ABSTRACT
            An assessment of sex-related differences in
mathematics achievement and related attitude variables of 13-year-old
students from 20 different countries is presented in this study. The
analyses of student achievement were based on pretest and posttest
data from seven of the participating countries and a single-test
condition from the remaining 13 countries. Data were obtained from
items which addressed the areas of arithmetic, algebra, geometry,
measurement, and statistics. An extensive questionnaire, which also
contained five subscales, was used to measure student attitudes
toward mathematics. The subscales focused on: (1) mathematics as
process; (2) home support; (3) mathematics and society; (4)
mathematics and myself; and (5) gender stereotyping. The pattern of
achievement results indicated that girls were more successful than
boys in Belgium, Thailand, Finland and Hungary but least so in
France, Nigeria, Israel, and the Netherlands. With regard to attitude
measures, the largest differences between countries and sexes
occurred for the scale, gender stereotyping. Summaries are provided
in table and graph form. (ML)

# DIFFERENCES IN MATHEMATICAL ACHIEVEMENT LEVELS AND IN ATTITUDES

## FOR GIRLS AND BOYS IN TWENTY COUNTRIES

by

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Studies in Education

# DIFFERENCES IN MATHEMATICAL ACHIEVEMENT LEVELS

# FOR GIRLS AND BOYS IN TWENTY COUNTRIES

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The Second International Mathematics Study (SIMS), carried out in 20 countries, was an investigation into the relationship between teaching and student achievement. It sought detailed information from each of the participating countries on three interrelated aspects of mathematics teaching: the intended curriculum, the implemented curriculum and the attained curriculum.

This paper looks at the attained curriculum and assesses the scope of sex-related differences in the mathematics achievement and related attitude variables of Population A (the grade in which the modal student age lies between 13.0 and 13.11 years by the middle of the school year). This corresponds to the eighth grade in the United States and Canada.

Achievement data will be presented first, followed by those of the attitudes.

## A) MATHEMATICAL ACHIEVEMENT

In the past two decades researchers have shown considerable interest in the relationship between the gender and the mathematics achievement of children in the upper grades of the elementary schools. Some studies of sex-related differences have compared total test scores (Backman, 1972; Benbow & Stanley, 1980, 1983; Maccoby & Jacklin, 1974). Others have focused on the proportion of students who answered a particular item correctly, that is, on p-values (Armstrong, 1980; Fennema, 1978, Raphael, Wahlstrom, & McLean, 1984), or

on a comparison of the kind of errors made by male and female students (Marshall, 1983).

Studies to date purport to have established, on the one hand, that by age 13 there is a significant difference in mathematical ability between the sexes, and that it is especially pronounced among high-scoring exceptionally gifted students, with boys outnumbering girls 13 to 1 (Benbow & Stanley, 1983); and on the other hand, that very little difference exists, if any, and that when a difference is detected, it favours boys only slightly (Fennema & Carpenter, 1981). According to Schildkamp-Kuendiger (1982), reporting on research carried out in nine countries, sex-related differences in achievement were found to vary considerably both within and among countries.

THE DATA

The 20 countries participating in the study formed two groups. The first group consisted of the 7 countries that took part in the longitudinal version (pretest and posttest), while the second consisted of the 13 countries that took part in the cross-sectional version (tested once only).

The present analyses are based on both the cross-sectional and the longitudinal data. In the cross-sectional part of the study, there were 176 items; 40 items in the Core test and 34 items in each of four Rotated forms, while in the longitudinal part, there were 180 items; 40 in the Core test and 35 items in each of four Rotated forms. There were 157 items common to the two parts, so the total number of items in the present analysis is 199 (180 + 176 - 157). The results for the 157 common items are based upon 20 countries. Of the remaining 42 items, the results for 23 are based on the 7 countries in the longitudinal part of the study, while

those for the remaining 19 items are based on the 13 countries
in the cross-sectional part.

These items were distributed over 5 major content areas,
or subtests, as follows:

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INSERT TABLE 1 HERE
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This paper reports the results of the five subtests,
each of which was analyzed separately. Each subtest comprises
items from both the Core form and one of the Rotated forms.
Since each student responded to the Core form and to one of the
Rotated forms A,B,C, or D, responses to items on the Core
form are from the total sample of students, while responses
to items on any of the Rotated forms are from only one
quarter of the total sample. An item on the Core form thus
yields a greater precision of results, since it has about four
times as many respondents as one on a Rotated form.

PROCEDURE AND RESULTS

Every response to an item was coded into one of three
categories: correct, wrong, or item omitted. Within each
country the achievement results were obtained as follows:
for each item three percent values (p-values) (correct, wrong
and omitted) were calculated separately for boys and for
girls, with the student as the unit of analysis. Three mean
percent values were then obtained for each sex separately
and for each country by averaging the percent values for
the individual items in that country. Finally, the mean
percent values for subtest, country and sex were averaged
to yield an overall (for all the countries) average mean
percent value for each sex for each of the subtests, with
the item as the unit of analysis.

1. OVERALL DIFFERENCES BETWEEN BOYS AND GIRLS BY SUBTEST

1.1. Boxplots Displays

The boxplots in Figure 1 display the distribution of the differences in percentage of correct answers for all the countries taken together. The major results are the following:

1. The mean difference between girls and boys (defined as girls minus boys) in the Arithmetic subtest (62 items) was zero. The distribution of the differences is shown in the boxplot: the median difference is zero, the range is -9 to 8, and the distribution is more or less uniform across that range.

2. For the Algebra subtest, the mean success rate was slightly higher for girls; the mean difference was 0.5. The boxplot displaying the differences for the 42 items reveals that for 41 items the differences ranged from -3 to +4 with a median of +1, while one item was an outlier with a difference of -7.

3. In Geometry the picture is slightly different: the boys' success rates were higher than the girls' by a mean percent value of 1.7. (As the boxplot shows, there was a difference of 21 percentage points on one of 51 items in that subtest). The girls' performance was higher on one quarter of the items.

4. On the 18-item Statistics subtest girls did slightly better than boys, their mean percent value being 0.4 higher than that of the boys. The boxplot shows that the differences between the sexes ranged from -4 to +3 percentage points.

5. Boys did better than girls on the Measurement sub-

test.  For 26 items the mean was higher for boys
by 1.4.  The differences ranged from -9 to +5.
The boys' performance was higher on about 70%
of the items.

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BOXPLOT OF SUBTESTS HERE

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1.2  Overall Differences by Subtest and Item Difficulty

To display the differences between boys and girls as
a function of item difficulty, the data were also plotted
in 'flat' plots, in which the Y-axis represents  the difference
in p-values (Girls-Boys) for all the countries taken together,
and the X-axis the average in p-values ((Girls + Boys)/2).
Thus the differences in p-values were plotted against the
total proportion of correct answers - which is, in effect,
the index of item difficulty.  Each * in the plot represents
one item.

A number of points illustrated by these plots may be of
interest:

(a)  It is evident from the Arithmetic plot that differ-
ences between boys and girls tended to be in the boys' favour
for the more difficult items (index of difficulty up to 35%),
and in the girls' favour for the less difficult ones (index
above 65%).  The plot of the differences between the genders
for items in the middle range of difficulty (35 to 65%)
reveals no relationship between the values of X and Y.

(b)  In Algebra, the only item that showed a difference
exceeding 5% is in the 45% level of difficulty.  The
differences in the girls' favour are spread over the entire
range of item difficulty, as are those in the boys' favour.

(c)  The plot for the Geometry subtest indicates that
boys did better than girls on the majority of the items over
the entire range of difficulty; when results were better for

girls, they were also spread out over the entire range.  The item on which boys were considerably more successful than girls was not the most difficult;  its average rate of success was 59%.

(d) Girls tended to do better than boys on the easier items in the Statistics subtest.  The range of difficulty for the items on which the boys were more successful was from 22 to 60, while girls were more successful on items in the difficulty range from 45 to 85.

(e)  In measurement there is a clear pattern of greater success rate for boys on the more difficult items.  Boys  did better than girls on all the items in difficulty range from 18 to 45.  For the items in the difficulty rate of 46 or more, there is no clear pattern in the distribution of p-values.

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INSERT PLOTS HERE
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2.   SEX DIFFERENCES WITHIN AND BETWEEN COUNTRIES
2.1.  Paired t tests Analyses

For each subtest and each country the mean percent correct responses for girls was compared to that for boys, using the paired t test with the item as the unit of analysis. Statistical significance at the .01 level in that contest means:  if these items were a random sample from a large set of items, then the average difference between the sexes for that set of items is (or is not) zero.

The statistically significanty differences are presented in Table 2-1.  A positive difference in mean percent correct represents a high mean percent for girls, a negative difference, a higher mean for boys; a dash (-) indicates that the difference was not statistically significant.

As Ta le 2 shows, most of the differences did not reach statistical significance at the 1% level.  Moreover, the differences that did reach statistical significance were not large, ranging from     +5 to -7.  Looking at each sub-

test separately it appears that for two of the five topics,
Measurement and Geometry, the significant differences
occurred consistently in the boys' favour:  in 7 of the 20
countries boys had higher p-values and in 10 countries boys
had higher p-values in Measurement and Geometry respectively.

The pattern of results for countries indicates that in
relation to boys, girls were more successful in Belgium (fl),
Thailand, Belgium (fr), Finland and Hungary, and less  so in
France, Nigeria, Israel and the Netherlands.

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INSERT TABLE 2-1 HERE
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## 2.2.  Multivariate Analysis of Variance

Since the same items were administered to all countries
the data represent repeated measures of each item, and are
certainly not independent or uncorrelated measures, making
the assumptions of univariate analysis of variance unrealistic.
The advantage of using a multivariate model of analysis of
variance is that it allows the country and sex results to be
intercorrelated or to display different variances, without
invalidating the F-statistic.

The results of the tests of significance for the common
items in each of the subtests are listed in Table 2-2.

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INSERT TABLE 2-2 HERE
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The sex effect exceeds the critical F value at the .01
level for two of the five subtests:  Measurement and Geometry.
There are no significant differences among sex groups in mean
percent correct for Algebra, Arithmetic, and Statistics.

