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A COMPARISON OF THE DIVERGENT PRODUCTION ABILITIES OF DEAF AND HEARING CHILDREN IN WESTERN CANADA

by

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ABSTRACT

The purpose of the study was to ascertain the similarities and differences on measures for divergent production between groups representing hearing and deaf children in Western Canada. Divergent production was defined as the generation of ideas from given information. There are four measurable factors within divergent production: fluency, flexibility, originality, and elaboration; i.e. the number of ideas, their classes, statistical unusualness, and embellishments.

The Torrance Test of Creative Thinking, Figural Form B, was chosen as the instrument because it measures the four divergent production factors, and requires non-verbal responses. The regular test instructions were modified by the researcher to a non-verbal form in order to facilitate administration of the instrument to both deaf and hearing subjects.

The study was in two phases. Phase 1, the Pilot Study, was designed to trial test the modified protocols, and Phase 2, the Main Study, to compare the deaf and hearing subjects. The Pilot Study data was analysed by univariate and multivariate F-tests and by discriminant analysis (Tatsuoka 1970) for protocol and sex effects, and the Main Study data by univariate and multivariate F-tests for hearing status and sex effects, discriminant analysis for the statistically significant F-tests, and Hotelling's T^2 routine for the within grade effects. For both phases an α level of .05 was chosen.

The Pilot Study, employing a randomly split class of 66 pupils, revealed a high possible educative effect by the modified protocols. However, the modified protocols were used in the Main Study since both groups of 114 hearing and 114 deaf subjects observed the same instructions and used the same test instrument.

The results of the Main Study showed the hearing subjects to be statistically different from the deaf subjects on a composite factor of the four divergent production factors with a multivariate F-value of 4.555 and an associated probability of .001 on a two-tailed test. Hearing boys were also statistically different from hearing girls with an F-value of 2.764 and an associated probability of .029.

The univariate F-tests reached statistical significance for only figural flexibility and originality on the comparison of the hearing and deaf subjects. Discriminant analysis revealed that the underlying differences amongst the dependent figural factors was at the flexibility end on a figural fluency/flexibility discriminant dimension.

None of the other comparisons by hearing status, sex, and within grade effects reached statistical significance. However, grade by grade developmental patterns and boy or girl dominance on individual figural factors compared favourably with other studies. Boys tended to score higher than girls on figural originality, and girls higher on figural elaboration. By grade, the hearing subjects exhibited the characteristic "Grade Four Slump" but the deaf subjects did not.

The only major difference between these results and those of Kaltsounis (1970) was on the comparison of hearing and deaf subjects. Kaltsounis found his deaf subjects to be significantly superior at the

.01 level on a two-tailed test whereas in this study the hearing subjects were superior at the .05 level (computed $p < .001$) also on a two-tailed test.

The researcher noted several possible causes of the above major difference suggesting that in this study biases in the modified protocols may have favoured the hearing subjects, and in Kaltsounis' study biases in the ordinary protocols may have favoured the deaf subjects. Finally, questions were posed enquiring into the importance of divergent production in the education of the deaf.

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CHAPTER I

INTRODUCTION

1.1 Statement of the Problem

During 1971 the researcher worked with, and observed, deaf children as they were involved in learning experiences with Elementary Science Study (ESS) units. Children of grade levels 2, 5, and 6 were observed individually within a group and as whole groups of seven per class. Activities based on such science units as Water Play, Ice Cubes, and Batteries and Bulbs were observed.

From these observations it was tentatively concluded that the deaf children generated fewer original ideas when active with science materials than did hearing children of similar age groups. (During his undergraduate years the researcher also worked with, and observed, hearing children as they used ESS units.) With the deaf children an idea usually developed slowly from one child and then quickly disseminated throughout the group with few apparent modifications to the original idea. In one class session of 1 1/2 hours only six different ideas were produced by seven deaf children working with coloured straws, pins, string, and clay. Previous science teaching experience led the researcher to believe that hearing children of a similar age group typically produce more ideas in the same time using the same materials.

Regarding educational achievement, Levine (1960) stated "the general conclusion is deaf children show a three- or four-year retardation compared with their hearing peers," and "in visual acuity, the results of deaf children are below those of hearing children" (p. 53).

Furth (1966) tested 180 deaf and hearing children using his own concept tasks, and 42 deaf and hearing children using Piagetian tasks. He discovered that deaf and hearing children scored the same, (or were not significantly different statistically), on non-verbal concept and visual memory tasks. However, where verbal knowledge was required the deaf children produced lower results than did the hearing children. On Piagetian tasks the deaf children had a one-to-five year lag, but Furth added, this lag might be attributable to verbal elements or to difficulties in administering the tasks.

Quite contrary to the above observations, Kaltsounis (1970) reported deaf children produce higher scores on creativity tasks than do hearing children as measured by the non-verbal _Torrance Tests of Creative Thinking_ (TTCT). These tests were used in this study.

The above statements reveal some disagreement about the comparative abilities of deaf and hearing children. Perhaps, as Furth and Kaltsounis suggested, on non-verbal tasks the deaf children are equal or possibly superior to hearing children. The purpose of this study is to gain further knowledge about the differences between deaf and hearing children, especially on the relationship of divergent production and the handicap of deafness, by comparing the groups of children on the _TTCT_, _Figural Form B_.

The _TTCT_ was originally designed as a measure for the creative ability of hearing children but the instructions were modified by the researcher of the present study to enable him to administer the tests to both deaf and hearing children.

1.2 Definition of Terms

The deaf children involved in this study were boys and girls whose hearing deprivation was substantial enough to prevent them from participation in an ordinary public school. Both hard-of-hearing and profoundly deaf children are included in the term 'deaf children.' Prior to the testing procedure no attempt was made to select the children according to mental and hearing abilities. Subjects were children attending elementary schools-for-the-deaf.

Guilford (1967) defined divergent production as the "generation of information from given information, where the emphasis is upon variety and quality of input from the same source" (p. 215). The intent of this study is to quantitatively measure this ability of "generating new information from given information."

This definition of divergent production involves memory, recall from memory, new inputs, and the processing of these in order to produce new and varied outputs. These outputs may be behavioural, verbal, figural, or simply thoughts. However, in this study divergent production refers to observable outputs only, and more specifically, figural outputs. The utility of the outputs was not considered since, by definition, divergent production pertains only to products, not to their social value.

Guilford divided divergent production into four measurable factors: fluency, flexibility, originality, and elaboration.

Fluency is considered to be "the ready flow of ideas" (Guilford 1967, p. 137), in that a person produces many ideas. Fluency ability is the "efficiency of calling out from memory storage items of information to fill certain specifications" (Guilford 1962, p. 13). Fluency, then, is a quantitative production ability whereby the memory is scanned in order to recall ideas that are relevant to the given information.

The importance of memory storage and recall was stressed by Guilford (1962). He stated "in spite of the fact that we often hear disparaging remarks about persons who have good memories, in view of the need for stored information we see the importance for having good retention as well as retrieval of information when we want it" (p. 13). A person with low fluency ability may have poor memory storage, or inefficient recall ability, or both.

Flexibility is conceived as the ability to shift between classes (Guilford 1967, p. 452), e.g., a brick may be used as a paper weight in one idea category and as a nut-cracker in another. These two ideas are different classes of usage. With flexibility only the changes between classes are scored, whereas with fluency all responses are scored. Each class scores one point. This ability to change classes enables a greater possibility of producing original responses.

Originality. As stated above, the greater the flexibility the greater is the probability of producing unusual ideas. By "unusual" Guilford (1967, p. 154) meant statistically rare.

Torrance (1968, pp. 19-20) calculated statistical rareness by analysing the responses of over 500 subjects. Common responses (5% or more of the subjects) are scored zero, less common responses (from 2%-4.99% of the subjects) are scored one point, and rare responses (from less than 2% of the subjects) are scored two points.

Elaboration. Guilford (1967, p. 138) characterized elaboration as the ability to embellish with details. In figural drawings, the more details added the greater is the elaboration score. Guilford (1967, p. 159) believed this ability to be in close association with what he called the implication ability, i.e., one idea implies another. A person with a high elaboration ability is able to build, or expand, upon his own ideas or upon given information.

Divergent Thinking and Convergent Thinking. For the purposes of this study, divergent thinking is taken to be what occurs in the mind, such as thinking of ideas, whereas divergent production is the outward expression of these ideas in the form of observable products. Similarly, convergent thinking can be considered as the thinking of an idea, and convergent production the outward expression of the idea in the form of one or more observable products.

Divergent thinking is taken as thought involving a search for many possible solutions which take the form of divergent products, and convergent thinking as thought involving a search for one solution in the form of a convergent product. These two distinct operations are illustrated by Guilford (1967) in Figure 1.

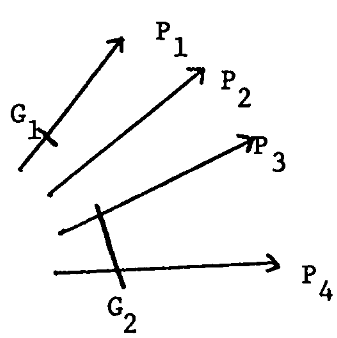


Figure 1. Divergent and Convergent Thinking

Guilford explained:

> We may visualize the difference between convergent production and divergent production by using a simple diagram as above. Let G be some particular given information, such as a certain item in a test. With instructions sufficiently open, such as 'Give words opposite meaning,' the production could be P1, P2, P3, and P4. But if supplementary information specifying limitations, in the form of G1 and G2, such that G1 excludes P1, and G2 excludes P3 and P4, is given, then the only possible production is P2, a convergent output. (p. 172)

This model gives the impression that a person doing divergent thinking or convergent thinking has all possible solutions, P1, P2, P3, and P4 available, and that if there is a need to converge towards one solution this will be accomplished by using "supplementary information specifying limitations." This suggests that in both divergent thinking and convergent thinking persons have equal information available.

The researcher believes this is misleading. By definition, a person who performs extreme divergent thinking is able to search out many possible solutions, P1, P2,... and perhaps choose the best or most desirable solution; but the person who predominantly thinks convergently is only able to converge on one of a few solutions by considering limiting information. This suggests that the term 'supplementary information specifying limitations' is too narrow. There are other factors that restrict a person's ability to find possible solutions. Hudson (1966, p. 115) believes that a person doing predominantly convergent thinking has inhibitions, repressions, and controls, so that he is withdrawn. Hudson (1966) believed that character traits restricted an individual's ability to branch out, to look for new ideas, and to see new ideas. This suggests that G1 and G2 in Guilford's illustration need not be "given" limiting information but also may be mental blocks, poor recall ability, and lack of experience, so that P1, P3, and P4 are not even available for the individual to produce.

Simply stated, divergent thought involves recall and invention of many possible solutions, and convergent thought entails thinking towards one possible solution by eliminating given alternatives.

Torrance Tests of Creative Thinking (TTCT). Torrance (1966), after nine years of developmental research, produced a series of activities which he claimed tested for "creative thinking abilities" (p. 2). These activities he named Torrance Tests of Creative Thinking. Test booklets each consisting of three activities were designed "to bring into play somewhat different mental processes, yet each requires the subject to think in divergent directions" (p. 3). Each test booklet is scored on the divergent production factors: fluency, flexibility, originality, and elaboration.

Torrance developed two variations of the tests, Verbal and Figural, and forms "A" and "B" of each variation. The tested child is required to produce written responses to questions on the Verbal Forms, and pictoral responses to figural stimuli on the Figural Forms. Further details of the TTCT, Figural Form B are given under 3.3 Instrumentation.

