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Family size, social class, intelligence and
achievement: A study of interactions

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ABSTRACT

The paper investigates interactions between family size and social class with respect to intellectual achievement. One purpose of the paper is to study the limits to the applicability of the "Confluence model" proposed by Zajonc and Markus; another purpose is to investigate methods for studying interactions between variables. The data consists of a longitudinal sample of 8288 subjects, which at the age of 13 was given a testbattery, standardized achievement tests, and interest inventories. Information also was gathered about social background and number of siblings. For investigating interactions between social class and sibsize three different analytical models are tried: two multiple regression (MR) models and analysis of variance (ANOVA). These models to different degrees impose constraints on the kinds of effects which may be represented. Comparisons between the three models indicate that the more constrained the model, the better is the power for detecting interaction effects. In those cases, however, when a model only poorly represents the effects in the data, the less constrained models yield lower p-values for the test of interaction effects. The substantive results indicate, among other things, that for most of the outcome variables there is an interaction between social class and number of siblings, such that within lower social classes sibsize is more strongly negatively correlated with outcome variables than in higher social classes. The confluence model predicts such a negative relationship between sibsize and intellectual outcomes, but it does not allow for relationships of different strength within different social classes. As an explanation of the lower explanatory power of the confluence model in higher social classes it is suggested that other socializing agencies than the family are more important in higher social classes than in lower social classes, thereby to some extent offsetting the negative effects on intellectual development of mutual influences among siblings in a larger family.

1 INTRODUCTION

Studies of the effects of family configuration on mental abilities have frequently shown a negative relationship between number of siblings and measures of intellectual achievements (e.g Anastasi, 1956; Eysenck & Cookson, 1970; Nisbet, 1953). This relationship has been interpreted as being a consequence of the more limited opportunities for each child to receive intellectual stimulation by the parents in a larger family. However, Zajonc and Markus (1975) proposed a more sophisticated model, called the "confluence model", to account for the effects of family size on mental ability, as well as for the quite complex effects of birth order which have also been found.

The essence of the confluence model is that intellectual development within the family context is seen as being dependent on the cumulative effects of the intellectual environment, which is conceived as an average of the siblings' and the parents' intelligence on an absolute scale. With each intellectual environment there is an associated growth parameter, and whenever the family configuration changes through additions or departures, the growth parameter changes as well. When, for example, a new child is born into a family, the family average of intelligence necessarily decreases and the family context provides a poorer environment for intellectual growth for all the non-mature members of the family. The confluence model predicts, therefore, a negative relationship between number of siblings and intellectual level at maturity.

The effects on cognitive level of number of siblings vary, however, with ordinal position and the spacing of the children. When a child is born into a family in which there are already several children, the relative decrease in the average level of family intelligence is smaller than when a child is born into a family with few children. The age of the siblings is also important. If, for example, the siblings of a new-born have already reached intellectual maturity the intellectual environment will be more favorable than if the siblings are very young. Since the birth-order effect is a function both of the number of siblings and the gaps between successive children it is quite complex. A normal pattern would be, however, that birth order is associated with decreasing intelligence.

Zajonc and Markus (1975) obtained quite good agreement between predictions from the confluence model and empirical findings. It was found, however, that the model was unable to account for a frequently observed handicap for single children and last born children. Another parameter was, therefore,

introduced in the model, reflecting the positive effects on intellectual development of acting as a "teacher" or a "tutor" of younger siblings.

With this refinement the model conforms quite well with a rather large set of empirical findings (Zajonc, Markus & Markus, 1979). But there also are results which contradict the model. Svanum and Bringle (1980) were unable to find the birth-order effect predicted by the model, even though they did obtain support for the predicted effects of family size. Velandia, Grandon and Page (1978) tested the model on a large Colombian sample and did not, in lower social classes, find the predicted negative relationship between number of siblings and intellectual level. In other studies too it has been found that the effects of family size vary as a function of social class. In all these studies, however, the negative effects of family size have been found to be smaller in higher social classes (e.g. Anastasi, 1956; Marjoribanks, Walberg & Barga, 1975; Moshinsky, 1939; Page & Grandon, 1979).

Such interactions cannot easily be accounted for within the framework of the confluence model, and even though the evidence is conflicting the interactions between social class and family size have been found so frequently that they are worthy of further study.

The main purpose of the present study is to study simultaneously the effects of family size and social class on ability and achievement, in order to test the generality of the confluence model predictions. While findings that the effects of family size vary as a function of social class do not necessarily imply that the model must be rejected in its entirety, they do indicate that modifications may be necessary, or that the boundary conditions for the model to apply must be established.

It may be suspected that one reason why the interaction between social class and family size tends to be elusive is that there are methodological problems associated with the study of interactions. Another purpose of the present work is, therefore, to bring into focus some technical problems in the study of interactions.

2 METHOD

The present investigation is part of a longitudinal project (the Individual Statistics Project) which started in 1961 with the collection of information (intelligence tests, achievement tests, social background, among other things) on all pupils in Sweden born on the 5th, 15th, and 25th of any month in 1948. This information has then annually been supplemented with data concerning educational choice and school achievement. A detailed description of the project is given by Härnqvist and Svensson (1973).

