	4.60±2.07(.88)	–	3.47±1.98(.40)
	$\bar{y}$	7.03	–	2.98
1	1948	–	4.07±2.00(.50)	2.94±2.02(.64)
	$\bar{y}$	–	4.35	2.49
	1953	4.43±2.00(.55)	4.18±2.04(.78)	3.65±2.00(.47)
	$\bar{y}$	5.26	3.02	3.42
Total	1948	5.33±1.96(.28)	4.34±1.96(.28)	4.43±1.96(.12)
	$\bar{y}$	6.84	4.71	4.06
	1953	4.88±1.96(.22)	4.16±2.02(.65)	4.00±1.96(.17)
	$\bar{y}$	5.72	3.28	3.54

Appendix 5:2. Confidence interval ($\bar{y}'_{ij} \pm t_{.05}(s_{\bar{y}'_{ij}})$) of the *v-s* factor. Workers.

Educ. level		Occupational structure group V	O	T_1	T_2	T_3
4	1948	–	–	–	–	–
	$\bar{y}$	–	–	–	–	–
	1953	5.54±2.00(.48)	4.68±1.98(.42)	4.31±2.07(.89)	4.13±2.00(.52)	3.10±2.00(.50)
	$\bar{y}$	6.78	4.01	5.55	3.98	2.38
3	1948	5.55±1.98(.40)	4.83±1.96(.38)	4.99±1.98(.39)	5.12±1.96(.38)	5.18±2.00(.59)
	$\bar{y}$	6.13	5.54	5.06	4.15	4.35
	1953	5.04±2.00(.61)	4.23±2.00(.64)	4.26±2.08(.98)	4.69±2.00(.57)	3.86±1.98(.46)
	$\bar{y}$	5.97	5.08	3.34	4.59	3.17
2	1948	3.83±2.04(.73)	4.19±1.98(.41)	4.03±1.96(.33)	3.84±1.96(.34)	3.61±1.96(.35)
	$\bar{y}$	4.89	4.78	3.83	4.11	2.90
	1953	3.91±2.02(.63)	3.33±2.00(.47)	3.06±1.96(.27)	3.08±1.96(.27)	2.99±1.96(.26)
	$\bar{y}$	7.41	3.65	3.21	2.69	2.50
1	1948	4.69±2.00(.52)	4.58±1.96(.21)	4.42±1.96(.28)	4.48±1.96(.22)	4.11±1.98(.40)
	$\bar{y}$	5.54	4.92	4.35	3.87	3.79
	1953	4.26±1.98(.46)	3.99±1.96(.30)	3.71±1.96(.30)	3.84±1.96(.25)	3.40±1.98(.43)
	$\bar{y}$	4.16	4.40	3.91	3.71	2.57
Total	1948	4.84±1.96(.29)	4.54±1.96(.16)	4.46±1.96(.19)	4.45±1.96(.17)	4.16±1.96(.24)
	$\bar{y}$	5.72	5.03	4.47	4.00	3.43
	1953	4.47±1.96(.26)	3.94±1.96(.21)	3.55±1.96(.20)	3.69±1.96(.17)	3.30±1.96(.19)
	$\bar{y}$	5.87	4.25	3.61	3.43	2.62