Ordinary Protocols. The TTCT, Verbal and Figural Forms were developed for hearing children. Consequently the test instructions were designed to be given orally. The test administrator is directed to request the children to listen carefully while he reads aloud a set of instructions. These instructions are described in Torrance (1968).

Modified Protocols. Because the deaf children involved in this study were unable to lip-read, the ordinary protocols would be biased against them. Furthermore, if two types of protocols were used, one for the deaf and another for the hearing children, reliable statistical comparisons of group scores would be impossible. To overcome these biases the researcher modified the ordinary protocols of Torrance (1968) to a non-verbal form. The modified protocols are detailed under 3.3 Instrumentation.

1.3 Need for the Study

After studying the nature of modern scientific work and science history, Kuhn (1963, pp. 342-4) commented in his paper The Essential Tension that the sciences demand flexibility and open-mindedness characteristic of divergent thinking. But, he continued, this is not enough because normal research is a highly convergent activity. Kuhn believed there exists a tension within the individual scientitists and their scientific communities. This tension was caused by the need to be highly convergent in thought so as to find solutions to problems, and yet sufficiently divergent in order to see, cause, and accept change. With respect to science education in schools, Guilford reported "(it) has emphasized abilities in the areas of convergent thinking . . . , often at the expense of divergent thinking." Kuhn agreed with this statement and emphasized that divergent and convergent thinking are equally important for the scientific community and for individual scientists.

In discussing varieties of giftedness in children, Getzels and Jackson (1962, p. 2-3) reported that on typical intelligence tests children must be able to recall, recognize, or even solve problems but not necessarily be able to invent or innovate. These researchers discovered that IQ scores rarely accounted for more than a quarter of the variance in school achievement and academic performance. Other intellectual factors such as creativity also contributed to the prediction of achievement. Getzels and Jackson wondered whether the "slackening of progress in the understanding of gifted children might not be due to the too-heavy reliance on the concept of intelligence" at the expense of other abilities, especially creativity.

Guilford (1962, p. 117) suggested that creativity is comprised of five factors of mental ability: cognitive thinking, memory, divergent thinking, convergent thinking, and evaluative thinking. Divergent thinking is the most important of these abilities within creativity for the production of <u>new</u> ideas (Taylor 1964, pp. 19-20).

There is, then, evidence for the education of hearing children in both intellectual and creative abilities as represented by convergent and divergent thinking. Many writers, especially the leading researchers of creativity and divergent thinking (Guilford, Parnes, Taylor, and Torrance), have stressed the need for educational practices to include programmes encouraging both convergent and divergent thinking. They assume this nurtures the individual child's mental health and culminates in maximum psychological development. However, Kaltsounis (1970) who used the <u>TTCT</u> to measure "creativity" pointed out that "the majority of the studies conducted on deaf children have dealt mainly with the discovery of the factors affecting their intelligence. . . . There is very little literature in reference to creativity and deafness" (pp. 1-2).

Consequently there is a need to gain further knowledge about the divergent thinking of deaf children if new science programmes are to be designed to increase the children's output of divergent products. Furthermore, this knowledge could be useful in creating balanced programmes encouraging both convergent and divergent production.

In order to measure the divergent production of hearing and deaf children null hypotheses were proposed comparing the subjects on the effects of hearing status, sex, and within grade groupings (Hypotheses 3.6).

CHAPTER II

REVIEW OF THE LITERATURE

2.1 Introduction

There have been few studies on the comparison of deaf and hearing children as measured on tests of divergent production ability or the related ability, creativity. Torrance (1971) in his bibliography of research into creativity gives only five references on deafness and creativity, four of which are by B. Kaltsounis and one by R. A. Silver. Silver showed that a group of deaf artists produced very high mean scores on the TTCT, Figural Form A. Kaltsounis' work, especially in 1970, is the only comprehensive research that has compared deaf and hearing children with respect to non-verbal creativity by using the TTCT, Figural Form A.

Although there is a wealth of related research comparing the creative abilities of differing groups of hearing children there is little research on the abilities of divergent production. Therefore, this review of the literature will survey a selection of creativity studies and then specifically review Kaltsounis (1970) since in many respects this research replicates his.

2.2 Deaf and Disadvantaged Hearing Children

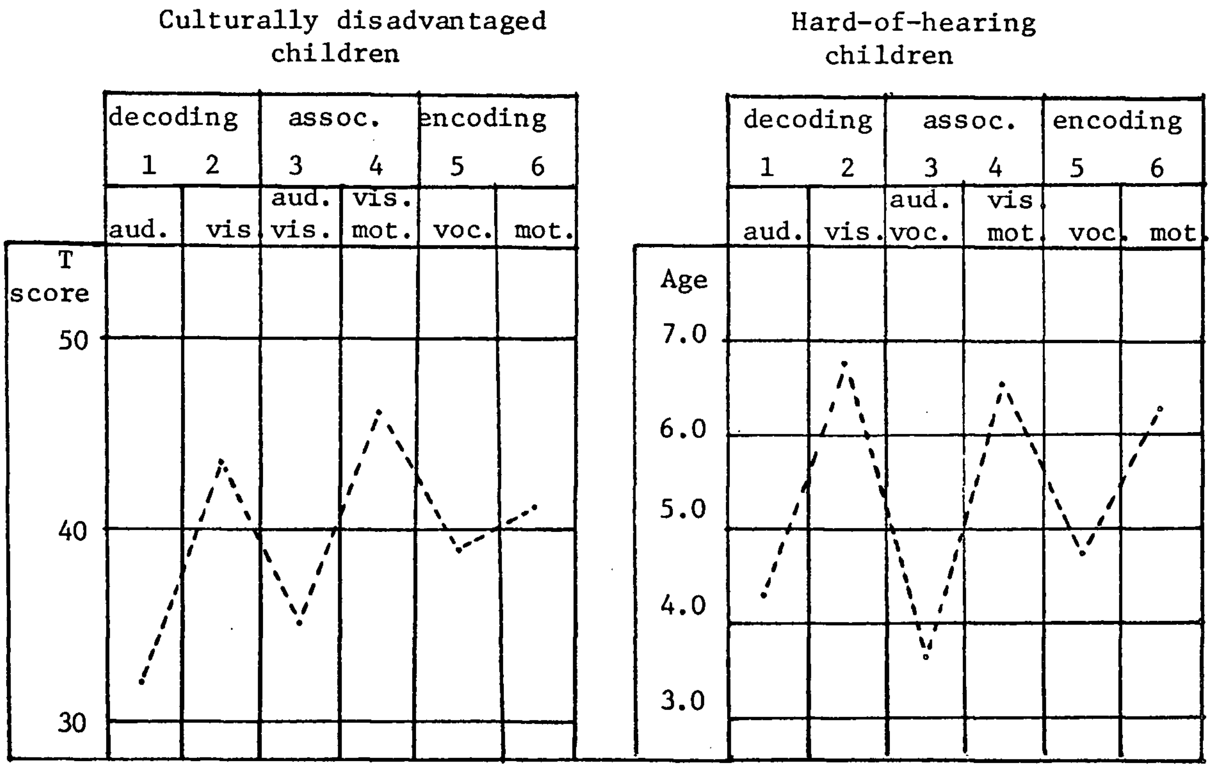
Rogers (1968) tested 125 pupils in grades 5 and 6 on the TTCT, Figural Forms A and B, and on the Meier Art Judgment Test. The children were selected according to arbitrarily set minimum standards of intelligence and reading achievement in order to guarantee ability to understand reading instructions. The children were grouped as "advantaged" and "disadvantaged" on the basis of family income, education of parents, types of jobs parents held, and geographical residence. On drawing ability, the advantaged children were found to be significantly superior to the disadvantaged children. Although the disadvantaged children were handicapped by this lack of drawing ability, on the Meier Art Judgment Test they showed no differences in art judgment ability when compared with the advantaged group. On the TTCT, Figural Forms A and B, the disadvantaged children as a group scored higher on both figural fluency and figural originality, although only figural fluency was statistically significant at the .05 level on a two-tailed test. In his conclusion Rogers proposed, "a visual answer can be as concrete and as real as a verbal answer," and "educators may be overlooking one of the competencies of the disadvantaged pupil: his ability to learn through visual techniques."

Torrance (1964, p. 74) supported Rogers' finding. He stated that on figural fluency and figural originality disadvantaged children hold their own or are superior to similar advantaged groups (although, he added, figural flexibility and figural elaboration tend to be less outstanding). Torrance also reported that disadvantaged children are highly creative in such areas as visual arts, creative movement, games, sports, humour, and making up stories. Most of these are non-verbal areas. Torrance (1969) also stressed "if you are searching for gifted children among disadvantaged populations, you will be assured of greater success if you seek them in areas I have just identified (rather) than in traditional ways" (pp. 75-6).

In discussing the effects of environmental deprivation on intelligence, Ausubel (1965) pointed out that the disadvantaged child in the culturally deprived home lacks the "objects, utensils, toys, pictures, etc., requiring mental labelling and serving as referents for language acquisition in middle class homes. The culturally deprived child is not spoken to, nor read to, very much by adults" (pp. 46-7). This, Ausubel reported, causes the disadvantaged child's auditory discrimination to be poor, because he receives little corrective feedback regarding enunciation, pronunciation, and grammar. The disadvantaged child may be retarded in language development, but this retardation is mainly in the formal and abstract elements of language, and not in the more concrete, expressive, and informal aspects. The disadvantaged child relies upon the concrete and the tangible, and often communicates in non-verbal expressive ways.

The above references indicate disadvantaged children have a poorer verbal input than advantaged children, and further, disadvantaged children put greater reliance on non-verbal skills and non-verbal communication. In these respects deaf children can be considered as disadvantaged not necessarily from a socio-economic point of view but from an aural-input point of view. Much like the disadvantaged children, deaf children also put great reliance on non-verbal skills and non-verbal communication techniques.

Bateman (1968, pp. 34 and 41) checked 24 hard-of-hearing children between the ages 4.5 and 5.5 years old, and 18 disadvantaged children with a 5.2 mean age, using the 1961 Illinois Test of Psycholinguistic Abilities. The graphical profiles of these two groups (Figure 2) are



N = 18
Mean IQ = 83.4
Mean age = 5.15 yrs.
Mean MA = 4.5 years

N = 24
Mean IQ = 107
Mean age = 5.5 yrs.
Mean MA = 5.9 yrs.

Figure 2. Profiles of culturally disadvantaged and hard-of- hearing children as measured on the 1961 Illinois Tests of Psycholinguistic Abilities (From Bateman 1968). (For explanation of terms see Appendix A.)

very similar other than the hard-of-hearing children show greater extremes between visual and verbal abilities. Because of the similarities between the two groups it could be hypothesised that deaf children would produce similar results to disadvantaged children on the TTCT, Figural Forms A and B. That is, as a group the deaf children may tend to score higher on non-verbal tasks than do hearing children.

Kaltsounis (1970) undertook an extensive study of 233 deaf children using the TTCT, Verbal and Figural Forms. He compared these deaf children to a group of 605 hearing children tested in another study two years previously. His results showed the deaf children to be statistically superior at the .01 level of significance on a two-tailed test on figural fluency, flexibility, originality, and elaboration. Also, in the comparisons by grade, the deaf children's mean scores were higher for all figural factors.