2.1 Subjects

The expected number of pupils in the 10 per cent sample is 10 413 (Svensson, 1971, p. 43). The number in this investigation is smaller, however. The reason for this is that only pupils with complete data have been used in the study. Table 1 reports how the sample is reduced by various types of drop-outs.

Insert Table 1 about here

Drop-outs I comprise pupils without scores on intelligence and/or achievement tests. In most cases, absence from school on the day of testing accounts for these drop-outs. There is no reason to believe that these subjects differed in any important way from the pupils included in the investigation.

Drop-outs II include such pupils as have given incomplete information about father's education and occupation. Unlike the previous group of drop-outs, it cannot be assumed that this is random. Most of these pupils gave information on the education of the mother, which suggests that children living with mother alone are overrepresented in this group.

Drop-outs III include the pupils who did not supply any information to the project. The cause of this was that, for one reason or another, they had not been reported by their schools, and were therefore not registered. This group of drop-outs may be smaller or larger depending on errors in the assessment of the size of the sample. As in drop-outs I, it is assumed

that there are no systematic differences between these drop-outs and the investigation group.

Owing to the exclusion of pupils for whom information on father's education is not available, children from incomplete families are under-represented among the pupils in the investigation. This can, however, for the purposes of the present study be seen as an advantage since confounding with this variable is avoided. Otherwise it is assumed that the investigation group comprises a representative sample of all normal-age pupils in Sweden, who in the spring term of 1961 were attending grade 6.

2.2 Variables

Three intelligence tests were included in the original collection of information: one test of verbal ability, one of spatial ability and one of reasoning ability. The verbal test consists of 40 items in which the task is to find the opposite of a given word among four choices. The spatial test also consists of 40 items and the task is to find among four choices the three-dimensional object that can be made from a flat piece of metal with bending lines marked on the drawings. The reasoning test, finally, consists of 40 items where the task is to complete a series of 8 numbers, 6 of which are given. The tests were all constructed for the present project. For a fuller description than can be given here the reader is referred to Svensson (1964, 1971).

Since the mid-1940's, standardized achievement tests have been used in Sweden to give teachers information on the standard of the class in relation to other classes in the country. In 1961, achievement tests were set in grade 6 in the subjects reading, writing, mathematics and English. For a detailed description, see Svensson (1971, pp 50-51).

About 20 per cent of the subjects in the sample have continued their education at the university level. For these students there is information on faculty, year of entrance and year of graduation. This information was used to create two dichotomous variables: entered/not entered into higher education, and graduated/not graduated. The information on field of study was thus left aside.

The dependent variables in the study thus include the three cognitive tests, the four achievement tests, and the two higher education variables.

As an indicator of the pupils' socioeconomic background (SES) a joint classification of the father's occupation and education was used. A

detailed description of the principles of the classification is reported by Svensson (1964). In Anglo-American terminology the groups can be characterized in the following way:

1. Laborers.
2. Agricultural except laborers.
3. White collar, small business, and skilled trades with lower education.
4. White collar, small business, and skilled trades with education at least at the secondary level.
5. Professional and large business.

In the quantitative analyses the SES variable was coded as is indicated above.

The original collection of data included a question about how many older and younger siblings the pupil had. In these analyses the information about birth order has been disregarded. The sibsize variable (SIB) was coded as the number of children in the family, except that families with 5 or more children were grouped into the same category. Table 2 presents the joint distribution of the sample for the SES and SIB variables.

Insert Table 2 about here

The two-child family tends to be the most common one. This holds true in all social classes except the one coded 2. In this group, consisting mainly of farmers, three children is the typical size of the family.

2.3 Models of analysis

Many different approaches have been used in investigations of interactions between sibsize and social class, ranging from quite unsophisticated analyses based on cell means or correlations to complicated regression analyses. The different methods can be assumed to have different power of detecting interactions and they can also be assumed to differ with respect to what kinds of interaction effects they can represent. It is likely, therefore, that the conflicting pattern of results mentioned earlier is at least partly due to the fact that different methods of analysis have been used in the studies.

During the last decade generalized multiple regression analysis, in which qualitative variables are represented as dummy variables, and interactions as cross-products between variables, has become increasingly popular (Walberg & Marjoribanks, 1976). The main advantages of the MR approach are that it is versatile and powerful, since no information is lost through blocking the variables into few levels. However, the kind of effects which may be represented in an MR analysis is completely determined by what model is specified. For example, if the regression on one or more of the predictors is curvilinear and no terms to represent curvilinearity have been entered into the regression equation the curvilinearity will not be detected in the MR analysis.

In the analyses to be presented below, comparisons will be made between three different methods for analyzing interactions: two MR models, differing with respect to the complexity of effects they can represent, and analysis of variance (ANOVA) in which there are no restrictions on the kinds of effects which may be discovered.

The LIN model: As was mentioned earlier, interactions between predictors can in MR be represented by special independent variables, formed as crossproducts between predictors. If there are two independent variables, SES and SIB for example, the simplest MR model which may represent an interaction between the predictors is, therefore, a model containing three predictors: SES, SIB and SES X SIB. This MR model will be referred to as the LIN model.