APPENDIX 6

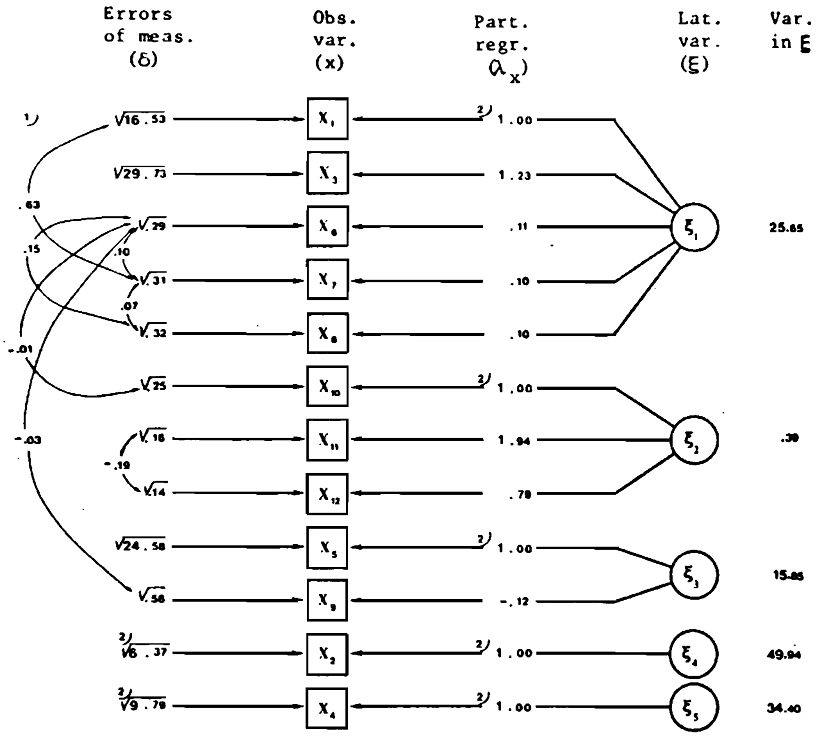
Appendix 6:1. Standardized partial regressions of independent variables in the 1953 sample.

	Total group	Students	Workers
Verbal-scholastic ability			
Opposite test	.80	.69	.76
Number series test	.72	.75	.71
Mark in Swedish	.70	.70	.64
Mark in mathematics	.64	.69	.62
Mark in English	.69	.69	.65
Social background			
Father's education	.92	.78	.84
Social group	.78	.94	.81
Mother's education	.63	.79	.60
Verbal interest			
Verbal spare time activity	.67	.62	.81
Book reading frequency	-.25	-.51	-.39
Spatial ability			
Metal folding test	.94	.94	.94
Technical interest			
Technical spare time activity	.87	.87	.87

Appendix 6:2. Standardized partial regressions of dependent variables in the 1953 sample.

		Total group	Students	Workers
η_1	Verbal ability:			
Y_1	Instructions	.89	.90	.89
Y_2	Concepts	.85	.81	.83
η_2	Technical/spatial ability:			
Y_3	Form-board	.66	.58	.61
Y_4	Mechanical comprehension	.71	.77	.74

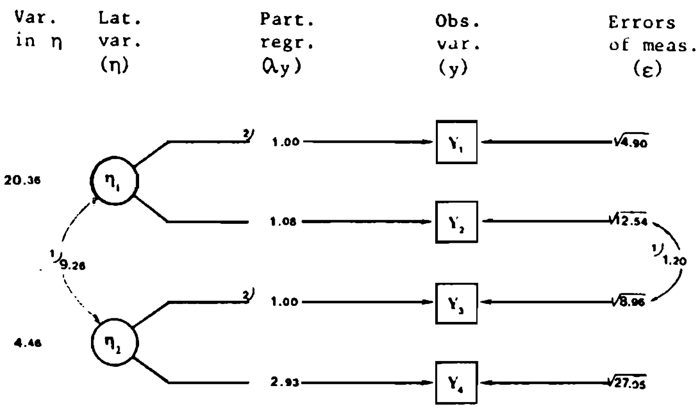
Appendix 7:1. Measurement model of independent variables for the student group in the 1953 sample.