The F statistics for country differences are all signi-
ficant, that is, for every one of the subtests there are

differences among country means.

The multivariate test of the country-by-sex interaction is a test of equality of sex differences across countries. It is significant for all five subtests, and thus indicates that any sex differences that might exist are not consistent across countries.

2.3. Patterns in Two-Way Coded Tables

To describe overall patterns in the data and highlight individual extraordinary data values, the table of differences, between boys and girls, in correct responses by country and by item was reproduced in coded form. In the coded table the actual differences were replaced by one-character codes as follows:

| Girls better than boys | | Boys better than girls | |
|---|---|---|---|
| Data | Code | Data | Code |
| 10 to 14 | : | 10 to 14 | - |
| 15 to 19 | # | 15 to 19 | = |
| 20 and above | > | 20 and above | < |

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CODED TABLES HERE

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The coded table for the Arithmetic subtest shows that sex alone is not a good predictor of relative success in Arithmetic. Differences of 10 or more percentage points are present in either the girls' or the boys' favour depending on the country. Very few items show consistent differences across countries. On the other hand, country differences show a strong pattern of consistent positive or negative differences. The columns of data for Belgium (fl) and Finland indicate that girls outperform boys by 10% or more on

a large number of items; the situation is reversed for France, Israel, Luxembourg, and the Netherlands.

The other four coded tables reveal the same inconsistent pattern of differences in items, except for item #159 in Geometry where in all the countries but England, the boys did much better than girls.

B) ATTITUDES TOWARDS MATHEMATICS

Within the research area "Women and Mathematics", attitudes towards mathematics have been looked at from different points of view:

I) Attitudes have been treated as characteristics of the students which can explain mathematical achievement, at least up to a certain degree. If sex-related achievement differences do occur in a study, different aspects of the global concept "attitudes" are then locked for, either as supposed causes of the achievement differences or as correlates with achievement differences.

If no sex-related achievement differences occur, it is of interest whether or not the relationship between attitudes and achievement is the same for both sexes.

The study of Boswall (1985) is an example of the latter type where no overall achievement differences are found. With regard to attitudes towards mathematics the results are typical. In the case of some attitudinal aspects there are significant differences between male and female students responses and in the case of others there are not. Moreover, dissimilarities between the sexes have been found relative to the relationship between these attitudinal aspects and achievement.

II) Other studies have focused on the development of different aspects of math-related attitudes. How these aspects have been influenced by past events and also their impact on future achievement and course-taking behaviour have been investigated. The development process is often looked upon

as being influenced by the perceptions significant others hold
about mathematics and/or the students' success and failure
experiences in mathematics. Relatively consistently, male and
female students differ with regard to their attribution of
good and poor math achievement and their self-confidence in
doing mathematics. Sex-related differences seem to occur
even when there are no achievement differences (Eccles-Parsons
et al. 1982, Hansen & O'Leary 1985, Kuendiger 1985).

Overall, research demonstrates that learning about math-
ematics leads to sex-related differences for certain attitudinal
aspects on the students' side. Moreover, the relationship
between attitudes and achievement varies according to the sex
of the student.

THE DATA

An extensive questionnaire about different aspects of
math related attitudes has been answered by students included
in the SIMS. They indicated their opinion on 5-point-scales,
reaching from strongly disagree to strongly agree.
Results of the following attitude scales are presented:

(a) Mathematics as a Process (15 items).
   The extreme positions are characterized by:
   mathematics is a science which is not going
   to change in the future, (low score); and
   mathematics is a developing science, open
   to changes (high score).
(b) Home Support (9 items).
   This scale evaluates the extent to which
   students perceive their parents as supportive
   in learning mathematics.
(c) Mathematics and Society (8 items).
   These items have been designed to evaluate students'

perception about the practical value of mathematics, or its utility.

(d) Mathematics and Myself (14 items)

The items focus on feelings involved in success and failure experiences as well as on intended effort to keep on with mathematics. The positive extreme position (high score) can be characterized by: feeling good about succeeding in mathematics and by intending to engage oneself further in the subject.

(e) Gender Stererotyping (4 items)

(1) Boys have more natural ability in mathematics than girls.

(2) Boys need to know more mathematics than girls.

(3) Men make better scientists and engineers than women.

(4) A woman needs a career just as much as a man does.

The items are coded so that a high score means: women are as able as men in mathematics, and as engineers. Women need math, and a career, as much as men do.

Results for the following countries will be presented; the code numbers listed are those used when results are displayed:

Belgium (fr) (16)               Luxembourg (59)
Canada, British Columbia (22)   Netherlands (62)
Canada, Ontario (25)            New Zealand (63)
Finland (39)                    Nigeria (64)
France (40)                     Scotland (72)
Hong Kong (43)                  Swaziland (75)
Hungary (44)                    Sweden (76)
Israel (50)                     Thailand (79)
Japan (54)                      U.S.A. (81)

Apart from Belgium (fl) (15) and England (37), these are the same countries for which achievement results were reported earlier in this paper. Belgium (fl) is excluded here as for most of the questionnaires the information about the sex of the students is not available. England (37) will be included, as soon as confirmed results are available.
Moreover, it should be noted that for Canada, Ontario (16), the results for 3 out of 8 items in the scale "Mathematics and Society" are not available. For Scotland (72) the results for 2 out of 9 items in the scale "Home Support" are not available.

PROCEDURES AND RESULTS

Students' attitudes are looked upon as outcomes of their learning about mathematics. The following questions will be approached:

- Are these attitudinal learning outcomes mostly the same for boys and girls in a country?
- If not, is there some kind of pattern in the differences between countries?

Up to now only descriptive information is available to answer these questions.

An initial impression of the variety of results was obtained by calculating arithmetic means and standard deviations for each subscale and each set to characterize the distribution in each country.

A more detailed insight will be gained by comparing the percentages of extreme responses of girls with those of boys on the items level. At the moment these results are available only for the subscale "Gender Stereotyping".

For Graph B1 to B5 arithmetic means for the 5 subscales are displayed by countries. The arithmetic means of girls $\overline{x}_{\female}$ are plotted against the difference of means of girls and boys $\overline{x}_{\female} - \overline{x}_{\male}$.

If necessary the items have been inverted, so that a

higher mean indicates a more favourable attitude.

1) Subscale: "Mathematics as Process"

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INSERT GRAPH B 1

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The results are mostly the same for all countries and both sexes:

- all arithmetic means for girls are included in the interval: $2.9 < \bar{X}_\varphi < 3.3$
- all mean differences between the sexes are included in the interval: $-0.04 < \bar{X}_\varphi - \bar{X}_\sigma < 0.07$
- all standard deviations lie in the interval: $0.22 < s < 0.36$

For this scale the most outstanding feature is the consistency of responses with regard to both the sexes and the countries.

2) Subscales: "Home Support"; "Mathematics and Society"; and "Mathematics and Myself"

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INSERT GRAPH B 2, 3, and 4

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Results for these three scales are quite similar. The arithmetic means of girls vary more strongly than for the scale "Math as a Process". The intervals are:

| | |
|---|---|
| "Home Support" | $1.9 < \bar{X}_\varphi < 3.0$ |
| "Mathematics and Society" | $2.9 \leqslant \bar{X}_\varphi \leqslant 3.9$ |
| "Mathematics and Myself" | $3.0 \leqslant \bar{X}_\varphi \leqslant 4.0$ |

For all three scales most of the differences are located in
the interval: $-0.15 \leqslant \overline{X}_\circ - \overline{X}_{\circ\!\!\!\nearrow} \leqslant 0.15$.
Exceptions are:

a) for the scale: "Home Support"
the Netherlands (62) with girls perceiving more support,
and Thailand (79) with girls perceiving less support by
their parents compared to boys;

b) for the scale: "Mathematics and Society"
the Netherlands (62), Luxembourg (59) and France (40),
with girls evaluating the practical value of mathematics,
or its utility, comparatively lower;

c) for the scale: "Mathematics and Myself"
the Netherlands (62) with girls having a more negative
view. Nigeria (64) lies with $\overline{X}_\circ - \overline{X}_{\circ\!\!\!\nearrow} = -0.16$ just
outside the borders.

Standard deviations vary in similar ways for all three scales:
$0.44 \leqslant s \leqslant 0.75$, indicating a higher variety between countries
as well as between sexes when compared to the scale "Math as
a Process".

3) <u>Subscale: "Gender Stereotyping"</u>

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INSERT GRAPH B 5

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Results of this scale demonstrate the highest differences
among countries and between sexes so far.
Girls' mean responses range between $2.7 < \overline{X}_\circ < 4.5$,
mean sex differences between $-0.5 < \overline{X}_\circ - \overline{X}_{\circ\!\!\!\nearrow} < 1.0$,
and standard deviations between $0.6 < s < 1.0$.

The countries with outlying results are:
- Swaziland (75) where the girls have the least favourable attitude, even lower than that of the boys;
-  Japan (54) and Nigeria (64); for these two countries the girls; means are relatively  low too, with Japan showing comparatively low sex differences and Nigeria comparatively high sex differences in favour of girls.

For further insight, results of each of the 4 items are displayed separately.  It should be noted that 3 of the 4 items are phrased negatively; for these items girls' percentages of the categories 'disagree' and 'strongly disagree' are plotted against the sex differences of these percentages.  For the positively phrased item the corresponding results of the categories 'agree' and 'strongly agree' are plotted.

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INSERT GRAPH B6 to 9
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In all graphs the line indicating extreme responses of 50% of the boys has been entered.  For the two items referring directly to mathematics, there is quite a variation with regard to  extreme boys' responses.  For the item, "Men make better scientists and engineers than girls", less than 50% for all countries except Swaziland (75).  For the item, "A woman needs a career just as much as a man does", the opposite is mostly true.  In all countries besides Swaziland (75) and Japan (59), more than 50% of the boys agree or strongly agree, although the responses of the girls are more extreme.

D)  SUMMARY
     The pattern of achievement results indicates that in relation to boys, girls were more successful in Belgium (fl), Thailand, Belgium (fr), Finland and Hungary, and least so in France, Nigeria, Israel and the Netherlands.  None of these

differences exceeded 7%.

With regard to the attitude scales considered here, the largest differences between countries and sexes occurred for the scale "Gender Stereotyping".