2.3 Sex Differences of Hearing Children

Torrance (1961) in his report, the "Minnesota Studies of Creative Thinking in Early School Years," showed that through grades 1, 2 and 3 boys were increasingly superior to girls on the verbal and non-verbal tasks of fluency, flexibility, originality, constructiveness, prediction, and asking questions. By grade 4 the boys started to lose ground and, overall, the girls became superior on these tasks. Torrance claimed this to be due to peer and social pressures.

These sex differences in creative abilities are supported by Yamamoto (reported in Torrance 1965, pp. 126-30) who tested an entire elementary school population in a small Minnesota town. He used the verbal "Ask-and-Guess" creativity test to study sex differences. Figure 3 illustrates his results. The boys were superior to the girls in grades 2, 3, and 4. Girls then became superior from grade 5 onwards. The original graph continued to grade 12.

Torrance and Alliotti (1969) compared 59 boys and 59 girls of grade 5 age level who had been randomly sampled from three Wisconsin counties. The children were measured on the TTCT, Figural Forms A and B. On both test forms there were no significant differences between the group means of the boys and girls on figural fluency and figural flexibility. However, boys' mean scores were significantly superior statistically over girls' mean scores on figural originality at the .05 level, and girls' mean scores were significantly superior statistically on figural elaboration at the .01 level, on a two-tail test.

2.4 Creative Development of Hearing Children

Torrance and staff (1967) compiled data on hearing children in order to study creative abilities. There were clear periods of decline in their creative abilities at approximately the ages 5, 9, 13, and 17. He reviewed studies of other abilities and found similar declines. These abilities included perception, production of articles, originality, curiosity, suggestibility, and risk taking. He also observed that the number of school referrals and letters from concerned parents increased at the ages when the creative abilities declined. Based on these studies Torrance suggested an association exists between the development curve for creative thinking and a child's general physical, psychological and sociological development.

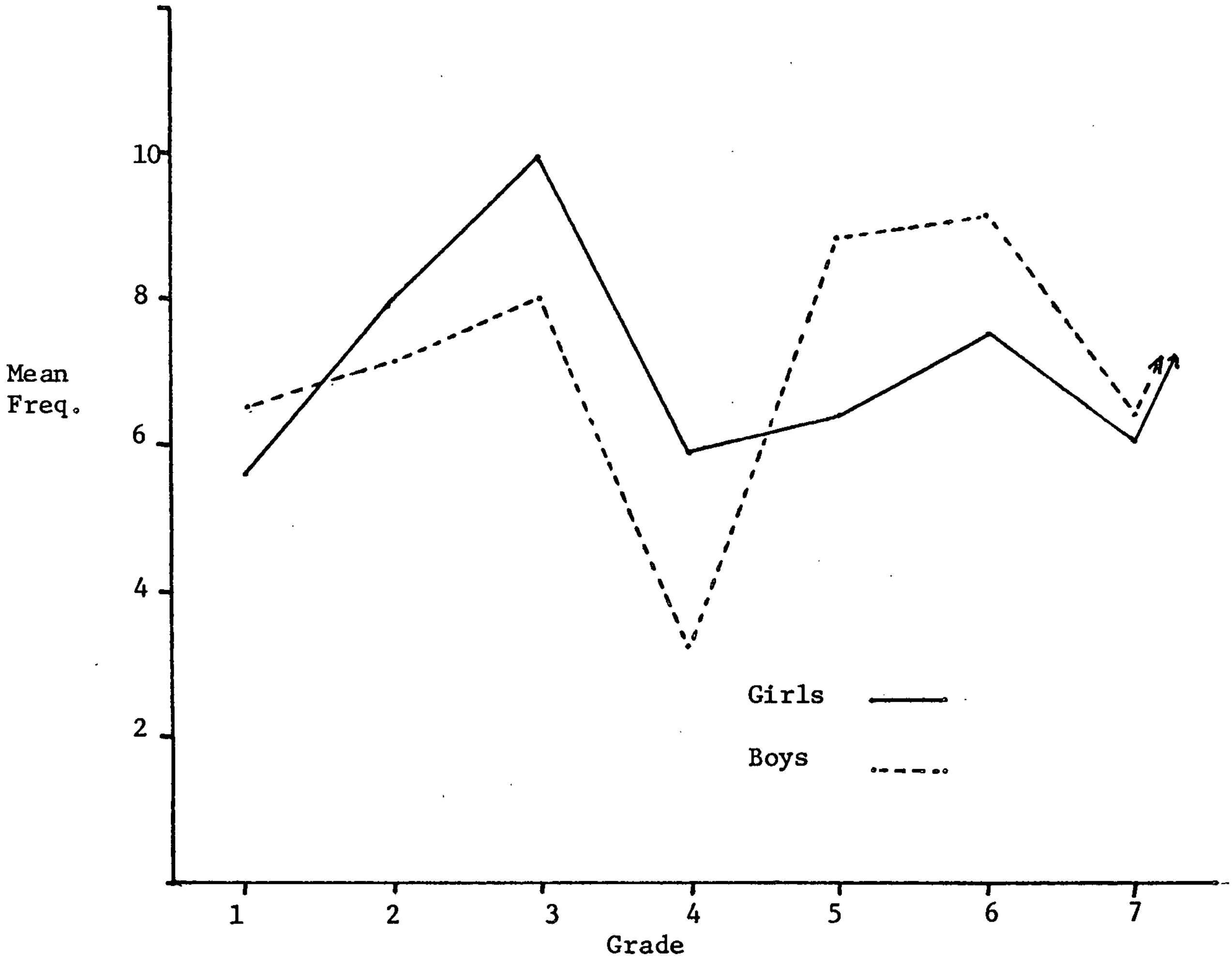


Figure 3. Development curve for the mean frequencies of questions asked on Part 1 Ask, of the "Ask-and-Guess Test." (From Yamamoto 1962, cited in Torrance 1965, p. 127.)

Using the data from a study by Walker and Lev (1953), Torrance (1967, p. 47) illustrated the typical sex-by-grade differences and the "Grade Four Slump" of boys and girls. For all figural factors of divergent production a decline occurred at grade 4 (age 9). Figures 4, 5, 6, and 7, adapted from Torrance (1967, p. 47), reveal the sex-by-grade differences and the "Grade Four Slump." Boys' figural flexibility was the only factor that did not show a definite slump at grade 4. Girls' mean scores were slightly higher than the boys' on figural fluency and flexibility. Boys' mean scores were definitely higher in all grades on figural originality, and girls' definitely higher in all grades on figural elaboration.

2.5 Review of Kaltsounis' Study (1970)

2.51 Introduction

In his study, Kaltsounis employed two psychologists of the school for the deaf to administer the TTCT, Verbal and Figural Forms A. The psychologists used natural, and finger sign, languages in order to give the test instructions. The comparison group of hearing children were the subjects of another study carried out two years earlier. Campbell and Stanley (1963) consider a long delay between test administrations for group comparisons as poor research design. For the deaf subjects 172 Caucasian and 61 Negroid children from separate North Carolina residential schools for the deaf were tested. The hearing subjects consisted of 605 Caucasian children from a Georgia elementary school.

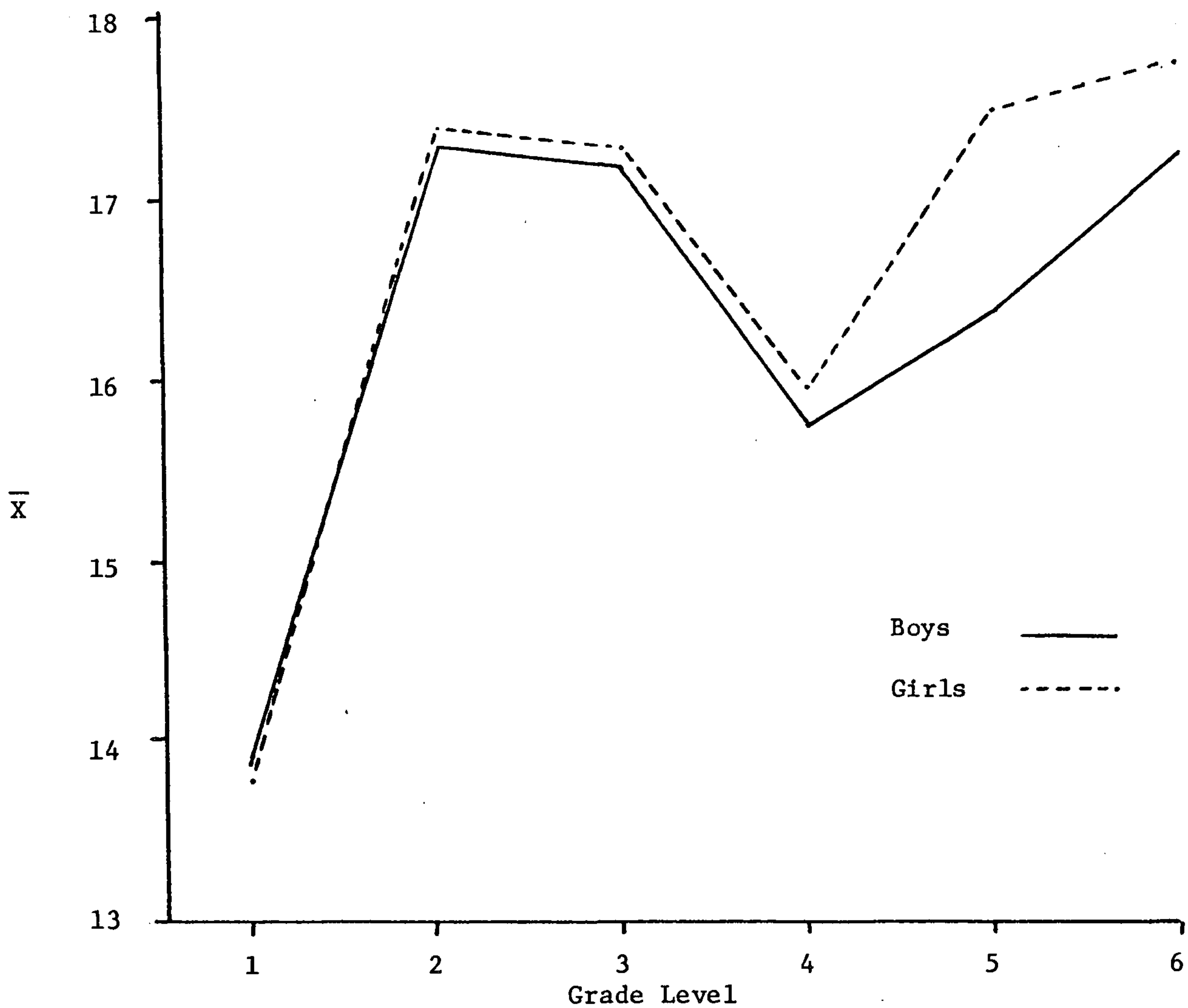


Figure 4. Figural fluency mean scores by grade and sex to illustrate the "Grade Four Slump." (Graph drawn from data on Table I, Appendix B.)