The significance of the least-square estimated regression coefficients can, for one or more predictors simultaneously, be tested through comparing one model containing all the predictors (the full model) and one model not containing the predictors the significance of which is being tested (the restricted model). If the full model is called Ω and the restricted model is called ω a standard F-test (Scheffé, 1959) is given by:

$$(1) \quad F = \left[\frac{df(\Omega)}{df(\omega-\Omega)} \right] \left[\frac{SS_e(\omega) - SS_e(\Omega)}{SS_e(\Omega)} \right]$$

where $SS_e(\Omega)$ and $SS_e(\omega)$ are the residual sums of squares for the two models, and $df(\omega-\Omega)$ and $df(\Omega)$ are the degrees of freedom for the numerator and denominator, respectively.

While a multiple regression equation in two independent variables can be represented graphically as a plane in three-dimensional space, the addition of a term representing interaction will, if the interaction exists, graphically result in a surface where the slope of the regressions for one of the variables varies as a function of level on the other variable. It

is necessary, however, that the slope of the regression on one of the predictors varies strictly linearly as a function of level on the other predictor.

There is reason to suspect, however, that such a linear interaction is not the only possible kind of interaction between SES and SIB. Anastasi (1956), for example, refers to some studies in which the highest negative correlations between SIB and intelligence were found for intermediate levels of SES. There is, furthermore, reason to suspect that there are curvilinear relations between sibsize and ability (Marjoribanks et al. 1975), which may also be predicted from the confluence model.

Marjoribanks et al. (1975; cf Marjoribanks & Walberg 1975) argued that the inverse of sibsize (INSIB) can be used as a derived variable instead of SIB in the LIN model to study a hyperbolic relation between family size and ability. The rationale behind this suggestion was that as the number of children in the family increases the amount of parental attention which each child receives decreases in such a way that the decrements in shared attention become successively smaller.

However, the mathematical form of the curvilinear relationship is strictly fixed when the INSIB variable is used and unless the functional relationship is of the specified kind, suboptimal prediction will result. From the more elaborate confluence model it follows that the relationship between family size and ability is not well represented by the INSIB variable.

Marjoribanks et al. (1975) compared what is here called the LIN model, using SES, INSIB and the product of these two as predictors, with other, more elaborate, MR models containing quadratic variables to represent curvilinearity. They found that the LIN model parsimoniously accounted for as much variance as the complex many-termed MR models. However, they studied a small sample and it may be that the power of the analysis was not sufficient to detect even rather gross deviations in the data from the LIN model.

It can be observed, for example, that in one analysis, using verbal ability as the dependent variable, Marjoribanks et al. (1975, pp. 111-112) found the highest predicted scores for the one-child family at the lowest occupational level. However, for all the smaller sibsizes there were higher predicted than observed scores for the lowest SES level. This is an indication that the model used only poorly represented the effects in the sample.

The CURVE model: Another approach to study curvilinear relations is to add quadratic terms to the regression equation. Since the regression

coefficients are estimated from data a wider range of hyperbolic relationships can be represented than if a derived variable such as $INSIB$ is used. A regression equation taking into account possible curvilinear regressions on the two variables SES and SIB , as well as the interaction, would thus include the predictors SES , SIB , SES^2 , SIB^2 and $SES \times SIB$. This MR model will be called the CURVE model.

Using the standard F-test presented in (1) it can be tested whether the two quadratic terms mean an improvement of prediction as compared with the LIN model and the significance of each coefficient of regression can be tested.

With the CURVE model it should be possible to represent quite complicated regression surfaces. However, still the model induces constraints on the data and there may of course be effects which are impossible to represent even with this model. In principle it is possible to approximate any relationship through adding to the regression equation polynomial and crossproduct terms of higher and higher orders, thus less and less constraining the possible relationships between the variables. It is, however, in principle possible to formulate an infinite number of regression models and the MR models themselves give no indication when to stop adding terms.

There is, thus, a need for an approach imposing no constraints at all as to what effects can be represented, which could be used to assess the maximum amount of variance possible to explain in even the most elaborate model.

ANOVA: The analysis of variance (ANOVA) has the advantage that it is not necessary to specify in advance the nature of the main effects and the interaction effects; any effect can be represented. Thus, when there are only few levels on each factor and/or the sample is large, ANOVA may be used to assess the maximum amount of variance which may be predicted.

As has been pointed out by Cohen (1968), among others, there is a close similarity between MR and ANOVA; both are built on the same general linear model. Consider for example the case when one-way ANOVA is usually applied, i.e. when there is one independent variable with two or more levels. The correlation ratio, or eta-square (E^2), which in ANOVA is defined as the between groups sums of squares (SS_b) divided with the total sums of squares (SS_t), amounts to the same numerical values as the squared multiple correlation (R^2) which would be obtained if group membership was coded with dummy variables and an MR analysis was performed (Cohen, 1968; Kerlinger & Pedhazur, 1973). This generalizes to two-way ANOVA as well since the unpartitioned SS_b is the same as that which would be obtained in a one-way analysis.