Looking at the attitudinal results under the perspective of sex-related achievement differences, the question arises whether there is a relationship between these two learning outcomes.

The attitudes scales reveal the following:

a)  in countries where the achievement results favour boys, boys also have more positive attitudes with regard to the subscales "Mathematics and Myself" and "Mathematics and Society";

b)  in countries where the achievement results favour girls, the mean results for girls are more positive than or equal to those of the boys with regard to the same subscales.

But the mean scale differences are only small.  It will be investigated if this pattern becomes more obvious on the item level.

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**Table 1:** Number of items in each subtest

| | Number of Items | | |
| --- | --- | --- | --- |
| Subtest | Longitudinal | Cross-Sectional | Common |
| Arithmetic | 62 | 46 | 46 |
| Algebra | 32 | 40 | 29 |
| Geometry | 42 | 48 | 40 |
| Measurement | 26 | 24 | 24 |
| Statistics | 18 | 18 | 18 |
| Total | 180 | 176 | 157 |

```
MTB > boxp c2 c1

                                   --------
         0                 ---------I   +  I------
                                   --------


                                    -----
         1                 *       ---I + I----
                                    -----


                                  -------
         2 0               ----I     +I----------
                                  -------


                                  -------
         3                 ---I  +  I-
                                  -------


                                  --------
         4                 -------I +    I-----
                                  --------


              -+----------+----------+----------+--------

ONE HORIZONTAL SPACE = 0.70E+00
FIRST TICK AT    -21.000
MTB > stop
```

ITEMS BY FEMALE-MALE PERCENT CORRECT AND ITEM DIFFICULTY
BY SUBTEST:   POPULATION 4

SUBTEST=ARITHMETIC

PLOT OF FM*TOTAL      SYMBOL USED IS •
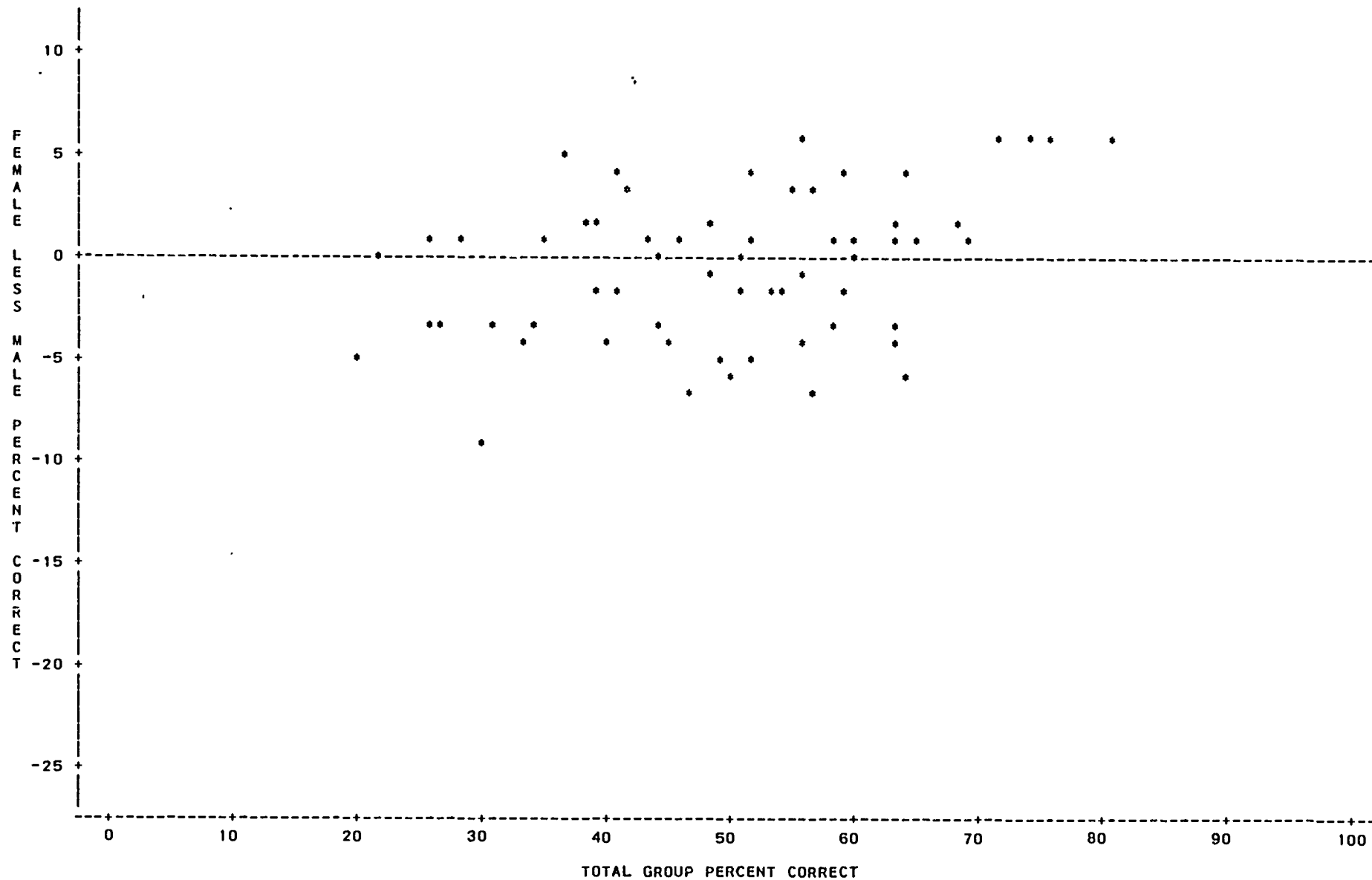


TOTAL GROUP PERCENT CORRECT

NOTE:        1 OBS HIDDEN

23                                                                    24

ITEMS BY FEMALE-MALE PERCENT CORRECT AND ITEM DIFFICULTY
BY SUBTEST: POPULATION A

SUBTEST=ALGEBRA

PLOT OF FM*TOTAL      SYMBOL USED IS *

```
                                                                          2
F  E  M  A  L  E     L  E  S  S     M  A  L  E     P  E  R  C  E  N  T     C  O  R  R  E  C  T

   10 +
                                         *
    5 +
                                                          *
                                                          *
                                                   *      *
              *  *          *      *   **       *    *    *   *       *    *
    0 +- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                        *           *  *       *   *    *           *
                    *           **      * *     *  *    *
        *                    *
                          *       *                                    *
   -5 +
                                  *
  -10 +
  -15 +
  -20 +
  -25 +
        +------+------+------+------+------+------+------+------+------+------+--
        0     10     20     30     40     50     60     70     80     90    100
                            TOTAL GROUP PERCENT CORRECT
```