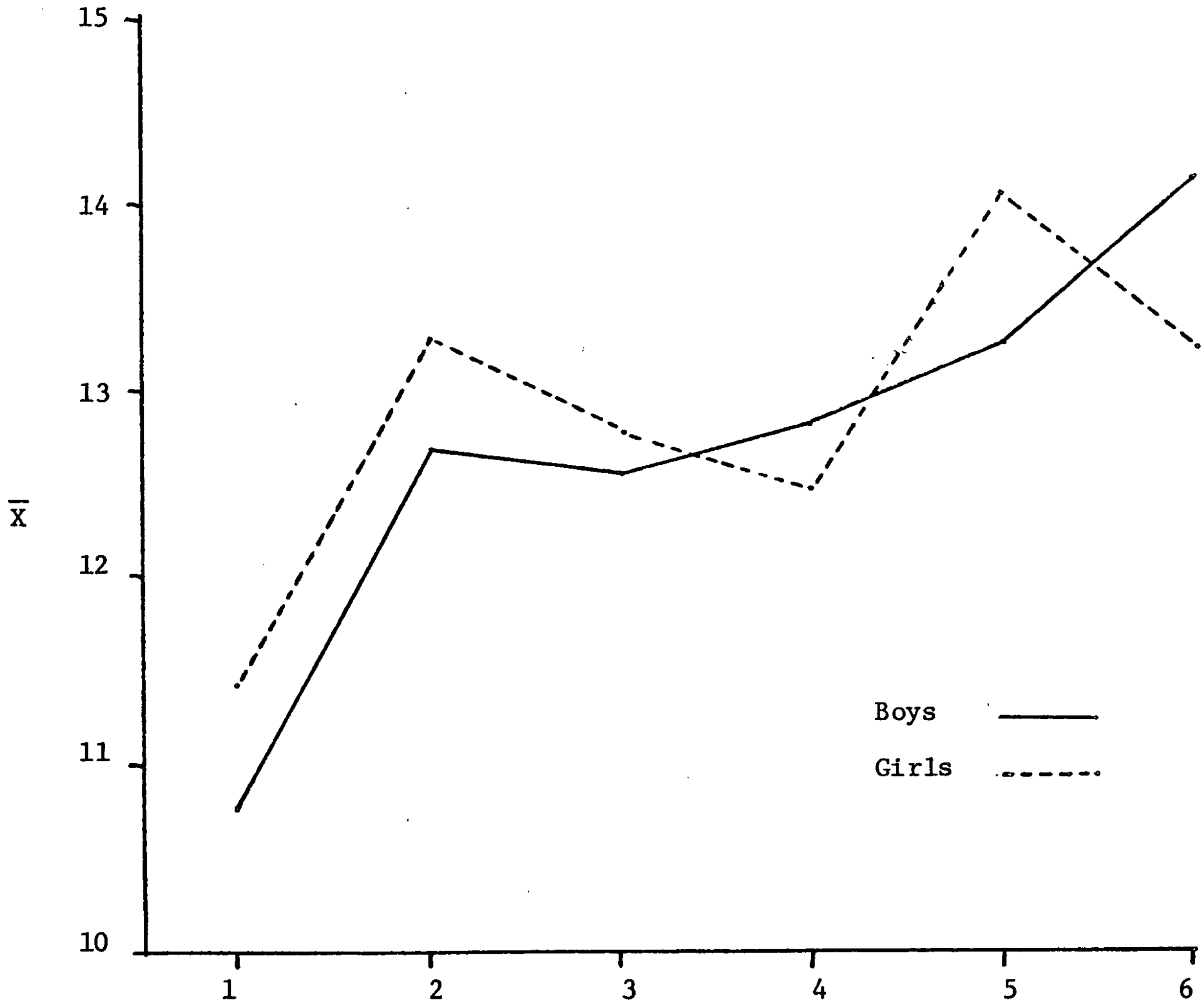


Figure 5. Figural flexibility mean scores by grade and sex to illustrate the "Grade Four Slump." (Graph drawn from data on Table I, Appendix B.)

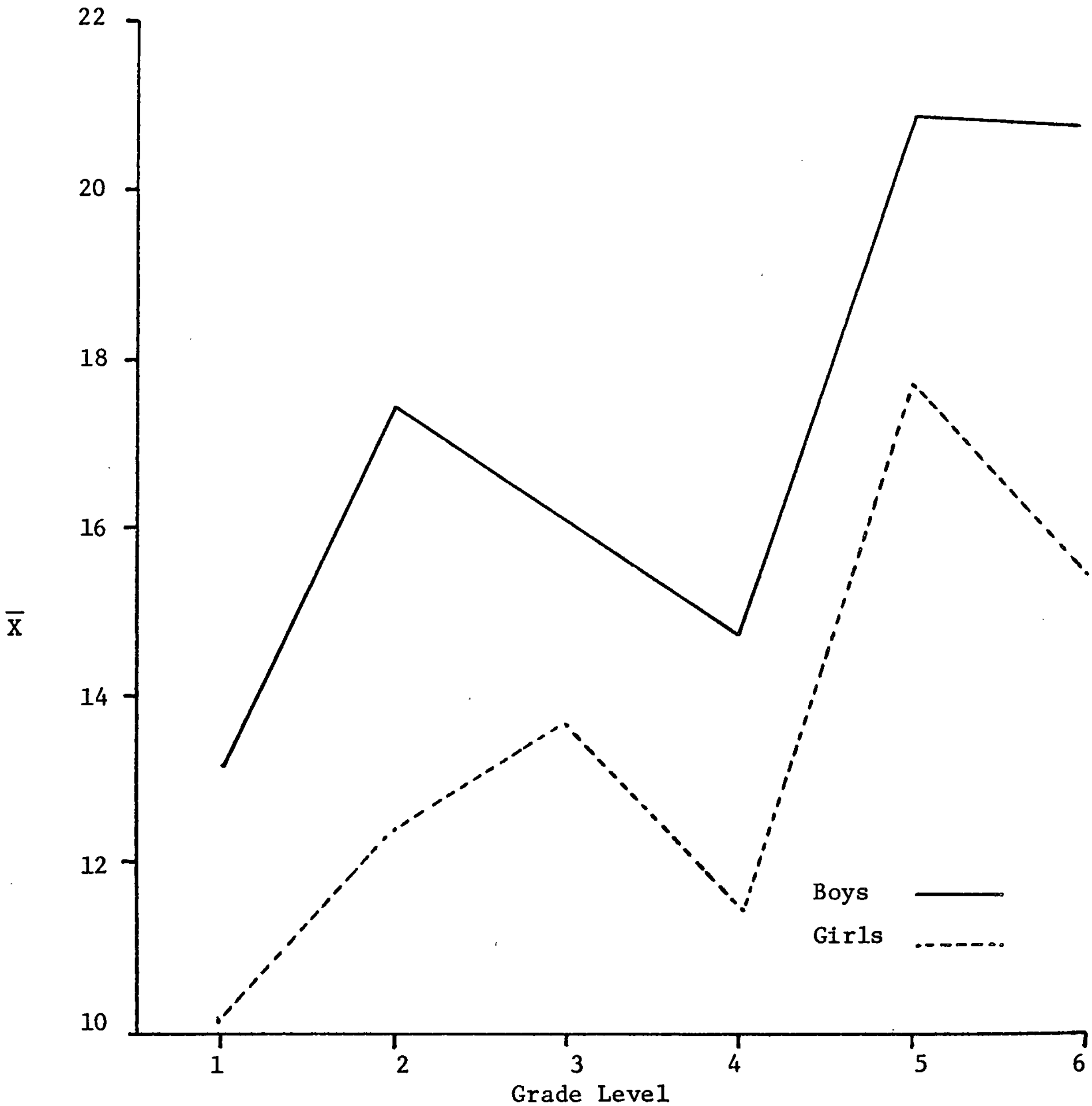


Figure 6. Figural originality mean scores by grade and sex to illustrate the "Grade Four Slump." (Graph drawn from data on Table I, Appendix B).

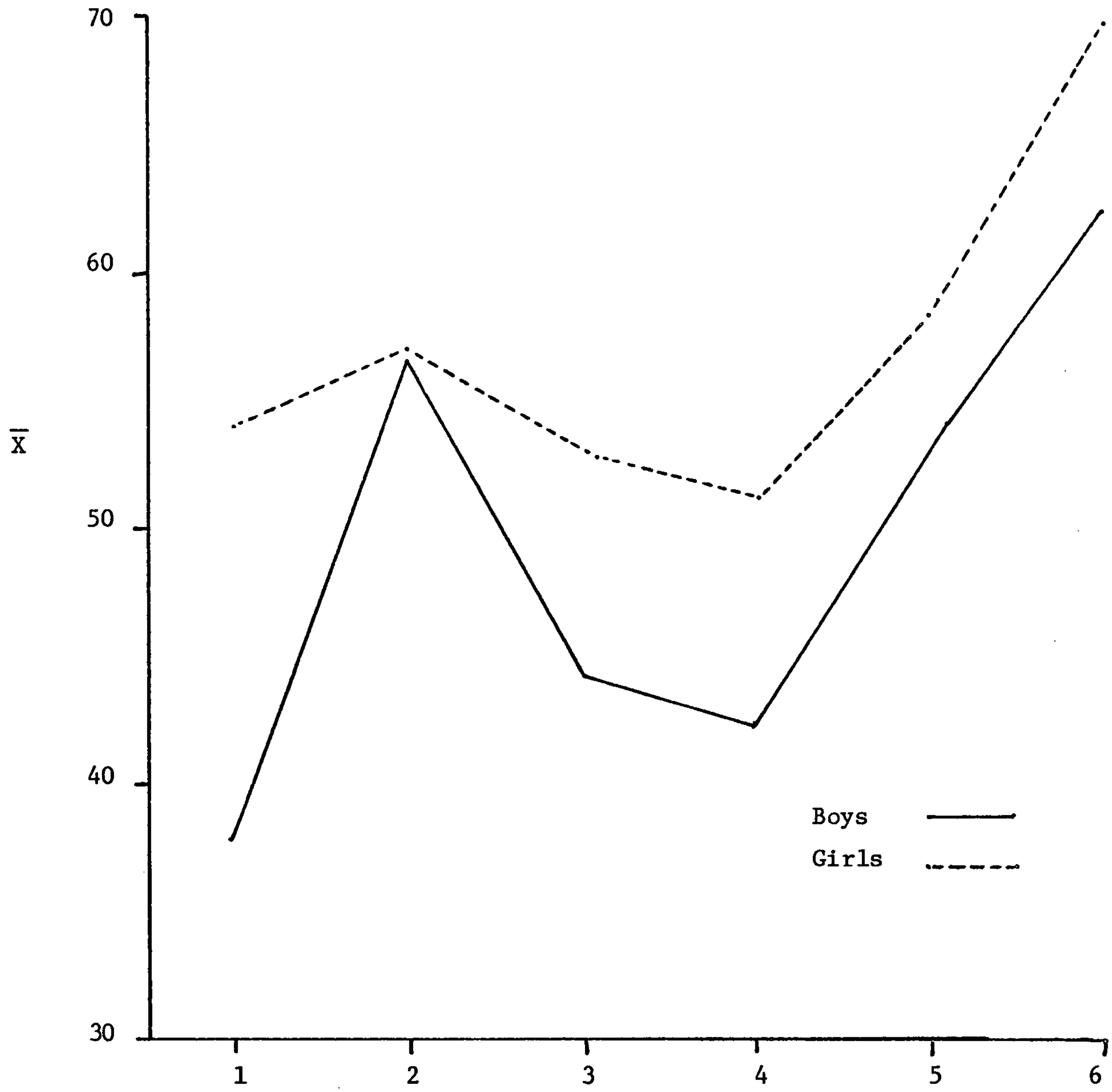


Figure 7. Figural elaboration mean scores by grade and sex to illustrate the "Grade Four Slump." (Graph drawn from data on Table I, Appendix B.)