It is thus possible to express on the same scale, in terms of R^2 , the amount of variance explained in these different methods of analysis. Within the MR framework it is always possible to test for significance the increase in R^2 obtained through adding one or more variables to the regression equation. Although it may be doubtful, the same method for testing significance will be used across methods, using ANOVA as the full model and entering the appropriate df 's and SS 's into (1). The reason why this method may be doubtful is of course that in this case it is not tested whether nested models explain different amounts of variance, but rather whether one set of predictors (group membership in ANOVA) explains more variance than another set of predictors (the independent variables in MR). Nevertheless, this method of significance testing should give a rough indication whether the additional degrees of freedom spent in ANOVA represent any improvement in comparison with the few degrees of freedom spent in MR.

The reasoning above applies to one-way as well as factorial ANOVA since no partitioning of the SS_b takes place. When testing the main effect and the interaction such partitioning is of course necessary and when cell sizes are unequal it is problematic. However, in the present analyses the tests of the main effects in ANOVA are of little interest and the test of the interaction in a two-way analysis is exact even when cell sizes are unequal.

In a first step analyses will be presented under each of the three models (LIN, CURVE, ANOVA) and the results will be compared with respect to two aspects: (1) the amount of variance explained; and (2) the probability value (p-value) for the test of the hypothesis that the interaction between SES and SIB is zero. If the effects are such that they can be adequately represented with the more constrained LIN and CURVE models, smaller p-values are expected under these models than under ANOVA, but if there are more complicated effects which the more constrained models cannot capture there may be smaller p-values for the interaction in ANOVA.

Models for higher-order interactions: These analyses will thus encompass the two independent variables SES and SIB. It is conceivable, however, that there are higher order interactions involving other variables as well. A possible candidate for such a variable is sex (SEX), even though findings involving interactions with this variable and the others have been scarce (e.g. Anastasi, 1956).

Under both the MR and the ANOVA approaches it is quite simple, however, to investigate the presence of interactions involving more than two variables. Under ANOVA a three-way analysis is of course carried out, and under MR a host of different models involving the three variables and their interactions can be specified. As was mentioned earlier it is possible to

include in the regression equation also dichotomous independent variables such as SEX, through coding them as dummy variables. If the CURVE model is extended to take into account the SEX variable there will be 11 predictors: SES, SIB, SEX, SES², SIB², SES X SIB, SES X SEX, SIB X SEX, SEX X SES², SEX X SIB² and SES X SEX X SIB. Such a model would allow the regression surface specified under the CURVE model to be different in every possible respect for the two sexes.

Comparisons will be made of the results obtained under this model with the results obtained under a three-way ANOVA, with the same purpose as in the other comparisons between different models of analysis, and of course also with the purpose to see whether there are any interactions of a higher order involving sex and the other variables.

3 RESULTS

The results of the study will be presented in three steps. First comparisons will be made between the LIN, CURVE and ANOVA models. Then higher-order interactions with SEX will be studied and in the last step closer descriptions of the effects found in the other two steps will be made.

3.1 Model comparisons

Table 3 presents the multiple correlations achieved under each of the LIN, CURVE and ANOVA models, F-ratios for the increase in amount of variance explained under each less constrained model, and p-values for the test of significance of interaction under each model.

Insert Table 3 about here

It is in all cases found that the CURVE model accounts for significantly more variance than the LIN model. This implies that for all the dependent variables the regression on one or both of the SES and SIB predictors is curvilinear. It can be observed, however, that the curvilinearity is differently pronounced for the dependent variables since there is a great variation in the level of the F-ratios.

When ANOVA and CURVE are compared it is, for the dependent variables verbal ability, writing, English and mathematics, found that ANOVA account for significantly more variance than does the CURVE model. This indicates that for these dependent variables there are more complicated effects of SES and SIB than can be accounted for even with the quite elaborate CURVE model.

The p-values for the test of the interaction effect tend to be lowest for the LIN model; this holds true for all comparisons between the LIN and CURVE models and for most of the comparisons between the LIN and ANOVA models. The reason why LIN appears to give a more powerful test of the hypothesis of interaction than CURVE is that the quadratic terms in the CURVE model account for some of the variance accounted for by the cross-product term in LIN.

With respect to verbal ability and mathematics achievement lower p-values are found for ANOVA than for LIN. Obviously there are cases when ANOVA may give a more powerful test of interaction effects than MR. It can also be noted for both these dependent variables ANOVA is found to account for more variance than the MR models.

In conclusion, the model comparisons have shown that there is a tendency that the more constrained is the model, the more powerful is the test of interaction. But this only holds true as long as the model is able to represent the effects accurately; when there are more complicated effects the completely unconstrained ANOVA may be the more powerful one.

3.2 Interactions with SEX

The F-ratios pertaining to the first- and second-order interactions involving SEX in three-way ANOVA analyses and the CURVE model are presented in Table 4. There is only one significant interaction.