NOTE:      5 OBS HIDDEN

2b
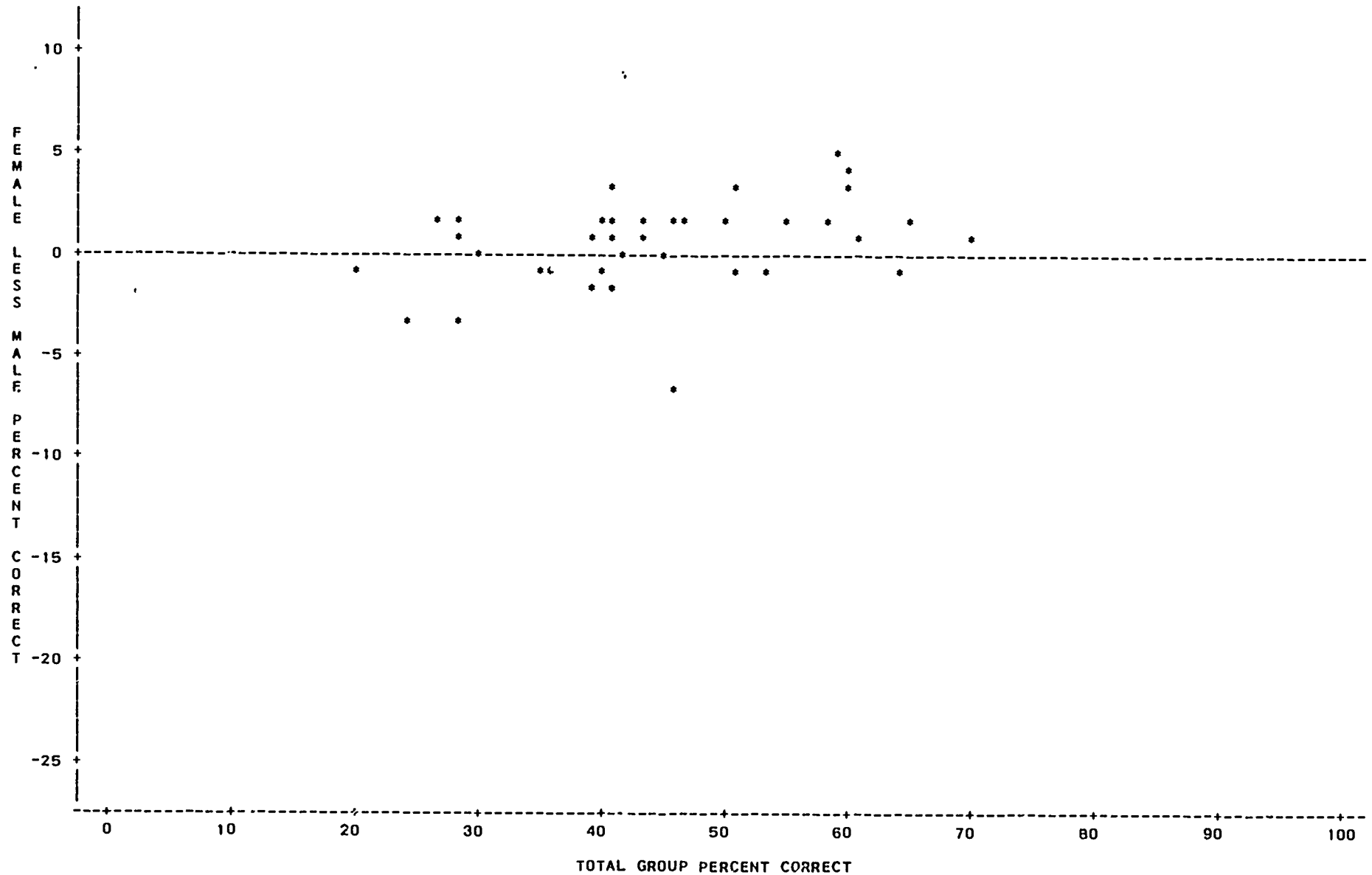
25

ITEMS BY FEMALE-MALE PERCENT CORRECT AND ITEM DIFFICULTY
BY SUBTEST:  POPULATION A

SUBTEST=GEOMETRY

PLOT OF FM*TOTAL    SYMBOL USED IS *
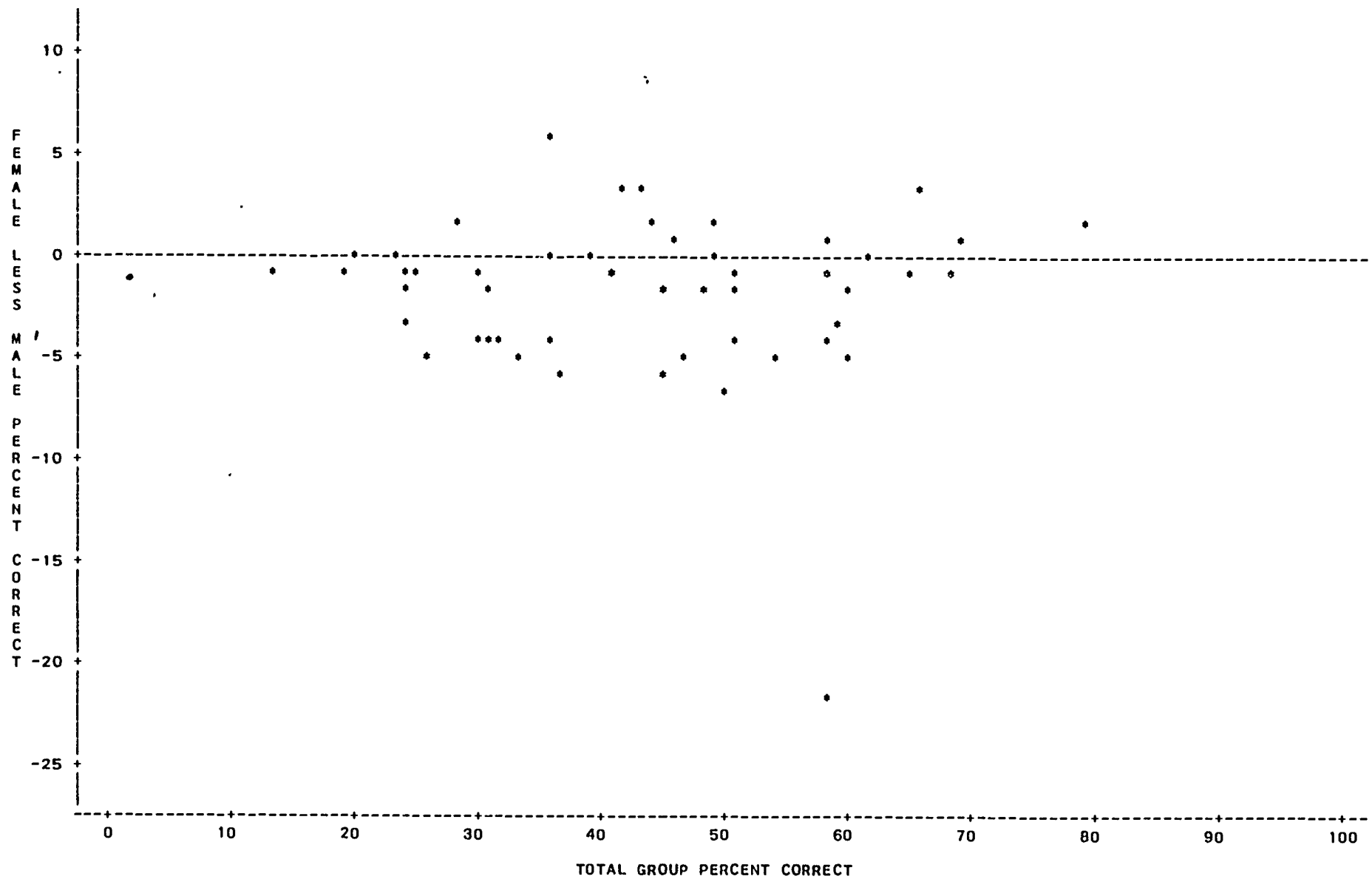


TOTAL GROUP PERCENT CORRECT

NOTE:      1 OBS HIDDEN

28

27

ITEMS BY FEMALE-MALE PERCENT CORRECT AND ITEM OIFFICULTY
BY SUBTEST:   POPULATION A

SUBTEST=PROBABILITY & STATISTICS

PLOT OF FM*TOTAL     SYMBOL USEO IS *
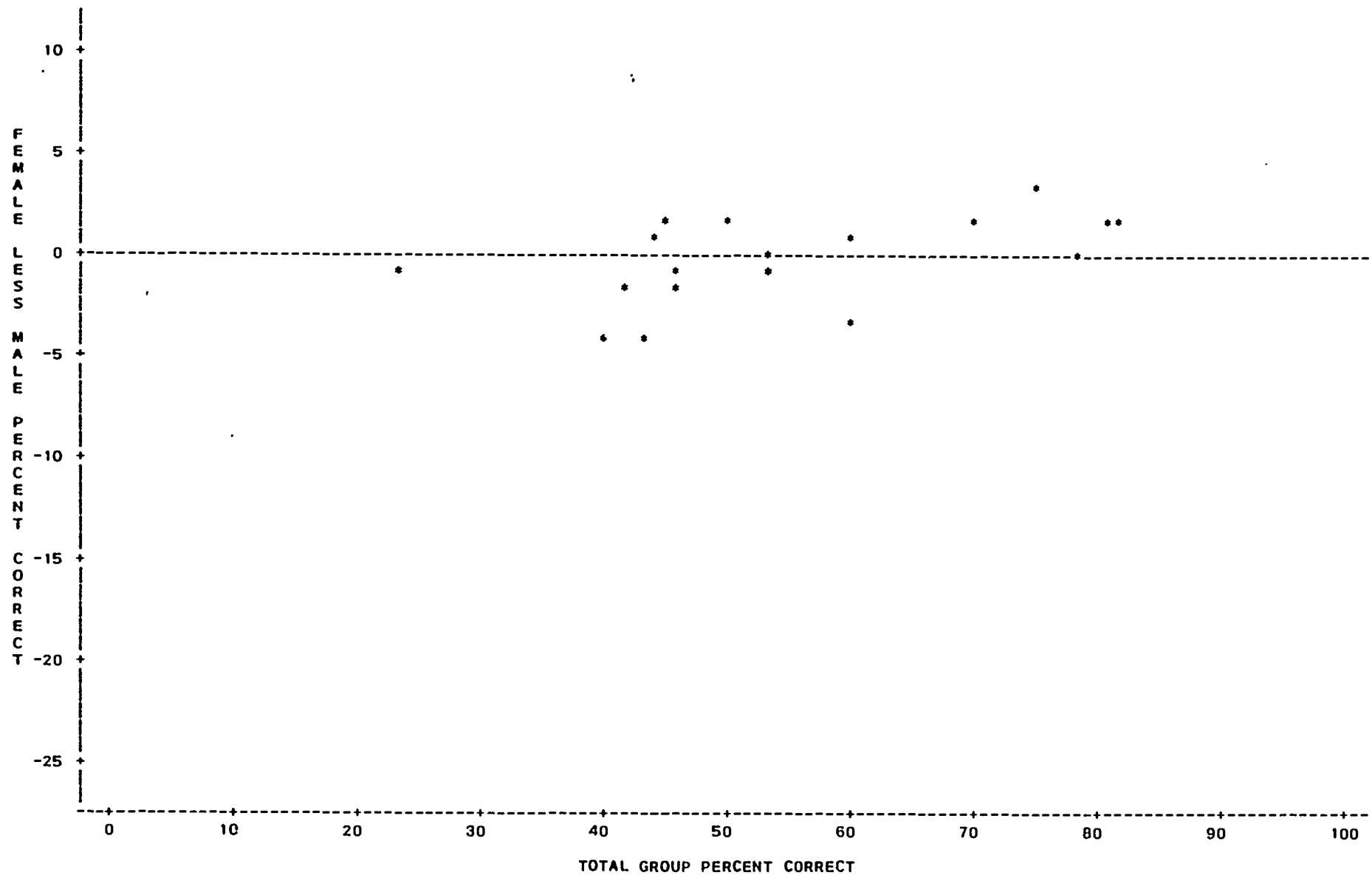


TOTAL GROUP PERCENT CORRECT

29

30

ITEMS BY FEMALE-MALE PERCENT CORRECT AND ITEM DIFFICULTY
BY SUBTEST: POPULATION A

SUBTEST=MEASUREMENT

PLOT OF FM*TOTAL     SYMBOL USED IS *



TOTAL GROUP PERCENT CORRECT

31

32
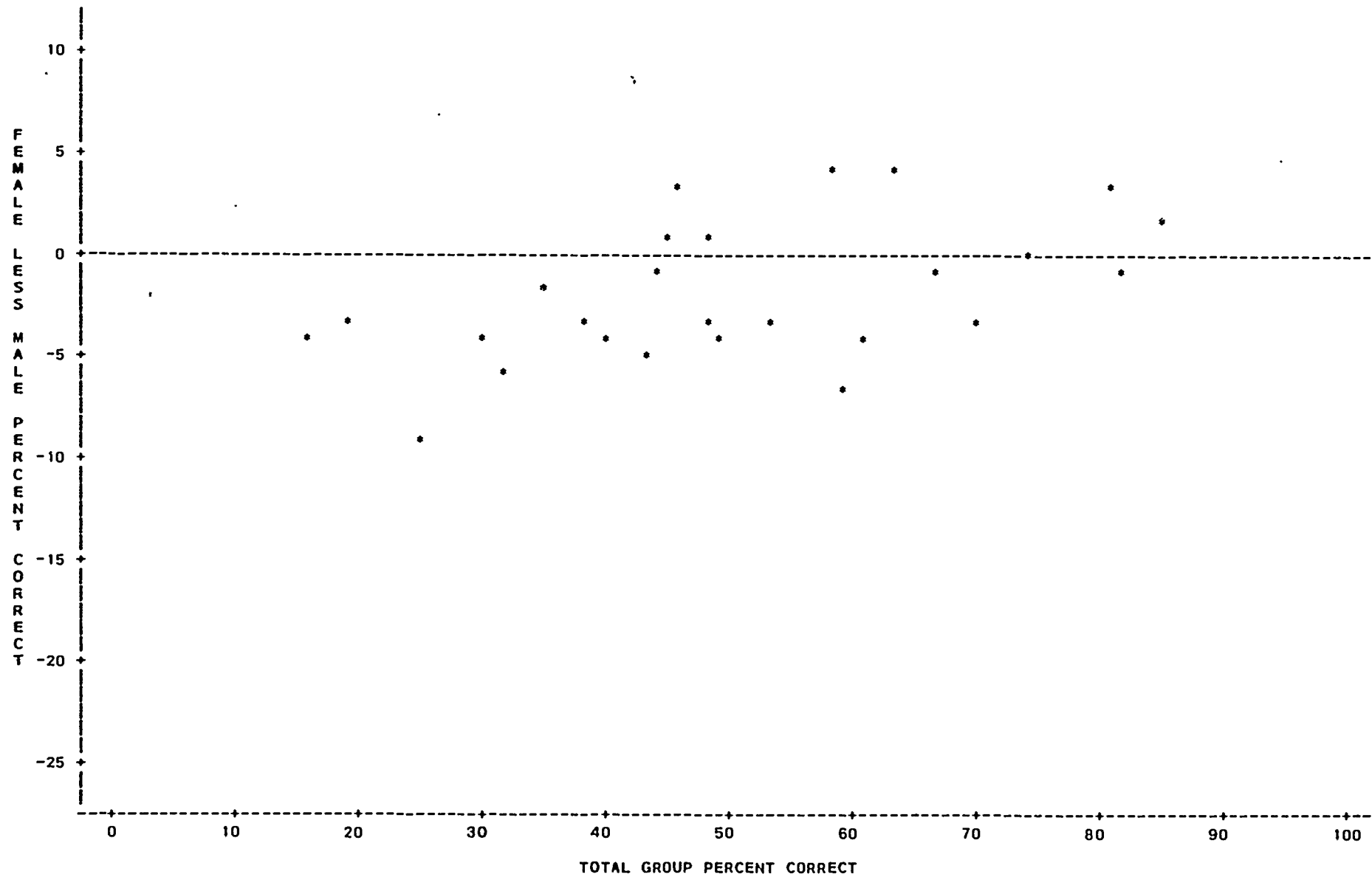
**Table 2-1:** Mean Percent Differences of Correct Responses Reaching Statistical Significance at the 1% Level by Country and Subtest

| | Alg (32) | Arith (62) | Stats (18) | Meas (26) | Geom (42) |
|---|---|---|---|---|---|
| Belgium (fl) | +5 | +4 | — | — | — |
| Thailand | +2 | +2 | — | — | — |
| British Columbia | — | — | — | — | -2 |
| USA | — | — | — | -2 | -2 |
| Ontario | — | — | — | -3 | -2 |
| New Zealand | — | -2 | — | -3 | -3 |
| France | -2 | -4 | -3 | -5 | -6 |

| | Alg (40) | Arith (46) | Stats (18) | Meas (24) | Geom (48) |
|---|---|---|---|---|---|
| Belgium (fr) | +4 | +2 | — | — | — |
| Finland | +5 | — | +4 | — | — |
| Hungary | +4 | — | — | — | — |
| England | — | — | — | — | — |
| Japan | — | — | — | — | — |
| Scotland | — | — | — | — | — |
| Swaziland | — | — | — | — | — |
| Sweden | — | — | — | — | — |
| Hong Kong | — | — | — | — | -2 |
| Luxembourg | — | -4 | — | — | -5 |
| Nigeria | -4 | -3 | — | -4 | -3 |
| Israel | -2 | -3 | -5 | -6 | -5 |
| Netherlands | -1 | -4 | -3 | -7 | -5 |

33

**Table 2-2:** Summary of Multivariate Analysis of Variance for Two-Way Design:
F-Values by Subtest and Source of Variation

| Source | DF | Alg (30) | Arith (46) | Stats (18) | Meas (24) | Geom (40) |
|---|---|---|---|---|---|---|
| Sex | 1 | 1.39 | .17 | .15 | 8.75* | 12.33* |
| Country | 19 | 20.28* | 24.76* | 25.62* | 11.86* | 12.33* |
| Country x Sex | 19 | 9.81* | 10.18* | 6.65* | 10.20* | 8.03* |

| OBS | HUNG_NO | BFL | BC | ONT | FRA | NZE | THA | USA | BFR | ENG | FIN | HX | HUN | ISR | JAP | LUX | NET | NIG | SCO | SWA | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | > | | | | | | | | | # | | | | | | | | | | |
| 2 | 2 | | | | | | | | | | # | | | | | | | | | | + |
| 3 | 41 | + | | | | | | | | | # | | | | | | | | | + | + |
| 4 | 42 | | - | - | - | | - | | | | - | | | | | | | - | | = | - |
| 5 | 74 | | | | | | | | # | | + | | | - | | | | | = | | |
| 6 | 73 | # | | | | | | | | | # | | | | | | | | + | | |
| 7 | 105 | + | | | | | | | | | | | | | | | | | | | + |
| 8 | 106 | | | | - | | | | | ` | | | | | | | | - | - | | |
| 9 | 138 | | | | | | | | | | + | | | | | | | | | | |
| 10 | 137 | | | | | | | | | | | | | | | | | | | | |
| 11 | 4 | | | | | | | | | | | | | | | | | | | | |
| 12 | 3 | + | + | | | | + | | | | # | | + | | | | | | | | |