In this review, where possible, only deaf and hearing Caucasian children's data on figural creativity will be reported since Negroid children were not involved in this research.

Kaltsounis used a multivariate analysis of variance (MANOVA) statistical technique for analysing his data. He set the level of statistical significance at .01 on a two-tailed test.

2.52 Kaltsounis' Results

Kaltsounis found deaf children to be significantly superior to hearing children as measured on the TTCT, Figural Form A. For all figural factors the deaf children's mean scores were higher. They were significantly higher statistically at the .01 level on figural flexibility, figural originality, and figural elaboration.

This superiority was also reflected in sex groups. Deaf boys' mean scores were higher than hearing boys', and deaf girls' mean scores higher than the hearing girls'. Hearing boys scored higher than the hearing girls on figural originality, significant at the .01 level, and only slightly higher on figural elaboration. Deaf boys also scored higher than the deaf girls on figural originality (not significantly so), but deaf girls scored slightly higher on figural elaboration. Deaf girls' mean scores were significantly superior over deaf boys' on figural fluency.

Table 1 shows Kaltsounis' deaf-by-grade results. For figural fluency and figural originality the deaf children scored higher in grades 1, 4, 5, and 6, and for figural flexibility, higher in all grades. For figural elaboration there was little difference between the groups in grades 1 and 2, but thereafter the deaf children's mean scores increased, and the hearing children's mean scores declined, until grade 6.

Overall, the deaf children's mean scores increased with grade with only slight declines at grade 3 for figural fluency, figural flexibility, and figural originality, and at grade 5 for figural elaboration. Figural originality was the only factor that showed a terminal decline for the deaf.

The hearing children showed an overall erratic development with terminal declines in all factors except figural elaboration. Furthermore, the hearing children registered minimum mean scores at grade 4 in all four factors. This showed evidence of the "Grade Four Slump." No such slump was evident with the deaf children.

Kaltsounis did not separate Caucasian and Negroid deaf children's scores in his sex-by-grade study. However, since race differences were not significant, Kaltsounis' results are a good indication of the trends of the deaf Caucasian children.

Table 2 shows Kaltsounis' sex-by-grade results. Sex was not a statistically significant factor by grade. There were no significant differences between deaf boys' and deaf girls' mean scores at any grade level. A common pattern can be noticed. Deaf girls' mean scores were higher in grades 1, 2, and 3, but then in all four divergent production factors the deaf boys' mean scores were higher in grade 4.

2.6 Summary of Chapter

Rogers (1968) and Torrance (1964) have reported that disadvantaged children tend to be superior to advantaged children on figural fluency and elaboration. Deaf children can be considered disadvantaged because they have a poor verbal input just like hearing disadvantaged children. One can expect deaf children and disadvantaged children to produce similar results. The results of Kaltsounis (1970) support this statement.

Kaltsounis (1970) indicated that overall, deaf children were significantly superior to the hearing children as measured on the TTCT, Figural Form A. Deaf boys' mean scores were superior to hearing boys' mean scores, and deaf girls' to hearing girls'. Furthermore, the deaf children's mean scores tended to increase with grade level but with no "Grade Four Slump", whereas the hearing children's mean scores tended to increase to grade 3 and slump at grade 4. They did not show any general increase with grade level.

Deaf girls' mean scores were higher than the deaf boys' on all figural factors in grades 1, 2, and 3, then the deaf boys' became higher on all factors in grade 4.

Kaltsounis (1970) obtained his data by administering the TTCT, Figural Form A, to the deaf children by using psychologists at the schools for the deaf. His comparison group was a group of hearing children who had been administered the tests two years previously, and who had been given the ordinary verbal instructions.

TABLE 1. Means ($\overline{X}$) and standard deviations (s) of deaf and hearing Caucasian groups of children as measured on figural fluency, flexibility, originality, and elaboration. (From Kaltsounis 1970, pp. 15 and 91.)

	Grade	1	2	3	4	5	6
Figural Fluency							
Hearing	$\overline{X}$	16.91	21.83	20.54	16.46	19.29	15.50
	s	6.69	7.27	6.16	5.53	5.06	5.52
Deaf	$\overline{X}$	20.24	20.97	19.22	20.00	20.35	25.32
	s	5.56	4.85	5.33	5.07	5.09	4.35
Figural Flexibility							
Hearing	$\overline{X}$	12.73	15.86	14.49	12.63	14.52	12.70
	s	4.77	5.13	4.36	4.42	4.11	4.99
Deaf	$\overline{X}$	17.84	18.23	15.78	16.17	17.14	21.18
	s	4.24	4.25	4.61	3.85	3.36	3.67
Figural Originality							
Hearing	$\overline{X}$	16.98	35.52	17.28	13.16	17.04	16.36
	s	8.54	3.44	7.76	5.70	5.92	8.64
Deaf	$\overline{X}$	21.96	23.43	17.06	23.69	32.86	29.59
	s	7.19	6.55	4.02	7.51	4.87	6.01
Figural Elaboration							
Hearing	$\overline{X}$	49.87	65.69	31.04	26.54	29.44	37.83
	s	23.00	27.29	13.90	10.86	11.17	34.55
Deaf	$\overline{X}$	53.68	54.17	65.61	73.86	66.49	80.68
	s	16.15	11.66	19.20	39.74	23.81	20.82
N Hearing		128	104	102	90	81	100
Deaf		25	35	18	35	37	22

TABLE 2. Means ($\overline{X}$) and standard deviation (s) of deaf Negroid and Caucasian boys and girls as measured on figural fluency, flexibility, originality, and elaboration. (From Kaltsounis 1970, pp. 14 and 77.)

	Grade	1	2	3	4
Figural Fluency					
Deaf boys	$\overline{X}$	16.70	18.25	16.50	22.47
	s	5.55	5.42	7.04	6.10
Deaf girls	$\overline{X}$	20.06	20.96	20.04	21.51
	s	7.41	6.13	5.18	5.50
Figural Flexibility					
Deaf boys	$\overline{X}$	14.95	16.50	14.14	18.15
	s	4.65	5.04	5.72	4.45
Deaf girls	$\overline{X}$	17.22	17.62	15.92	17.83
	s	5.42	5.73	4.18	3.76
Figural Originality					
Deaf boys	$\overline{X}$	19.35	22.25	19.93	31.92
	s	6.91	6.87	9.55	3.84
Deaf girls	$\overline{X}$	22.06	22.83	21.29	26.34
	s	10.31	7.64	6.75	8.62
Figural Elaboration					
Deaf boys	$\overline{X}$	45.40	45.90	43.93	70.52
	s	15.57	13.44	24.52	24.48
Deaf girls	$\overline{X}$	46.28	52.37	59.52	68.62
	s	22.54	17.65	20.82	34.04
N Deaf boys		20	20	14	60
Deaf girls		18	24	24	53

CHAPTER III

METHOD OF STUDY

3.1 Procedures

The protocols of the TTCT, Figural Form B, were modified (3.3 Instrumentation) to a non-verbal form in order to allow the deaf and hearing children a more equal chance of understanding the test instructions.

This study was in two phases (Figure 8). Phase 1 was a pilot study designed to validate the modified protocols, and Phase 2 was a comparative study of deaf and hearing groups of children using the modified protocols.

3.11 Phase 1

Checking of Modified Protocols. The modified protocols were trial-tested with a group of hearing children in order to ascertain the children's understanding of the modified protocols. An independent observer checked the researcher's activities and observed the children's responses to the researcher's activities. Discussion between the researcher and the observer determined whether the modified protocols needed further modifications.

Selection of Subjects for Phase 1. A large class of 34 hearing boys and 34 hearing girls of grade 3 age level was made available for

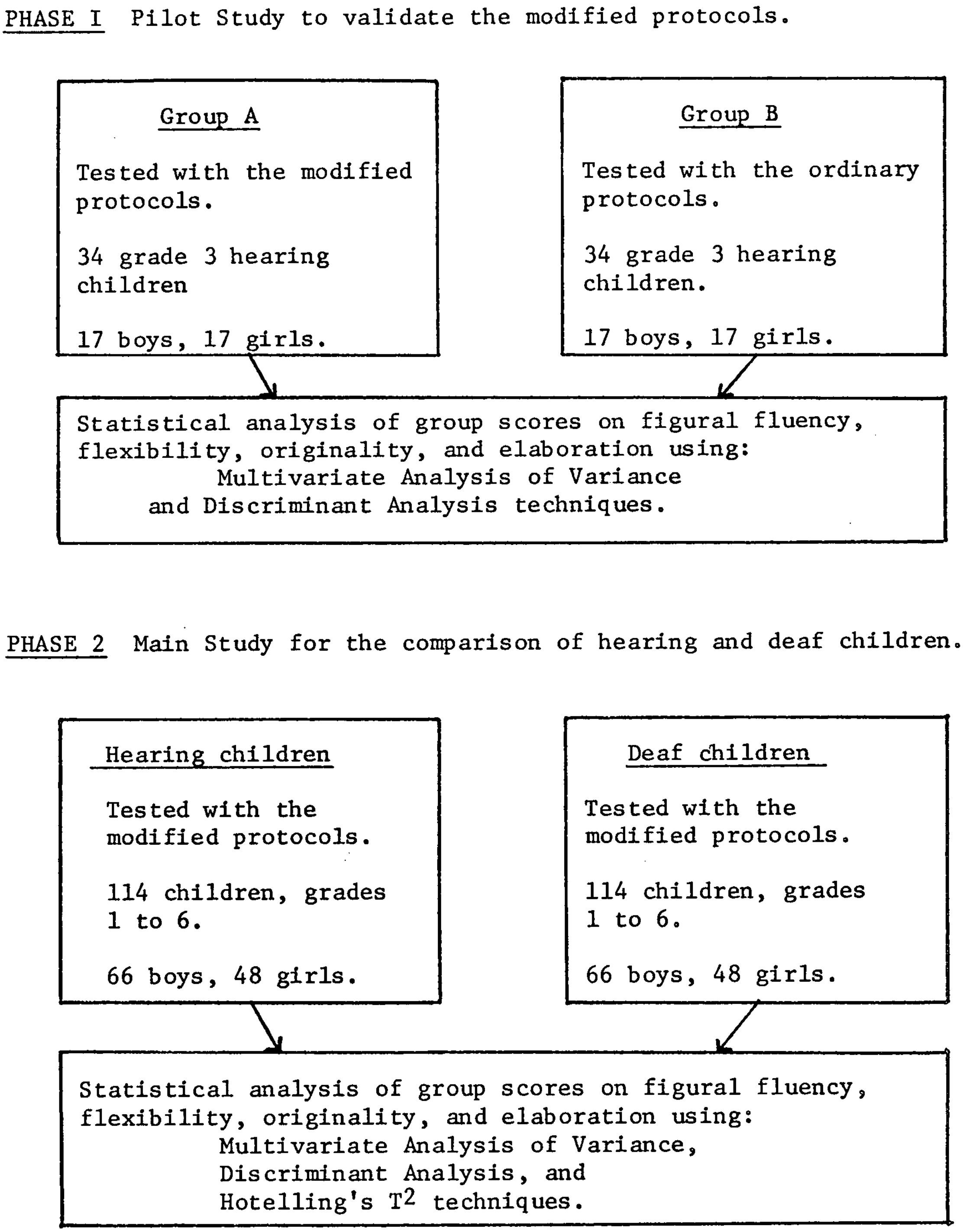


Figure 8. Research design for validating the modified protocols and comparing the groups representing hearing and deaf children.

this study by the principal of an elementary school in Vancouver, B. C. The class was divided into two groups, A and B, using random numbers. The assumption was made that there were no divergent production ability differences between the groups.