Insert Table 4 about here

In ANOVA a significant three-way interaction is found with respect to spatial ability, while with respect to this dependent variable all the tests of interaction in the MR analysis fall short of significance.

The analyses of the SEX variable thus show that interactions with this variable and SES and SIB are infrequent, which has also been found in other studies. However, when in the next step a closer analysis is made of the pattern of results it will be necessary to take into account the three-way interaction found with respect to spatial ability.

3.3 Descriptions of the pattern of results

The analysis so far has revealed that the LIN model in all cases represents the data more poorly than does the CURVE model, that ANOVA is in some cases superior to the CURVE model, and finally that for one of the dependent variables it is necessary to consider SEX as a qualifying variable.

In the closer analysis of the results we will concentrate on the results obtained under the CURVE model, without considering SEX, and will invoke the results obtained under the less constrained ANOVA models when this is indicated.

Table 5 presents the standardized regression coefficients in the CURVE model, along with tests of significance of each coefficient.

Insert Table 5 about here

There are highly significant main effects for SES with respect to all the dependent variables. The effects are weaker, however, with respect to the tests measuring spatial and reasoning ability. The pattern of results found for the SES variable thus closely parallels what has been found in numerous other studies: social class is more related to school achievement and to verbal ability than it is to non-verbal ability.

The main effects found for SIB tend to resemble those found for SES in that the strongest effects are found with respect to the test of verbal ability and with respect to the school achievement variables, with the exception of mathematics. With respect to the non-verbal variables no linear effect at all is found. This finding too parallels what has been found in some other studies.

The comparisons between the LIN and CURVE models indicated that there were curvilinearities present in the data, but not whether this was the case for one or both of the predictors. The tests of significance of the quadratic terms in the regression show that there tends to be curvilinearity with respect to both SES and SIB but also that the curvilinearity is more pronounced for SES, and that the two predictors tend to show curvilinearity for different dependent variables.

For SES a highly significant curvilinearity is found with respect to the verbally loaded dependent variables, and it will be recalled that strong linear relationships were also found between these and SES. The curvilinearity found on SES implies in this case that the regression is a positively accelerated function, i.e. for each level on the SES variable the regression is getting steeper.

For SIB the non-verbally loaded variables spatial ability, reasoning ability and mathematics achievement show curvilinearity along with English achievement. There is thus a clear tendency towards curvilinearity for those dependent variables for which no linear effect of SIB was found. The coefficient for the SIB² variable is throughout negative which here

implies that the highest scores are found for an intermediate number of siblings.

The interaction between SES and SIB is significant or nearly significant for most dependent variables, the only clear exception being Opposites. For the other variables effects of roughly the same size are found, and the coefficient for the cross-product term is throughout positive. Descriptively the interaction effect conforms to the pattern expected: The regression on SIB is more negative for lower levels of SES than it is for higher levels of SES.

Before going any further into analyses of complications found in the ANOVA analyses it may be worthwhile to summarize the results:

- The effects of SES are strongest with respect to verbal ability and the school achievement variables and for all the verbally loaded variables there are curvilinearities which imply that the effects of SES are stronger than can be captured in a linear regression.
- The SIB variable is linearly, and negatively, related to the verbally loaded variables and curvilinearly related to the non-verbal variables in such a way that the highest scores on these dependent variables are obtained for the intermediate levels of SIB.
- For most of the dependent variables there is a weak interaction between SES and SIB such that the regression on SIB within lower levels of SES is more negative than within higher levels of SES.

It will be recalled that ANOVA for verbal ability, writing, English, and mathematics accounted for significantly more variance than did the CURVE model. In order to get a more clear picture of the differences between the models the differences between predicted scores under the CURVE model and the cell means are, for the writing variable, presented in Table 6. Most of the large residuals are found for the two highest levels of SES, and the reason for this is that at those levels the cell means exhibit a rather irregular pattern which the CURVE model is not able to represent. The highest observed mean on writing is for the highest level on SES found with a sibsize of 3, for a sibsize of 4 there is a drop in the mean, and then at the highest level on SIB an increase. For level 4 on SES the highest means are found for sibsizes 1 and 4.

Insert Table 6 about here

Even though the ANOVA model through taking into account such irregularities accounts for more variance than the CURVE model it appears quite difficult to see any meaningful pattern in them.

For the other two verbally loaded variables for which ANOVA was found to account for more variance a very similar pattern of differences as for writing was found. One should hesitate, however, to take this fact as an indication that the irregularities are interpretable since all these variables are highly intercorrelated.

In conclusion the analysis of the differences between the ANOVA and CURVE models has shown that even though ANOVA in some cases is able to identify more complicated effects these are in this case so complex as being uninterpretable.

It will be recalled that a significant three-way interaction was found in ANOVA between SES, SIB and SEX with respect to spatial ability. Descriptively the following pattern of results was found: For the highest levels of SES there were for sibsizes 1, 2 and 3 particularly large differences in favor of the boys while at the same time for the highest level on SIB there were no consistent differences in favor of the boys. This finding appears quite regular and it will be taken up to closer scrutiny in the discussion.