| 13 | 44 | | | | - | | | | | | | | | | | | | | | | |
| 14 | 43 | + | | | | | | | | | | | | | | | | | | | |
| 15 | 75 | | | | - | | + | | | | | | | - | | - | | - | | | |
| 16 | 76 | | | | | | | | | | | | | - | | < | | - | | | |
| 17 | 107 | + | | | | | | | + | | + | | | | | | | | - | - | |
| 18 | 139 | + | # | | | | | | | | # | | + | | | | | - | + | | |
| 19 | 185 | | | | | | | | | | | | | | | | | | | | |
| 20 | 187 | + | | | | | + | | | | | | | | | | | | | | |
| 21 | 188 | | | | | | | | | | | | | | | | | | | | |
| 22 | 186 | + | | | | | | | | | | | | | | | | | | | |
| 23 | 6 | | | | | | | | | | | | | | | - | | | | | |
| 24 | 5 | | + | | | | | | + | | + | | | | | | | | | | |
| 25 | 7 | | | | - | | | | | | | | | | | - | | | | | |
| 26 | 45 | | | | | | | | | | | | | | | | | | | | |
| 27 | 78 | | | | | | | | | | | | | | - | | - | | | | |
| 28 | 77 | + | | | | | | | | | | | | | | | | | | | - |
| 29 | 108 | | | | | | | | | | + | | | | + | | | | | | |
| 30 | 109 | | + | | | | + | | | | # | | | | | | | | | | # |
| 31 | 141 | | | | - | | | | | | | | | - | = | | = | = | | | + |
| 3? | 140 | | | | | - | | | | | | | | > | | | | | | | = |
| 33 | 182 | | | | | | | | | | | | > | | | | | | | | |
| 34 | 184 | | | | - | | | | | | | | | | | | | | | | |
| 35 | 183... | | | | | | | | | | | | | | | | | | | | |
| 36 | 8 | | | | | | | | | | | | | | | | | | | | |
| 37 | 9 | | | | = | | | | | | | | | - | | < | - | | - | | |
| 38 | 46 | | | | = | | | | | | | | | | | | | | | | |
| 39 | 47 | | | | = | | | | | | | | | - | | - | - | | | | |
| 40 | 79 | | | | | | | | | | | | | | = | | - | - | - | | |
| 41 | 110 | | | | - | | | | - | | - | | | | = | | = | | | | |
| 42 | 143 | | | | | | | | | | | | | | + | | | | | | |
| 43 | 142 | + | | | | | | | | | | | | | | | | | | | |
| 44 | 189 | | | | | | | | | | | | | | | | | | | | |
| 45 | 181 | | | | - | | | | | | | | | | | | | | | | |
| 46 | 190 | | | | | | | | | | | | | | | | | | | | |
| 47 | 179 | - | - | | - | - | | | | | | | | | | | | | | | |
| 48 | 191 | | | | = | | | | | | | | | | | | | | | | |
| 49 | 192 | | | | - | | | - | | | | | | | | | | | | | |
| 50 | 178 | + | | | | | | | | | | | | | | | | | | | |
| 51 | 177 | | | | | | | | | | | | | | | | | | | | |
| 52 | 180 | | | | | | | | | | | | | | | | | | | | |
| 53 | 80 | | | | | | | | + | | | | | | | | | | | | |
| 54 | 111 | # | | | | | | | | | + | | + | | | + | | | | | |

35

36

| OBS | HUNG_NO | BFL | BC | ONT | FRA | NZE | THA | USA | BFR | ENG | FIN | HK | HUN | ISR | JAP | LUX | RET | NIG | SCO | SWA | SWE |
|-----|---------|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 55 | 144 | | | | - | | | | | | | | | - | | - | | | | | |
| 56 | 10 | | | | | | | | | | + | | + | | | | | | | | |
| 57 | 48 | | | | | | | | | | | | | | | - | | | | | |
| 58 | 112 | | | | | | | | | | | | | | | | | | | | |
| 59 | 11 | | | | - | | | | | | | | | | | | | - | | | |
| 60 | 81 | | | | | | | | + | | | | | | | - | - | - | | | |
| 61 | 145 | | | | | | | | - | | | | | | | = | - | | | | |
| 62 | 146 | | | | | | | | ; | | | | | | | | | = | | | |