Testing of Children. In order to assess the effects of the modified protocols, the TTCT with modified protocols was administered to group A, and the TTCT with the ordinary protocols was administered to group B.

Scoring of Test Instruments. Torrance (1968, p. 8) reports that test scorings by untrained markers have a high correlation with those of professional markers (fluency .96, flexibility .94, originality .86, and elaboration .91). In this case the researcher marked the completed test booklets. Before marking, the test booklets were randomly mixed in order to avoid possible researcher bias towards one group.

Analysing the Data. The figural fluency, flexibility, originality, and elaboration factor scores of the two groups were statistically compared in order to ascertain the differences between group scores due to the use of the different protocols. The statistical methods used were multivariate and univariate analysis of variance techniques (see 3.5 Statistical Treatment).

3.12 Phase 2

Selection of Samples. Personal data on the deaf children in the form of date of birth and sex was provided by the principals of the schools for the deaf.

The hearing children were drawn from an ordinary elementary school so as to correspond to the deaf group according to age and sex, (see 3.2 Populations and Samples). There were 114 children in each group.

Testing of Children. In order to compare the deaf children as a group, the TTCT, Figural Form B, with the modified protocols were administered to both deaf and hearing groups. The children were tested in class groups of approximately seven deaf children per class and thirty-four hearing children per class.

Scoring of Instruments. The test booklets of both the deaf and the hearing groups were randomly mixed into one pile. They were then marked by the researcher.

Analysis of Data. The figural fluency, flexibility, originality, and elaboration scores of the deaf and hearing groups were statistically compared by MANOVA, discriminant, and Hotelling's T^2 analysis techniques in order to test the hypotheses.

3.2 Population and Samples

3.21 Selection of Subjects for Phase 2

The deaf children for Phase 2 were sampled from two large urban areas in Western Canada: Vancouver, British Columbia, and Edmonton, Alberta. The children were from two day/residential schools for the deaf which are designated for both deaf and hard-of-hearing children. The school principals reported that all the children were prelingually deaf. Children with other handicaps such as blindness, speech organ defects, and physical deformities were not used in this study. Because nearly all the deaf children in Western Canada attend the two major day/residential schools then the deaf subjects of this study were virtually all the grade 1 to 7 deaf and hard-of-hearing children in Western Canada. Consequently, the subjects can be considered as a statistical population.

The hearing children were drawn from one urban area in which one of the schools for the deaf is located. The administration of the local school board was approached, and was requested to choose an elementary school within the board's jurisdiction so that lower, middle and upper socio-economic groups of parents were represented. From this school a group corresponding in age and sex to the deaf group was chosen using random numbers.

The deaf boys and girls were tabulated separately. On the tables they were ordered according to month and year of birth. There were 66 deaf boys and 48 deaf girls. Using random numbers, the class lists of the hearing children were scanned until pupil "X" was noted. If pupil "X" corresponded in sex and age level to a deaf child then pupil "X" was added to the table. If pupil "X" did not correspond to the table or if another hearing child had already filled a possible place then pupil "X" was rejected.

This procedure was continued until a group of hearing children was chosen corresponding in age and sex to the group of deaf children.

3.22 Coding the Subjects

All children's names were replaced by code numbers in order to protect their privacy. The coding of the children's names was as follows:

the children were ordered chronologically in each grade and then numbered 1, 2, 3, . . . respectively within the grade. The following code was then used:

D = deaf child

H = hearing child

B = boy

G = girl

1, 2, 3, . . . = grade level according to age

01, 02, 03, . . . = child's number in grade as ordered by age.

For example, DG102 = a deaf girl in grade 1 who is second oldest in her grade level.

3.3 Instrumentation

3.31 Introduction

Divergent production ability has been described as having four factors - fluency, flexibility, originality, and elaboration. For the purposes of this study the TTCT, Figural Form B, was chosen because the test is designed to measure these four factors. Although the test is categorized as a test for creativity, Torrance (1966) stated: "A high degree of these abilities . . . does not guarantee that the possessor will behave in a highly creative manner. A high level of these abilities, however, increases a person's chance of behaving creatively" (p. 7). Torrance used the four divergent production factors as predictors of creativity.

Guilford (1967) also stated "In a study . . . the results added another kind of ability, elaboration, to be considered along with fluency, flexibility, and originality, to make up the set that was to become known as divergent production abilities" (p. 138). In this study the TTCT, Figural Form B, was used.

3.32 The Instrument

The TTCT, Figural Form B booklet has three drawing activities: 1) Picture Construction, 2) Picture Completion, and 3) Circles. Under test conditions each activity is timed ten minutes. Activity 1 consists of a hot-dog shaped piece of red adhesive paper. The tested child is instructed to remove a protective paper backing from the adhesive surface, stick the shape to the next page, and construct any picture with the shape as a central part. A line for 'Your Title' is printed at the bottom of the page. Activity 2 has ten 3 x 3 inch squares each containing a different figural shape such as the examples in Figure 9. The child is instructed to add lines to each shape in order to produce ten pictures.

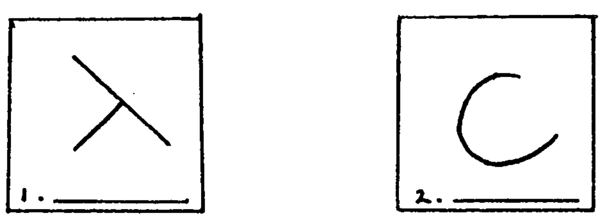


Figure 9. Examples of Picture Completion Activities in the TTCT, Figural Form B.

Under each shape there is a title line. Activity 3 consists of 36 circles each one inch in diameter. There are six circles on one page and thirty on the next. The tested child is expected to draw inside, outside, or in and outside of each circle in order to produce many different pictures. The child is requested to write a title beneath each of his circle pictures. In the test booklet at the beginning of each activity are instructions for that particular activity. Before starting each activity the test administrator reads aloud the instructions while the children read quietly along with him.

Activity 1 is scored on figural originality and figural elaboration, Activity 2 on figural fluency (maximum 10 points) figural flexibility, figural originality, and figural elaboration, and Activity 3 on figural fluency (maximum score 36 points), figural flexibility, figural originality, and figural elaboration. The titles beneath each drawing are necessary, otherwise many of the children's responses would be unrecognizable to the marker.

3.33 The Modified Protocols

The TTCT, Figural Form B booklets, used to test the hearing group A of Phase 1 and the deaf and hearing children of Phase 2, had all verbal instructions masked with paper. The instructions were then mimed and demonstrated by the researcher. The examples used were, where necessary, of zero score for originality as described in the Torrance Tests Scoring Guide (Torrance 1968). Fluency, flexibility, and elaboration factors were demonstrated briefly. This was in order to minimize the educational effects of the demonstration, and to prevent, if possible, 'setting' the children into fixed classes of ideas.

A large booklet, 24 inches by 17 inches, similar to the TTCT, Figural Form B, was constructed by the researcher. It was large enough to enable children at the back of a classroom to see its details when demonstrated at the front of a classroom. The figures in the constructed booklet differed from those in the Figural Form B. For Activity 1 Picture Construction, a rectangular shape was used; for Activity 2 Picture Completion, designs from Figural Form A were used; and for Activity 3 Circles, squares were substituted. The areas where the original test instructions should have been were masked with paper as in the actual test booklets. The pages of the constructed booklet were faced with transparent plastic film that was replaced after each demonstration so that the constructed booklet was re-usable.

3.34 Test Administration

A large clock was used as a timer and a play clock for demonstration purposes. These were placed so as to be visible by the children.

Step 1. The researcher was introduced to the children by the class teacher. The researcher explained to the hearing children that the instructions for the drawing activities were to be non-verbal because deaf children were to be given the same activities and a comparison of drawings was to be made. This explanation was to avert possible anxiety caused by the unusual instructions. Torrance (1966, pp. 28, 29-30) claims that anxiety affects test results.

The class teacher of the deaf children introduced the researcher to the deaf children but the explanation of why the modified protocols were to be used was considered unnecessary.

All children were provided with ordinary black lead pencils for use on the tests.

Step 2. The researcher indicated the play clock and moved its hands to 12 o'clock. He then flashed the classroom lights. (Light flashing was used because the deaf children are accustomed to this signal.) After the lights were flashed the demonstration booklet was opened.

The researcher removed the Picture Construction shape from page one and stuck it to page two. With a black felt pen he drew a house about the shape. A little after-thought elaboration was added, a tree beside the house and smoke from the house chimney.

Step 3. The play clock hands were slowly moved to 12:10 and the classroom lights flashed. The demonstration booklet's page was turned.

The researcher completed three designs to form three completely different pictures of zero originality score (see 1.2 Definition of Terms). This was to encourage flexibility. The completed pictures were:

a) a flying bird

b) a house

c) eyes.

Step 4. The play clock hands were turned to 12:20 and the classroom lights were flashed. The demonstration booklet's page was turned to the last activity - Squares (substituted for Circles).

The researcher completed three different pictures. Slight elaboration was encouraged by drawing inside and outside of the squares. The completed pictures were:

a) a box

b) a book

c) a face.

Step 5. The play clock hands were turned to 12:30 and the classroom lights were flashed. The demonstration booklet was closed.

Step 6. The test booklets were handed out and the children were requested not to write any words until after the drawing session had finished. (This was to encourage the children to draw freely rather than draw only pictures for which they had titles.) The teachers of the deaf were requested to sign these instructions to the deaf children.

The classroom lights were flashed and the test progressed as demonstrated. Individual children with difficulties were helped by the researcher using only mime or demonstration.

Each time the lights were flashed the researcher stood at the front of the class and demonstrated that the booklet's page had to be turned.

Step 7. After the drawing session was completed, the hearing children were asked to write their names, date of birth, and sex on their booklet cover, and to write a title for each of their drawings. The researcher and the class teacher helped the deaf children individually to write the required information and titles. Great care was taken to avoid suggesting titles for apparently recognizable drawings. This titling procedure was necessary because the researcher needed to know what the children had drawn in order that he could score the children's responses because some drawings were unrecognizable. Torrance (1968) stated "if the children are unable to write their own titles or labels, be prepared to interview each child briefly to obtain titles or labels. Otherwise, reliable scoring of the pictures will not be possible" (p. 7).

3.4 Limitations of the Study

3.41 Limitations Due to Sample Selection

The deaf subjects involved in this study were from two schools for the deaf. Individual classes for the deaf had age ranges spanning two or three grade levels. Consequently, individual teacher differences were minimized by changing class grouping into grade-level-by-age grouping. This minimization of teacher differences was not possible with the hearing subjects because age spans in individual classes were not as broad as in the classes of the deaf. Differences in test administration were minimized by having one researcher give the test instructions to each class, both for deaf and hearing children.

Inability of hearing people to clearly communicate with deaf people causes many difficulties. Such questions as: "Does he really understand what I mean?" or "Am I clearly understanding what he is trying to express?" frequently puzzled the researcher while he worked with the deaf children on science units. The approach of this research was specifically designed to overcome these communication difficulties through the use of non-verbal instructions (see 3.1 Procedures), and by the measurement of only observable figural products. Even so, the clarity with which each child received the test instructions is unknown.