Before doing so, however, the results for the two variables related to higher education will be presented. Since these variables are dichotomous they do not fulfill the scale assumptions underlying the methods of analysis being compared and they have therefore been left aside. Even though methods are beginning to evolve for the analysis of dichotomous dependent variables, we will here just treat the results for the two higher education variables descriptively.

The proportions of the sample entering into higher education are for each of the combinations of levels on SES and SIB shown in Table 7. Also given is the conditional proportion, given entry to higher education, who have taken an exam before 1975. For the three lowest levels on SES there is a continuous drop in the probability of entering higher education as a function of sibsize. This is not the case for the two highest levels on SES; for level 4 the highest proportions are observed for the smallest and largest sibsizes, and for the highest social class the highest proportion is observed for a sibsize of 4. There is thus for this variable an interaction between SES and SIB of the same type as was observed for the other dependent variables, even though it appears to be stronger.

Insert Table 7 about here

For the exam variable even more drastic effects are observed. For the lower levels of SES the conditional probability of taking an exam is negatively related to sibsize; for the higher levels, and particularly for level 4, it is positively related to sibsize.

4 DISCUSSIONS AND CONCLUSIONS

The purposes of the present study are to investigate whether there is an interaction between social class and family size with respect to intellectual achievement, and to investigate techniques for studying such interactions. It may be concluded that for most outcomes studied there is an interaction, and it may also be concluded that it matters profoundly which technique is chosen to investigate interactions. These results, and others, are discussed below, and we will start with some comments related to the technical questions.

The importance of the question of choice of analytical technique is illustrated by the fact that with respect to the ability tests the different models resulted in different conclusions: under ANOVA no interaction was found between social class and sibsize, but the regression analyses afforded the conclusion that there is an interaction with respect to non-verbal ability. The reason for this divergence of results is that for these outcomes the CURVE model explained as much variance as ANOVA did, but since ANOVA consumes more degrees of freedom power is lower in this type of analysis.

It was also argued that ANOVA may be used as a technique to determine whether a regression model includes enough terms to account for the effects in the data. In some cases it was found that ANOVA accounted for significantly more variance than did the CURVE model, and in those cases the p-value for the interaction under ANOVA tended to achieve the same level as the p-value for interaction in the MR-models. Thus, support was also obtained for the conjecture that when a model is too constrained to represent the effects in the data, a more elaborate model may provide greater power. However, the conclusion also had to be drawn that even though these more complicated effects were significant, they were so complex as to be uninterpretable.

The interpretation of results will, therefore, be based on the results obtained under the CURVE model, which in all cases proved to be a better model than the LIN model. In the discussion effects associated with each independent will first be taken up, and then the interaction effects will be scrutinized.

With respect to social class strong main effects were found, which effects were stronger with respect to school achievement and verbal ability, than with respect to non-verbal ability. These results fit into a firmly

established pattern of findings. However, it was also found that especially for the verbally loaded outcomes (verbal ability, reading, writing, and English) there was a curvilinear component to the regression, such that the regression function was a positively accelerated curve. This thus implies that the effect of social class was stronger than can be captured by a linear regression, and that higher social classes tended to have even more of an advantage than would be revealed by a simple linear analysis.

One partial explanation for this finding may be the fact that the social class variable used here reflects both educational level and occupational status. The three lowest levels are, roughly, at the same educational level, while the two highest levels on the social class variable reflect increasing educational levels. Since the parents' level of attained education is likely to be a stronger determiner of the childrens' verbal achievements than occupation, this may account for the curvilinearities found. Whether this explanation is true or not, it is recommended that in further research not only linear regressions of intellectual achievement on social class are considered, but also curvilinear regressions.

The sibsize variable was found to be linearly, and negatively, related to the verbally loaded outcome variables. This result conforms to what has been found in numerous other studies, and of course also to what would be predicted from the confluence model. However, no linear effect of sibsize was associated with the non-verbal tests of ability or with mathematics achievement. With respect to these outcomes curvilinear effects of sibsize were instead found, such that the highest scores were obtained for an intermediate number of siblings, and lower scores for few and many siblings.

One way these findings can be reconciled with the confluence model is to invoke the special handicap hypothesized by Zajonc and Markus (1975) to fall upon the last born and the single child. It will be remembered that they had to include in the model a parameter to represent the case when a child is deprived of the possibility to act as a "teacher" for younger siblings. If it is assumed that the beneficial effects of such teaching is greater with respect to non-verbal than with respect to verbal ability, this could explain the curvilinear relation. Such an assumption may not be too far-fetched: It does seem more likely that a child teaches a younger sibling manipulatory skills than vocabulary, while the greater amount of parental attention that can be afforded a single child is likely to affect above all vocabulary. It can also be noted that the empirical results which forced Zajonc and Markus to modify the confluence model came from a study using the non-verbal Raven test as an index of intellectual level.

If this interpretation is correct it does support the modified confluence model, but it also carries the implication that different "teaching" parameters have to be assumed for different areas of intellectual achievement.

With respect to all outcome variables, except for the test of verbal ability, the hypothesized interaction between social class and family size was found. The fact that no interaction was found with respect to the vocabulary test was above all due to the fact that the effects were more complicated than could be captured with the CURVE model, and should, therefore, not be given too much weight.