37

38

| OBS | HUNG_NO | BFL | BC | ONT | FRA | NZE | THA | USA | BFR | ENG | FIN | HK | HUN | ISR | JAP | LUX | NET | NIG | SCO | SWA | SWE |
|-----|---------|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1 | 12 | | | | | | | | | | | | | | | | | | | | |
| 2 | 13 | - | | | = | - | | | | | | | | | | - | | | | - | |
| 3 | 50 | | | | | | | | | | | | | | | | | | | | |
| 4 | 49 | | | | | | | | | | + | | | | | | | | | | |
| 5 | 82 | | | | | | | | + | | + | | | | | | | | | | |
| 6 | 114 | | | | | | | | | | | | | | | | | - | | | |
| 7 | 113 | | | | | | | | | | | | | | | | | | | | |
| 8 | 14 | | | | | | | | | | | | | | | | | | | | |
| 9 | 51 | | | | | | | | | | | | | | | | | | | | |
| 10 | 83 | | | | | | | | | | | | | | | - | | | | | |
| 11 | 147 | | | | | | | | | | | | | | | | | | | | |
| 12 | 84 | | | | | | | | | | | | | | | - | | | | | |
| 13 | 172 | | | | | | | | | | | | | - | | | | | | - | |
| 14 | 15 | | | | | | | | + | | + | | + | | | | | | | | |
| 15 | 16 | | | | | | | | | | | | | | | | | | | | |
| 16 | 52 | | | | | | | | | | | | | | | | | | | | |
| 17 | 85 | + | | | | | | | | | + | | | | | | | - | | | |
| 18 | 116 | | | | | | | | | | | | | | | | | | | | |
| 19 | 115 | | | | | | + | | + | | + | | + | | | | | | | | |
| 20 | 148 | | | | | | | | | | | | + | | | | | | | | |
| 21 | 149 | | | | | | + | | | | + | | | | + | | | | | | |
| 22 | 195 | + | | | | | | | | | | | | | | | | | | | |
| 23 | 53 | | | | | | | | | | | | | | | | | | | | |
| 24 | 88 | | | | | | | | + | | | | | | | | | | | | |
| 25 | 150 | | | | | | | | | | | | | | | | | | | | |
| 26 | 17 | | | | | | | | | | + | | | | | | | | | | |
| 27 | 18 | | | | | | | | | | | | | | | | | | | | |
| 28 | 54 | + | | | | | | | | | + | | | | | | | | | | |
| 29 | 86 | | | | | | + | | | | + | | | | | | - | | | | |
| 30 | 87 | | | | | | | | | | | | | | | | | - | - | - | |
| 31 | 117 | | + | | | | | | | | | | + | | | Y | | | | | |
| 32 | 118 | | | | | | | | | | | | | | | | | | | | |
| 33 | 151 | | | | | | | | | | | | + | | | | | | | | |
| 34 | 196 | + | | | | | | | | | | | | | | | | | | | |
| 35 | 19 | | | | | | | | | | | | | | | | | | | | |
| 36 | 55 | | | | | | | | | | | | | | | | | | | | |
| 37 | 119 | | | | | | | | | | + | | | | | | | < | | | |
| 38 | 152 | | | | | | | | | | | | | | | - | | | | | |
| 39 | 20 | | | | | | | | + | | | | | | | | | | | | |
| 40 | 56 | | | | | | | | | | | | | | | | | | | | |
| 41 | 120 | # | | | | | | | + | | | | | | | | | | | | |
| 42 | 153 | | | | | | | | | | | | | | | | | | | | |

39

40

| OBS | HUNG_NO | BFL | BC | ONT | FRA | NZE | THA | USA | BFR | ENG | FIN | HK | HUN | ISR | JAP | LUX | NET | NIG | SCO | SWA | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | + | | | | | | | | | + | | | | | | | | | | |
| 2 | 57 | | | | | | | | | | | | | | | | | | | | |
| 3 | 89 | + | | | | | | | + | | | | + | | | | | | | | |
| 4 | 121 | | | | | | | | | | | | | | | | | | | | + |
| 5 | 154 | | | | | | | | | | | | | | | | | | | | + |
| 6 | 22 | | | + | - | | - | | | | | | | | | = | | - | | - | |
| 7 | 23 | - | | | - | | | | | | | | | - | | - | | | | | |
| 8 | 58 | | | | - | | | | | | | | = | | | - | | - | | | |
| 9 | 59 | | | | | | | | | | | | - | | | - | | | | | |
| 10 | 90 | | | | | | | | | | | | | - | | = | | | | | |
| 11 | 128 | | | | | | | | + | | | | | - | | - | | | | | |
| 12 | 123 | | | | | | | | | | | | - | | | | | | | | |
| 13 | 122 | | | | | | | | | | | | | | | | | | | | |
| 14 | 155 | | | | | | | | | | | | | | | - | | - | | + | |
| 15 | 25 | | | | | | | | | | | | | | | - | - | - | | | |
| 16 | 24 | + | | | | | | | | | | | | | | | | | | | |
| 17 | 91 | + | | | | | | | + | | | | | | | | | | | | |
| 18 | 124 | | | | | | | | | | | | | | | | | | | | |
| 19 | 26 | | - | - | - | | | | | | | | | = | | | - | - | | - | |
| 20 | 60 | | | | | | | | - | | | | | | | ~ | - | | | - | |
| 21 | 92 | | | | | | | | # | | | | - | - | | | - | | | | |
| 22 | 125 | | | | | | | | | - | | | | | | | | | | | |
| 23 | 156 | | | | | | | | | | | | | | | | - | - | | | |
| 24 | 197 | | | | | | | | | | | | | | | | | | | | |
| 25 | 176 | | | | | | | | | | | | | - | | | | | | | |
| 26 | 27 | | | | | | | | | | | | | | | | | | | | |
| 27 | 93 | | | | | | | | | | | | | | | | | = | | | |
| 28 | 193 | | | | | | | | | | | | | | | | | | | | |
| 29 | 29 | | | | | | | | | | | | | | | | | | | | |
| 30 | 28 | | | | | | | | | | + | | | | | | | | | | |
| 31 | 169 | | | | | | | | | | - | | < | | | | | | | | |
| 32 | 61 | | | | | | | | | | | | | | | + | - | - | | | |
| 33 | 94 | | | | | | | | + | | + | | | | | | | | | | |
| 34 | 175 | | | | | | | | | | | | | | | | | | | | |
| 35 | 126 | | | | | | | | | | | | | | | | | | | | |
| 36 | 62 | | | | | | | | | | | | | | | | | - | | | |
| 37 | 95 | | | | | | | | | | | | | - | | = | - | | | | |
| 38 | 127 | - | | | - | | | | | | | | | | | = | - | | | | |
| 39 | 157 | | | | | | | | | | | | | | | - | - | | | | |
| 40 | 30 | | | | | | | | | | | | | | | - | | | | | |
| 41 | 63 | | | | | | | | | | | | - | | | | | | | | |
| 42 | 96 | | | | | | | | | | | | | | | | | - | | - | |
| 43 | 158 | | | | | | | | | | | | | | | - | - | | | | |
| 44 | 64 | | | | | | | | | | | | | | | | | | | | - |
| 45 | 31 | | | | | | | | | | | | | | | | | | | | |
| 46 | 159 | < | < | = | < | < | = | < | - | < | < | < | < | = | < | < | - | < | = | < |
| 47 | 198 | | | | | | | | | | | | | | | | | | | | |
| 48 | 173 | | | | | | | | | | | | | | | | | | | | |
| 49 | 171 | | | | | | | | + | | | | | | | | | + | | | |
| 50 | 174 | | | | - | | | | | | | | - | | | | | - | | | - |
| 51 | 170 | | | | | | | | | | | | | | | | | | | | |

41          42

| OBS | HUNG_NO | BFL | BC | ONT | FRA | NZE | THA | USA | BFR | ENG | FIN | HK | HUN | ISR | JAP | LUX | NET | NIG | SCO | SW- | SWE |
|-----|---------|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1 | 65 | | | | | | | | | | | | | | | | | | | | |
| 2 | 32 | + | | | | | | | | | + | | | | | + | | | | | |
| 3 | 97 | | | | | | | | | | | | | − | | | | | = | | |
| 4 | 131 | | | | | | | | + | | | | | | | | | | | | |
| 5 | 34 | + | | | | | | | | | | | | | | | | | | | |
| 6 | 33 | | | | | | | | | | | | | | | | | | | | |
| 7 | 66 | | | | − | | | − | ⋅ | | | | | | | | | − | | − | |
| 8 | 98 | | | | | | | | | | + | | | | | | | | | | |
| 9 | 129 | | | | | | | | | | | | | | | | | | | | |
| 10 | 160 | | | | | | | | | | | | | | | | | − | | + | |
| 11 | 161 | | | | | | | | | | | | | | | | | − | | | |
| 12 | 35 | + | | | | | | | | | | | | | | | | | | | |
| 13 | 67 | | | | | | | | | | + | | | | | | | | = | | |
| 14 | 99 | | | | − | | | | | | | | | − | | | | − | | | |
| 15 | 130 | | − | | | | | | | − | | | | | | | | − | | | |
| 16 | 132 | | | | | | | | | | + | | | | | | | | | | |
| 17 | 162 | | | | | | | | | | | | | | | − | | | | | |
| 18 | 163 | | | | | | | | | | | | | | | = | | | | | |