3.42 Limitations Due to Measuring Techniques

The TTCT, Figural Form B, measures non-verbal divergent products only. Divergent production of verbal forms were not measured due to the language limitations of the deaf children. Torrance (1966, p. 82) showed the correlations between verbal and figural divergent production abilities to be moderate to low (fluency .52, flexibility .37, originality .43, and elaboration .18). Consequently, generalizations about all divergent production, i.e., combined verbal and figural, can not be made. Data for this study are strictly limited to scores for figural production.

Figural production is observable and therefore measurable. However, the amount of divergent thinking may be vast compared with what is outwardly expressed. If a child had an idea but did not outwardly express it on the test booklet then the product was unavailable as data. This study, then, is limited to the observable products drawn by individual children on their test booklets.

3.5 Statistical Treatment

3.51 Phase 1 and Hypotheses 1 to 5 of Phase 2

In Phase 1 the groups employing the modified and regular protocol were compared on measures for divergent production by univariate- and multivariate-F tests and discriminant analysis. The hypotheses 1 to 5 of Phase 2 were tested in order to determine if the variables of hearing status and sex were discriminating factors among the groups. To test these hypotheses the data was analysed using univariate F-tests for the individual divergent production abilities, multivariate F-tests for overall group comparisons, and discriminant analyses for the statistically significant groups as revealed by the F-tests in order to determine the dimensions along which the group differences occurred (Tatsuoka 1971).

The computer was programmed to utilize a formula for independent and numerically unequal groups. The computer calculated and printed out means, standard deviations, mean squares, univariate and multivariate F-ratios and associated probabilities, and discriminant analysis data.

3.52 Hypotheses 6 to 10 of Phase 2

In order to compare the within-grade groups of Hypotheses 6 to 10 of Phase 2 on the four divergent production abilities, the hypotheses were tested using Hotelling's T^2 (Bjerring 1972, p. 84). The Hotelling's T^2 programme takes all variables into consideration together rather than individually. By considering all variables together the programme circumnavigates the problem of finding some statistically significant differences simply due to the number of variables involved.

3.53 Discriminant Analysis

Table 3, adapted from Torrance (1966, p. 82), shows the correlations between the figural factors of divergent production as measured on the TTCT, Figural Forms. The correlations indicate a degree of overlap or the presence of common subfactors between corresponding pairs of the four factors. This may mean that the figural factors are not independent of each other.

For example, if factor P correlates even slightly with factor Q then there is a probability that a common subfactor, perhaps A, exists

TABLE 3. Intercorrelations of the figural factor scores of 608 grade 6 pupils as measured on the TTCT, Figural Forms. (From Torrance 1966, p. 82.)

	Figural Flu.	Figural Flex.	Figural Orig.	Figural Elab.
Figural Fluency	1.00	.77	.68	.20
Figural Flexibility		1.00	.66	.18
Figural Originality			1.00	.34
Figural Elaboration				1.00

such that P = X + A and Q = Y + A, where X and Y are completely independent subfactors. If P varies then Q <u>may</u> vary simultaneously due to the common subfactor A. ('May' is emphasized because P could vary due to X while A remains constant.)

If groups are compared by their means and standard deviations only these possible overlaps are ignored. For example, higher fluency and flexibility mean scores of one group over another group may be due to overlap from fluency and flexibility. Consequently there is the possibility of making an erroneous assumption that the first group scores higher on both fluency and flexibility when, in fact, overlap from fluency into flexibility causes both factors to vary simultaneously. Tatsuoka (1970) stated, "The danger of getting a distorted picture of the group differences <u>tends</u> (Tatsuoka's emphasis) to increase as the correlations among the variables become larger" (p. 2).

To overcome these possible distortions due to overlaps, the data of the statistically significant groups as checked by the multivariate and univariate F-tests is further tested by discriminant analysis, as described by Tatsuoka (1970). By differentially weighting the variances of the figural factor scores of the compared groups, and by forming the weighted factors into linear combinations, the multivariate problem is reduced to a univariate one; and by summing the multiples of the raw mean scores and the raw score weights, discriminant group means (group centroids) are calculated. The centroids are then plotted along a discriminant dimension determined by the high positive and negative standardized raw score weights. The relative positions of the group centroids along the dimension reveal the divergent production factor (or factors) that distinguish the groups and the relative magnitude of the difference.

For the purposes of this study the level of significance was set at .05 for a two-tailed test, since there was no predicted direction of the results. This level was chosen on the accepted practice of minimizing the possibility of committing type I and type II errors.

3.6 Hypotheses

In 1.1, Statement of the Problem, the researcher reported that his observations of the deaf children were not formally compared with his observations of the hearing children. Consequently the suggested divergent production differences between deaf and hearing children were only speculative. Furthermore, there is some disagreement in the literature regarding the polarity of these possible differences. Due to these uncertainties the following null hypotheses have been developed:

There are no significant differences on measures for divergent production by the TTCT, Figural Form B, using modified protocols, between the scores of the groups representing:

Hypothesis 1. Deaf and hearing children

Hypothesis 2. Deaf and hearing boys

Hypothesis 3. Deaf and hearing girls

Hypothesis 4. Deaf boys and deaf girls

Hypothesis 5. Hearing boys and hearing girls.

And furthermore, in order to ascertain the within grade effects:

Hypothesis 6. Deaf and hearing children

Hypothesis 7. Deaf and hearing boys

Hypothesis 8. Deaf and hearing girls

Hypothesis 9. Deaf boys and deaf girls

Hypothesis 10. Hearing boys and hearing girls.

Hypotheses 1 - 5 were tested using multivariate and discriminant analysis, and Hypotheses 6 - 10 using Hotelling's T^2 analysis techniques, as detailed in 3.4, Statistical Treatment.

3.7 Summary of Chapter

The TTCT, Figural Form B, was chosen to measure the divergent production factors, figural fluency, flexibility, originality, and elaboration. The protocols of the test were modified to a non-verbal form (mime and demonstration) in order to facilitate administration to both hearing and deaf children.

The modified protocols were trial tested in a Pilot Study employing a class of 68 hearing children randomly split into two groups. However, one group had two absentees. Statistical analysis of the raw data revealed the modified protocols to have a possible educative effect.

For the Main Study 114 hearing and 114 deaf subjects were administered the divergent production activities using the modified protocols for both groups. An assumption was made that the possible educative effect would be the same for both groups.

Classroom teacher effect, and varying clarity of the reception of the modified protocols by the subjects were seen as limitations and minimized where possible.

The raw data collected in the Pilot Study and Main Study were processed using univariate and multivariate analysis of variance, discriminant analysis where F-tests were significant, and Hotelling's T^2 statistic for the within grade effects. Null hypotheses were proposed for the Main Study in order to compare the hearing and deaf groups on hearing status, sex, and within grade effects.

CHAPTER IV

RESULTS

4.1 Introduction

First to be presented are the results of Phase 1, The Pilot Study, which was designed to check the effects of the modified protocols.

Next are the results of Phase 2. The means, standard deviations, multivariate and univariate F-values and probabilities of figural fluency, flexibility, originality, and elaboration for the main effects of hearing status and sex are presented in table form and are appropriately described. This is followed by the within-grade means, standard deviations, and graphical representations of the grade by grade development of the above main effects.

Comparison of these results, with those of other studies, is left until Chapter V.

4.2 Phase 1, The Pilot Study

A large class of 34 hearing boys and 34 hearing girls was randomly split into two groups, each comprised of 17 boys and 17 girls. Group A, which due to absenteeism finally had 16 boys and 16 girls, was administered the modified protocols as described in 3.33, The Modified Protocols, and the other group, B, was administered the regular protocols as described in 3.32, the Instrument. The collected data was analysed by MANOVA and discriminant analysis techniques. The results showed group A to be significantly superior statistically at the .05 level on a two-tailed test with an actual multivariate F-ratio of 7.006 and an associated F-probability of .0002. Individual figural factors showed significant differences on fluency and elaboration, and almost reached significance on flexibility.

The researcher concluded that the modified protocols have an educative effect, especially for figural fluency and elaboration which had computed univariate F-probabilities of .0009 and .0001 respectively. Because of the probable educative effect, the results of Phase 2 can not be compared directly with other studies such as Kaltsounis (1970). However, because both deaf and hearing groups were given the same modified protocols in Phase 2, internal comparisons can be made and patterns of development can be observed.

In Chapter V these patterns of development are compared with those of other studies such as Kaltsounis (1970) and Torrance (1967).

Detailed results of Phase 1 are given in Appendix C.

4.3 Phase 2, The Main Study

4.31 Introduction

The means and standard deviations of the groups representing deaf and hearing boys and girls are given in Tables 4 and 5.

As discussed in 3.5, Statistical Treatment, the significant or non-significant differences of the univariate F-tests on the four figural factors: fluency, flexibility, originality, and elaboration, can not be taken at face value if the factors are inter-correlated. Table 6 shows the inter-correlations of the factors for all the subjects, both deaf and hearing. Flexibility, according to the table, is highly correlated with fluency, and none of the other correlations are trivial. This suggests that statistically significant results may be due to overlap.

The principal-components analysis (Table II, Appendix B) and latent roots (Table III, Appendix B), reveal four components, the first of which is predominantly a single dimension of fluency and flexibility although the other two factors also load highly on it. Component II appears to be a bipolar dimension which could be called an originality/flexibility dimension. Component III appears to be a bipolar dimension of originality/elaboration, and Component IV of flexibility/fluency. Thus there appears to be a general dimension of divergent production underlying the scales (Component I) and three specific bipolar dimensions. Clearly the significance of the univariate F-tests of this study's results (Table 8) can not be taken at face value.

Comparison for the Hypotheses 1 and 5 which reached statistical significance are therefore tested with discriminant analysis techniques in order to ascertain the underlying nature of the group differences.

TABLE 4. Means ($\overline{X}$) and standard deviations (s) of the deaf and hearing groups of children as measured on the TTCT, Figural Form B, using the modified protocols.

		Figural Flu.	Figural Flex.	Figural Orig.	Figural Elab.
Hearing Boys and Girls	$\overline{X}$	21.27	14.60	21.08	95.99
N - 114	s	6.17	4.06	8.55	31.58
Deaf Boys and Girls	$\overline{X}$	21.18	13.39	18.66	88.35
N = 114	s	6.58	3.70	7.82	37.81

TABLE 5. Means ($\overline{X}$) and standard deviations (s) by hearing status and sex of the groups of deaf and hearing children as measured on the TTCT, Figural Form B, using the modified protocols.

		Figural Flu.	Figural Flex.	Figural Orig.	Figural Elab.
Hearing Boys	$\overline{X}$	20.76	14.27	22.17	93.73
N = 66	s	6.22	4.11	8.53	32.10
Hearing Girls	$\overline{X}$	21.98	15.04	19.58	99.10
N = 48	s	6.10	3.98	8.45	30.91
Deaf Boys	$\overline{X}$	20.83	13.30	19.42	84.24
N = 66	s	5.74	3.42	8.32	33.92
Deaf Girls	$\overline{X}$	21.65	13.50	17.60	94.00
N = 48	s	7.63	4.09	7.02	42.31

TABLE 6. Intercorrelations between the divergent production factors as measured on the TTCT, Figural Form B, using all subjects scores (N = 228).

Factors	Fluency	Flexibility	Originality	Elaboration
Fluency	1.00	.74	.38	.56
Flexibility		1.00	.39	.34
Originality			1.00	.44
Elaboration				1.00

TABLE 7. Results of the comparison by multivariate analysis of variance of the groups representing hearing and deaf children as measured on the TTCT, Figural Form B, using modified protocols.