With respect to all outcomes the interaction was such that in higher social classes sibsize had a smaller negative effect than in lower social classes. The interactions were quite weak and even in this quite large sample the test statistics reached just beyond the critical values. However, the regularity of the findings, and the fact that the results conform to what has been found in several other studies makes it worthwhile to discuss implications for the confluence model of the interactions.

Page and Grandon (1979) rejected, on the basis of findings similar to those reported here, the confluence model altogether. They argued instead in favor of an "admixture" theory to account for the family size and birth order effects. The admixture theory implies that the family size findings are accounted for in terms of between-family differences rather than as within-family effects; in particular Page and Gordon argued that different distributions of family sizes over social classes make social class differences appear as family size effects.

However, the admixture theory does not seem to be able to account for the findings in the present study. For one thing there are no important differences in the distribution of family sizes over social classes in the present data (see Table 2); for another the admixture theory fails to account for the negative correlation between number of siblings and intellectual level within lower social classes. Instead of rejecting the confluence model in its entirety it may, therefore, be better to discuss limits to the applicability of the model.

One hypothesis to account for the lack of adverse effects of family size in higher social classes may be that the intellectual environment is stimulating enough to overcome the decrement in intellectual stimulation caused by a large number of siblings. But this explanation implies an assumption that once the intellectual stimulation has reached a certain level, an increase beyond this level does not have any effect on cognitive growth. However, it seems unlikely that even the best currently existing environment could not be improved, so this hypothesis does not seem tenable.

Another possibility may be that the confluence model with a different degree of accuracy mirrors the socialization practices in different social classes. Only processes within the family context are, of course, represented in the model, and to the extent that intellectual growth receives impetus from other contexts the explanatory power of the model is reduced.

It could be that parents in higher social classes spend more time with the family, thereby compensating to some degree for the diluted intellectual environment caused by the children. However, this hypothesis has little foundation in empirical results. Andersson (1979), for example, found that during weekdays the amount of interaction between parents and children tends to be lower in higher than in lower social classes.

Another, and perhaps more likely explanation, is that the amount and quality of interaction with other adults differs between social classes. Other persons, such as nurse-maids, piano-teachers and private tutors, just to mention a few examples, can be hired and it is very reasonable to assume that the larger the family, the larger is the difference in favor of higher social classes when it comes to the possibility of using such extra persons in the socialization of the children. Furthermore, it is well known that school plays a more important part in higher social classes than in lower social classes: Well educated parents take a greater interest in their childrens' school work, have higher expectations on performance, and provide more control over school-work (e.g. Andersson, 1979). While in a large family the amount of direct help that can be given each child is likely to be lower than in a small family, the same expectations on achievement can be upheld for every child. School may, therefore, be of greater relative importance for cognitive growth for the children in a large family in higher social classes than for the children in a large family in lower social classes.

The explanation which is suggested here for the lower explanatory power of the confluence model in higher social classes is thus that other adults and other socializing agencies such as the school are more important relative to the family than in lower social classes, thereby to some extent offsetting the effects of the mutual intellectual influences in the family context. This explanation is, of course, highly tentative, but it should be possible to subject it to empirical tests.

It will be remembered that with respect to the variables reflecting entry into and graduation from higher education there were in higher social classes a tendency towards a positive relationship with sibsize, while in lower social classes there was a strong negative relationship with sibsize. While the general pattern of these results conforms with what was found for the other outcomes, it can be noted that such a positive relationship is inconsistent with the confluence model.

One mechanism which could account for the tendency towards a positive relationship between sibsize and the probability of graduating from higher education is that older siblings may set examples for younger siblings, and may be able to provide much concrete information concerning the process of higher education. Thus, if an older sibling goes into higher education this may cause an increase of the probability for the younger siblings to graduate as well.

Such a mechanism of propagation of probabilities may never come into operation in lower social classes because scarceness of economic resources make it impossible for a large family of lower social classes to support higher education for more than one or two of the children. Since the "economic environment" should follow much the same confluence pattern as the intellectual environment, the effects of limited economic resources should work in addition to the effects predicted from the confluence model, thereby strengthening the negative effects, in this particular respect, of being born into a large family.

It would seem, therefore, that the results obtained with respect to the higher education variables are only partly predictable from the confluence model: To account for the full strength of the negative relationship between sibsize and higher education in lower social classes it is probably also necessary to invoke economic factors, and to account for the positive relationship found in higher social classes it is necessary to invoke a mechanism like the one suggested in terms of propagation of probabilities.

Only in one case was a higher-order interaction with sex found, and this lack of moderating relationships of the sex variable conforms to findings in other studies. The one exception was with respect to the outcome spatial ability, for which a three-way interaction was found. The interaction was mainly caused by there in the highest social class for the smaller sibsizes being a particularly large differences in favor of boys.