GRAPH B1    MATHEMATICS AS A PROCESS    POP A
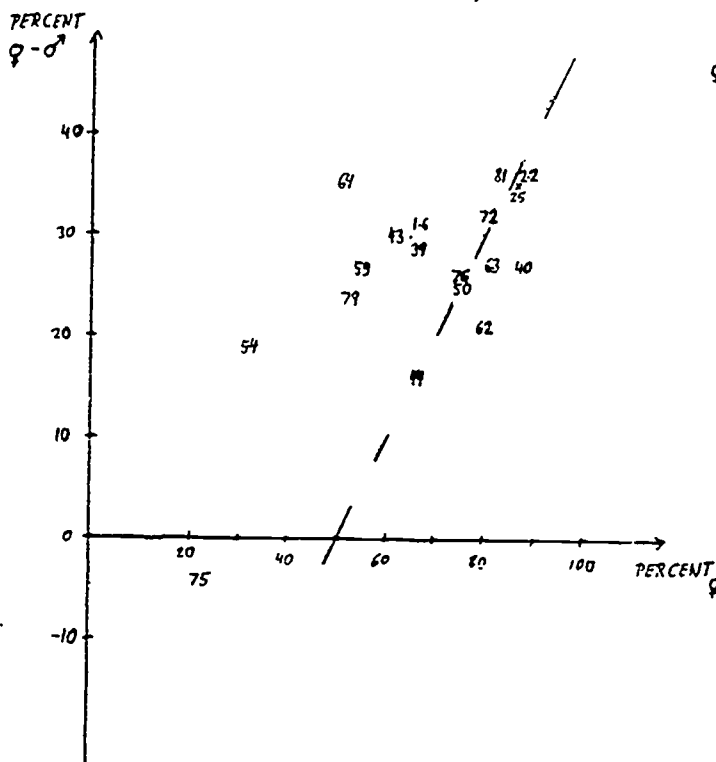


GRAPH B2

HOME SUPPORT    POP A

GRAPH B3

$\bar{x}_q - \bar{x}_\sigma$

MATHEMATICS AND SOCIETY     POP A



GRAPH B4

$\bar{x}_q - \bar{x}_\sigma$

MATHEMATICS AND MYSELF     POP A
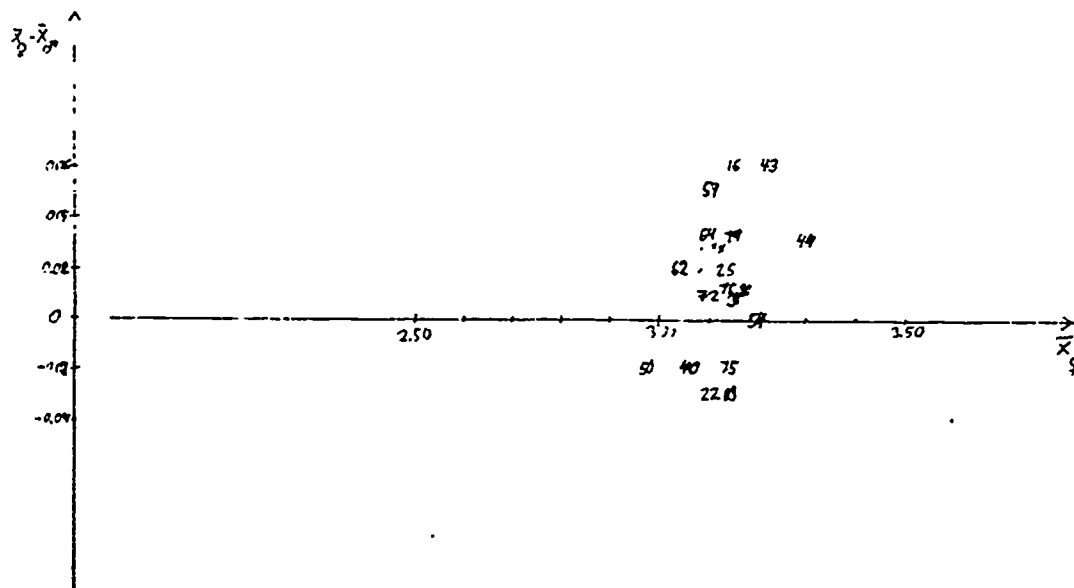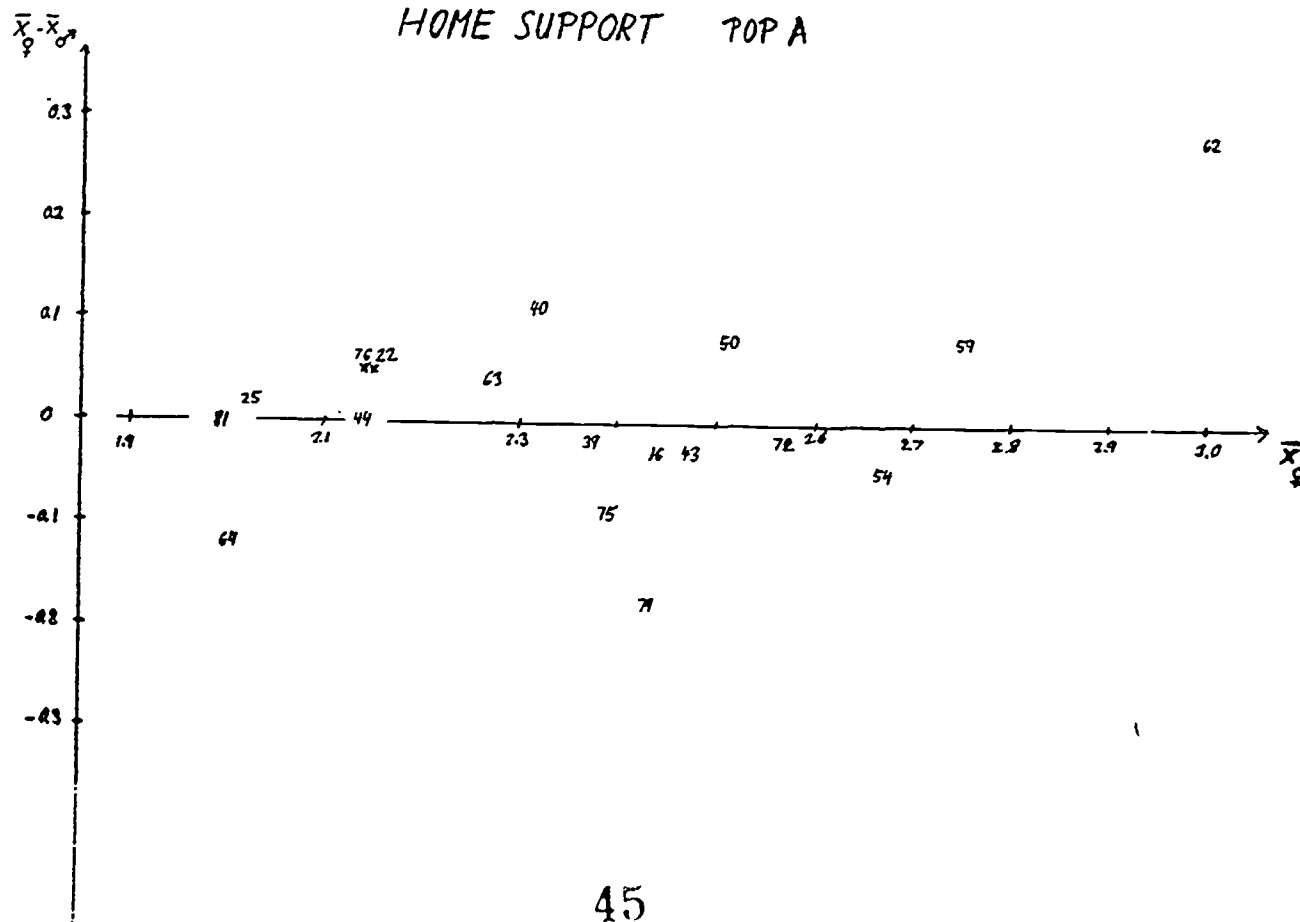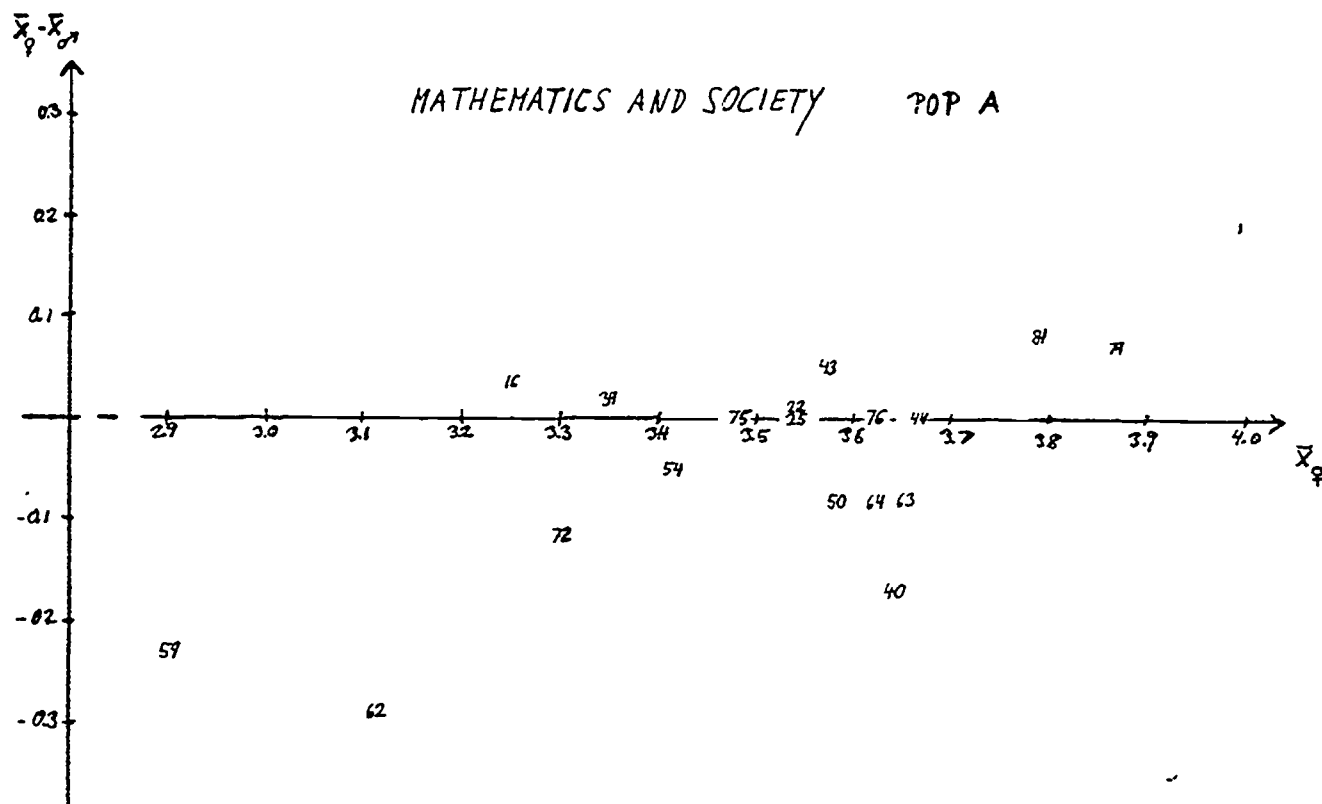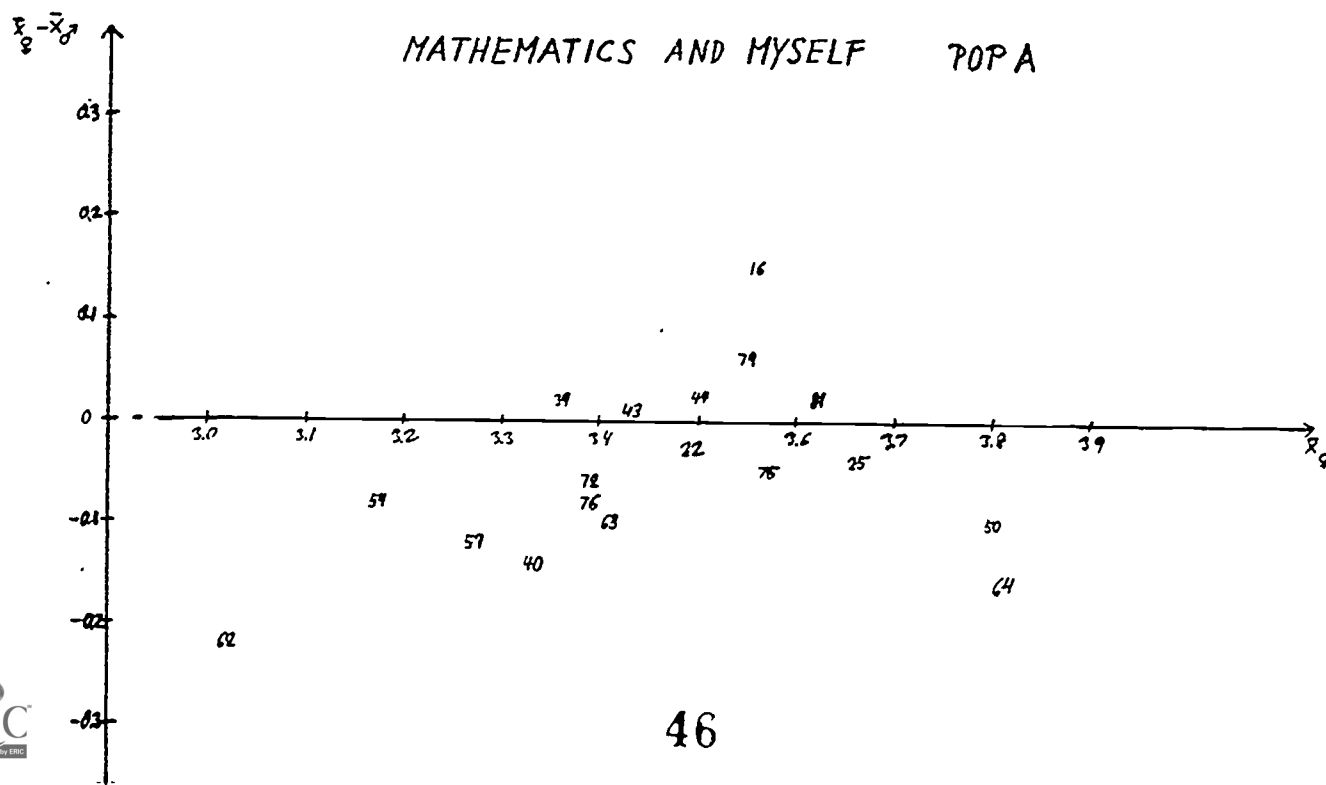
GRAPH B5