1) Covariance
2) Fixed parameter

x_1 Opposite test
x_3 Number series test
x_6 Grade in Swedish
x_7 Grade in mathematics
x_8 Grade in English
x_{10} Father's education
x_{11} Social class
x_{12} Mother's education
x_5 Verbal spare time activity
x_9 Book reading frequency
x_2 Metal folding test
x_4 Technical spare time activity

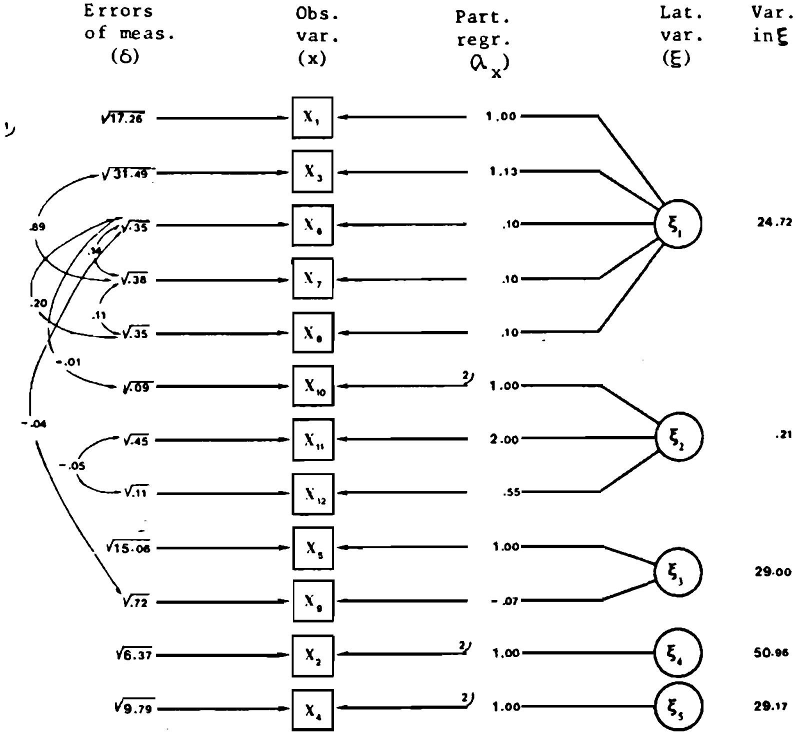
Appendix 7:2. Measurement model of dependent variables for the student group in the 1953 sample.



1) Covariance
2) Fixed parameter

Y_1 Instructions Y_3 Form-board
Y_2 Concepts Y_4 Mechanical comprehension

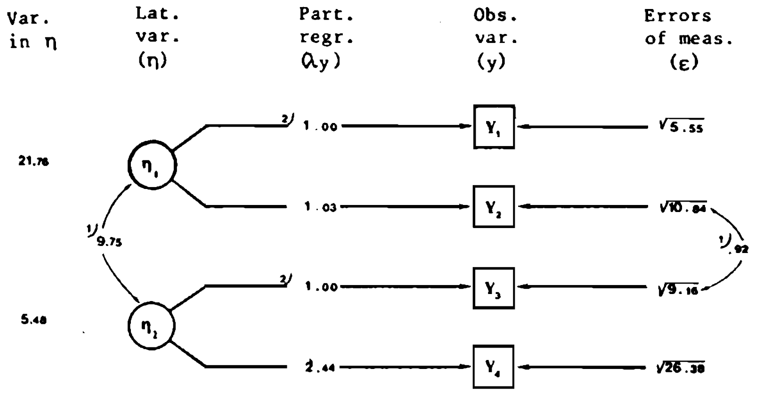
Appendix 7:3. Measurement model of independent variables for the worker group in the 1953 sample.



1) Covariance
2) Fixed parameter

x_1 Opposite test	x_{11} Social class
x_3 Number series test	x_{12} Mother's education
x_6 Grade in Swedish	x_5 Verbal spare time activity
x_7 Grade in mathematics	x_9 Book reading frequency
x_8 Grade in English	x_2 Metal folding test
x_{10} Father's education	x_4 Technical spare time activity

Appendix 7:4. Measurement model of dependent variables for the worker group in the 1953 sample.



1) Covariance
2) Fixed parameter

Y_1 Instructions Y_3 Form-board

Y_2 Concepts Y_4 Mechanical comprehension

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