Härnqvist and Stahle (1977) found in an ecological analysis of test score changes over time that the sex difference on this test diminished as a function of equality of treatment of boys and girls in the educational system. Assuming that a large number of siblings reduces the effect of differential socialization practices, this might suggest a more sex-typed pattern of socialization in the highest social class. This conjecture is highly tentative, however, and for lack of suitable data it cannot be directly tested here.

Table 1. Drop-outs and cases remaining for analysis.

	Number	Per cent
Expected total	10413	100.0
Drop-outs I: Pupil data not available	1549	14.9
Drop-outs II: Background data not available	454	4.4
Drop-outs III: Not on record	122	1.2
Cases remaining for analysis	8288	79.6

Table 2. Joint distribution of the sample on the levels of the SES and SIB variables.

SIB	SES					Total
	1	2	3	4	5	
1	705	93	377	159	64	1398
2	1329	274	689	369	151	2812
3	1031	315	417	217	136	2116
4	510	194	194	77	51	1026
5	519	226	115	40	36	936
Total	4094	1102	1792	862	438	8288

Table 3. Multiple correlations and p-values for interaction between sibsize and social class under three different models of analysis.

Dependent variable	Multiple correlation			F-ratio		P-value		
	LIN	CURVE	ANOVA	CURVE ¹⁾ vs LIN	ANOVA ²⁾ vs CURVE	LIN	CURVE	ANOVA
Ability tests:								
Verbal	.282	.287	.301	11.81*	3.91*	.272	.400	.060
Spatial	.167	.173	.175	8.68*	.31	.006	.016	.405
Reasoning	.190	.194	.200	6.43*	1.03	.001	.002	.131
Achievement:								
Reading	.307	.312	.317	15.32*	1.55	.001	.003	.003
Writing	.246	.253	.278	15.87*	6.20*	.004	.012	.026
English	.292	.303	.321	30.69*	5.39*	.004	.016	.049
Mathe- matics	.248	.253	.268	10.65*	3.64*	.001	.004	.000

1 $F_{.99}(2,8280)=4.60$

2 $F_{.99}(19,8263)=1.90$

Table 4. F-ratios for tests of interaction with SEX under the CURVE and ANOVA models.

	CURVE						ANOVA		
	Overall	SEX X					SEX X		
		SES	SIB	SES ²	SIB ²	SESXSIB	SES	SIB	SESXSIB
Ability:									
Opposites	1.54	1.11	.44	1.05	1.25	.58	2.44	.58	1.23
Metal Folding	2.14	.18	2.85	.08	2.05	2.22	1.43	2.31	2.06*
Number series	.75	1.22	.25	2.36	1.32	.07	3.04	1.35	1.13
Achievement:									
Reading	.90	.16	1.36	.11	4.07	.28	3.13	2.51	1.13
Writing	.67	.53	.06	.64	2.49	.01	1.48	1.63	.95
Mathematics	.79	.29	.27	1.09	1.51	.05	1.16	3.23	.75
Critical values (1%)									
	3.02	6.64	6.64	6.64	6.64	6.64	3.32	3.32	1.87

Table 5. Standardized regression coefficients and tests of significance of the terms in the CURVE model

	SES		SIB		SES ²		SIB ²		SOCXSIB	
	b	F	b	F	b	F	b	F	b	F
	Ability:									
Opposites	.206	213.1*	-.106	84.5*	.064	21.1*	.017	2.1	.009	.7
Metal folding	.128	78.3*	-.017	2.1	.046	10.0	-.032	7.0*	.026	5.8
Number series	.167	134.1*	-.010	.7	.023	2.7	-.037	9.9*	.034	9.5*
Achievement:										
Reading	.227	263.2*	-.103	80.6*	.069	25.0*	-.027	5.4	.032	9.2*
Writing	.180	159.9*	-.057	24.3*	.074	27.0*	-.024	4.3	.027	6.4
Mathematics	.216	230.0*	-.027	5.3	.032	5.3*	-.046	15.5*	.031	8.2*
English	.202	207.4*	-.076	44.3*	.099	50.0*	-.038	10.9*	.026	5.8

Note: * indicates significance at the 1 per cent level (critical value: 6.64)

Table 6. Differences between predicted scores under the CURVE model and cell means for the writing achievement variable.

SIB	SES				
	1	2	3	4	5
1	.06	.11	-.14	-1.13	1.31
2	-.24	1.21	-.20	-.60	1.38
3	.34	-.48	.68	.29	-.97
4	-.71	-1.03	-.01	-1.63	1.56
5	-.01	1.13	.10	-1.16	-.98

Table 7. Proportions entering (ENT) into higher education within the levels on SES and SIB, and proportions there of having taken an exam (EX).

SIB	SES									
	1		2		3		4		5	
	ENT	EX	ENT	EX	ENT	EX	ENT	EX	ENT	EX
1	.16	.35	.18	.53	.28	.46	.55	.37	.63	.57
2	.14	.39	.16	.57	.29	.43	.48	.42	.59	.40
3	.12	.41	.17	.44	.24	.41	.49	.37	.68	.51
4	.10	.36	.15	.35	.21	.40	.42	.59	.73	.57
5	.06	.21	.08	.21	.16	.39	.53	.72	.56	.60

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