GENDER STEREOTYPING    POP A

$\bar{X}_\female - \bar{X}_\male$

1.0

22

64

81   25

16    72

57    40

43    50   63

39         62   76

0.5

54    79

44

-0.1

.7    3.0    3.5    4.0    4.5    $\bar{X}_\female$

-0.4

75

47
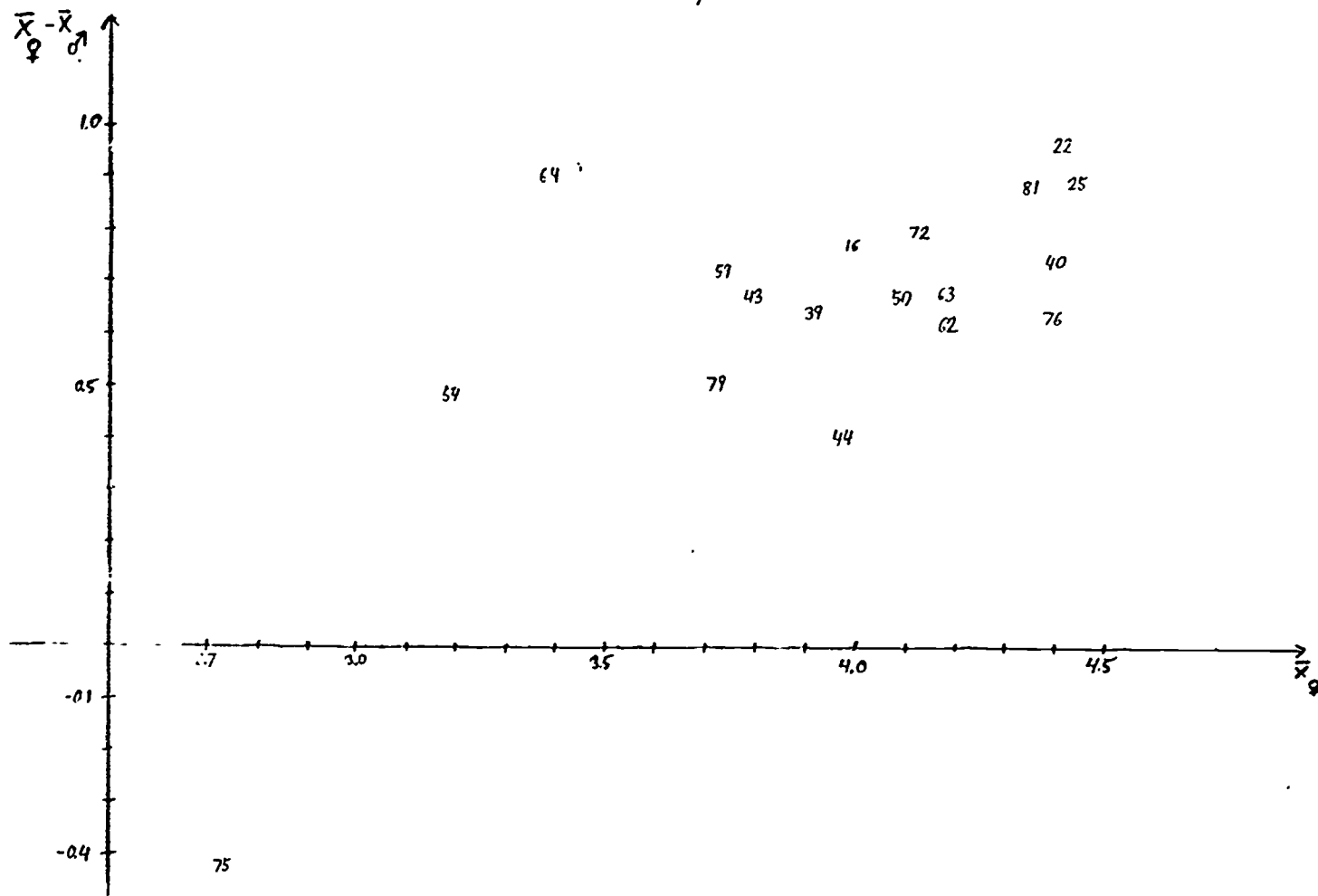
GRAPH B.6

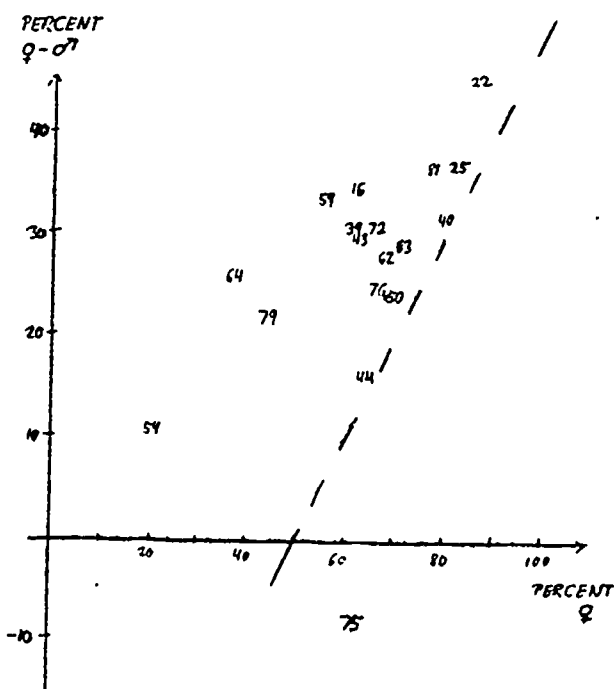BOYS HAVE MORE NATURAL MATH ABILITY
PERCENT DISAGEE AND STONGLY DISAGREE

GRAPH B.7

BOYS NEED TO KNOW MORE MATH
PERCENT DISAGREE AND STRONGLY DISAGREP
POPA

GRAPH B8

MEN BETTER SCIENTISTS AND ENGINEERS
PERCENT DISAGEE AND STRONGLY DISAGREE
POP A

GRAPH B9

WOMAN NEEDS CAREER AS MUCH AS A MAN
PERCENT AGREE AND STRONGLY AGREE
POP A

48