Source of variation	Degrees of freedom	F-ratio $V_1 = 4$ $V_2 = 221$	p
Sex			
Boys vs girls	1	3.348	<.001*
Hearing status			
Hearing vs deaf	1	4.555	<.001*
Hearing status & sex			
Hearing boys vs deaf boys	1	1.991	<.097
Hearing girls vs deaf girls	1	1.591	<.178
Deaf boys vs deaf girls	1	2.026	<.092
Hearing boys vs deaf girls	1	2.764	<.029*

* = significant on a two-tailed test at $\alpha < .05$ level.

TABLE 8. Results for the comparison by univariate analysis of variance of deaf and hearing children as measured on the TTCT, Figural Form B.

Source of Variation	Df		Figural Flu.	Figural Flex.	Figural Orig.	Figural Elab.
Hearing status						
Hearing vs deaf	1	F-ratio	.013	5.516	5.022	2.752
		F-prob<	.909	.020*	.026*	.099
Hearing status and sex						
Hearing boys vs deaf boys	1	F-ratio	1.017	1.085	2.788	.665
		F-prob<	.314	.299	.096	.416
Hearing girls vs deaf girls	1	F-ratio	0.450	0.071	1.384	2.189
		F-prob<	.503	.790	.241	.140
Deaf boys vs deaf girls	1	F-ratio	0.065	3.768	1.413	0.517
		F-prob<	.799	.054	.236	.473
Hearing boys vs hearing girls	1	F-ratio	0.005	2.050	3.731	2.456
		F-prob<	.946	.154	.055	.119

* = significant on a two-tailed test at the $\alpha < .05$ level.

Mean Squares and Error terms for the above univariate analysis of variance are presented in Table IV, Appendix B.

4.32 Results - Multivariate Analysis of Variance (MANOVA)

The MANOVA tests (Table 7) show that boys and girls, not taking hearing status into account, do differ significantly at the $\alpha < .05$ level on divergent production ability as measured by the TTCT, Figural Form B, using modified protocols, with all four factors taken in toto. On the other hand, the statistical difference between the hearing and deaf children while significant, does not seem to be due primarily to sex differences since only the sub-groups hearing boys and hearing girls show statistical significance. It would seem that another, yet untested, variable may be responsible for the significant difference between hearing and deaf children.

4.33 Results - Hypotheses 1 to 5

Hypothesis 1. The hypothesis for the comparison of the groups representing hearing and deaf children as measured on the factors, figural fluency, flexibility, originality, and elaboration may be rejected.

Table 4 shows the groups' means and standard deviations on each figural factor. The hearing children's means scores were greater than the deaf children's mean scores for all factors. The MANOVA test (Table 7) showed the hearing children to be significantly superior at the $\alpha < .05$ level on a two-tailed test with an actual F-ratio of 4.555 and an associated F-probability of .001. The univariate analysis of variance (Table 8) indicated the hearing children to be significantly superior at the $\alpha < .05$ level on figural flexibility and originality.

As discussed in 4.31, Introduction, the results of the univariate F-tests are open to suspicion. Consequently, the results under Hypothesis

1 (the comparison of hearing and deaf children) are subjected to discriminant analysis in order to determine the discriminating dimensions along which the groups may be distinguished.

The discriminant analysis of the data from the hearing and deaf children (Table 9) showed the discriminant function coefficients weighting in favour of figural fluency and flexibility (not figural flexibility and originality as suggested by the F-tests). The groups were differentiated at the flexibility end of a figural fluency/flexibility dimension (Figure 10). The hearing group, therefore, was discriminated from the deaf group along a figural fluency/flexibility dimension with flexibility being the major distinguishing factor between the groups.

Hypothesis 2, Hearing and deaf boys. The hypothesis for the comparison of hearing and deaf boys should be retained.

Although the hearing boys' mean scores (Table 5) were greater on figural flexibility, originality, and elaboration, and the deaf boys' greater on figural fluency, neither the multivariate F-test (Table 7) nor the univariate F-tests (Table 8) reached statistical significance.

Hypothesis 3, Hearing and deaf girls. The hypothesis for the comparison of the hearing and deaf girls should be retained.

The mean scores (Table 5) of the hearing girls were higher than those of the deaf girls on all figural factors but none reached statistical significance on the univariate F-tests (Table 8). The composite multivariate F-test produced an F-ratio of 1.591 with an associated F-probability of 0.1776 which is not significant at the predicted $\alpha < .05$ level.

TABLE 9. Discriminant function weights for the groups representing hearing and deaf children as measured on the figural factors, fluency, flexibility, originality, and elaboration.

Variable	Raw score weight	Standardized weight
Fluency	0.205	1.309
Flexibility	-0.310	-1.205
Originality	-0.036	-0.291
Elaboration	-0.017	-0.582

TABLE 10. Discriminant analysis - Group means ($\overline{X}_k$) and group centroids ($\overline{Y}$) for the groups representing hearing and deaf children.

	Figural Fluency $\overline{X}_1$	Figural Flexi-bility $\overline{X}_2$	Figural Origi-nality $\overline{X}_3$	Figural Elabo-ration $\overline{X}_4$	Centroid $\overline{Y}$
Hearing	21.27	14.60	21.08	95.99	-2.55
Deaf	21.18	13.39	18.66	88.35	-1.98

$$\overline{Y} = v_1\overline{X}_1 + v_2\overline{X}_2 + v_3\overline{X}_3 + v_4\overline{X}_4$$

where v_k = the raw score weight (Table 9).

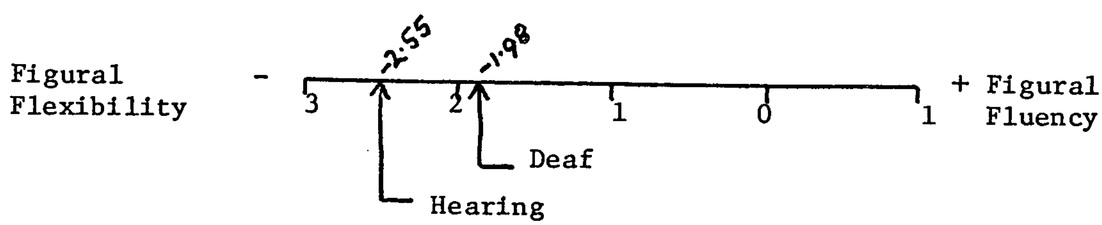


Figure 10. Group centroids along the discriminant dimension for the groups representing hearing and deaf children.

Hypothesis 4, Deaf boys and girls. The hypothesis for the comparison of the deaf boys and girls should be retained. Neither the multivariate F-test (Table 7) nor the univariate F-tests (Table 8) reached statistical significance.

The deaf boys' mean scores were greater than the deaf girls' mean scores on figural originality only (Table 5). The deaf girls' mean scores were slightly higher on figural fluency and flexibility but substantially higher, 94.0 to 84.2, on figural elaboration.

Hypothesis 5, Hearing boys and girls. The hypothesis for the comparison of the hearing boys and girls may be rejected. On the multivariate F-test (Table 7) the F-ratio was 2.764 with an associated F-probability of .029 which is statistically significant at the $\alpha < .05$ level on a two-tail.

The hearing boys' mean scores were greater than the hearing girls' mean scores on figural fluency, flexibility, and elaboration, and almost significantly superior on figural originality with a univariate F-ratio of 3.731 having an associated F-probability of .055 (Table 8).

Results of the discriminant analysis, shown in Tables 11 and 12, reveal that the discriminant function coefficients weighted in favour of figural fluency and flexibility (note Component IV, Table II, Appendix B), but with a strong figural elaboration influence also in association with the figural flexibility. This indicated the groups to be discriminated along a figural fluency/flexibility plus elaboration dimension. Figure 11 further indicates that the group centroids are placed at the figural flexibility plus elaboration end of the dimension which shows

TABLE 11. Discriminant function weights for the groups representing hearing boys and girls as measured on the figural factors, fluency, flexibility, originality and elaboration.

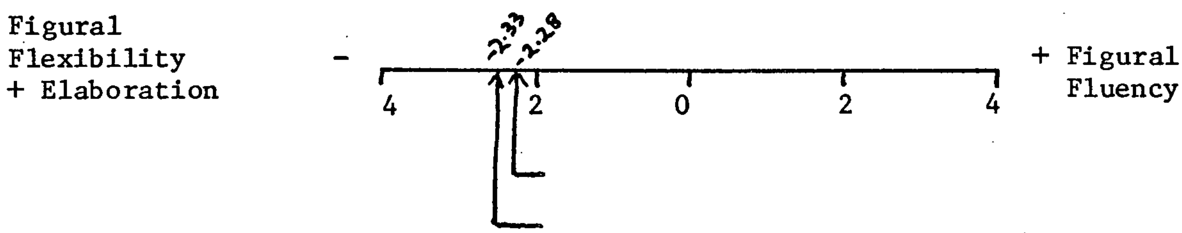
Variable	Raw score weight	Standardized weight
Fluency	.205	1.309
Flexibility	-.261	-1.016
Originality	-.045	-0.371
Elaboration	-.020	-0.694

TABLE 12. Discriminant analysis - Group means ($\overline{X}_k$) and group centroids ($\overline{Y}$) for the groups representing hearing boys and girls.

	Figural Fluency $\overline{X}_1$	Figural Flexi- bility $\overline{X}_2$	Figural Origi- nality $\overline{X}_3$	Figural Elabo- ration $\overline{X}_4$	Centroid $\overline{Y}$
Boys	20.76	14.27	22.17	93.73	-2.33
Girls	21.98	15.04	19.58	99.10	-2.28

$$\overline{Y} = v_1\overline{X}_1 + v_2\overline{X}_2 + v_3\overline{X}_3 + v_4\overline{X}_4$$

where v_k = the raw score weight (Table 11).



<u>Figure 11</u>. Group centroids along the discriminant dimension for the groups representing hearing boys and girls.

that figural flexibility and elaboration were the factors distinguishing the groups rather than figural originality, as suggested by the univariate F-tests.

4.34 Results - Hypotheses 6 to 10

The Hypotheses 6 to 10 for the within-grade comparisons of the groups representing hearing and deaf children by hearing status and sex should be retained. Not one of the Hotelling's T^2 values comparing within-grade level groups on composite factors of figural fluency, flexibility, originality, and elaboration reached the chosen $\alpha < .05$ level of significance for a two-tailed test (Table 13).

However, although none of the hypotheses were rejected, the grade by grade mean scores on the figural factors are described in order to point out possible patterns of development. First to be described are the results of the comparison of the groups representing hearing and deaf children (Table 14). This is followed by a description of the grade by grade results of the groups representing hearing and deaf boys and girls (Tables 15 to 18).

Hearing and deaf children by grade (Table 14)

Figural fluency (Figure 12). On figural fluency the hearing subjects scored higher than the deaf subjects in grades 1,2, and 3 although both groups increased their mean scores. In subsequent grades, the hearing groups' mean scores slumped to below the deaf groups' mean scores, made a slight recovery at grade 5, and then declined again at grade 6. The deaf groups mean scores increased consistently with grade until grade 5 but then declined slightly at grade 6. The deaf groups' mean scores were greater than the hearing groups' in grades 4, 5, and 6.

TABLE 13. Results of the comparison by Hotelling's T^2 analysis of the within grade groups representing hearing and deaf boys and girls as measured on the TTCT, Figural Form B, using the modified protocols.

Source of Variation	Hotelling's T^2	Grade 1	2	3	4	5	6
Hearing Status							
Hearing vs deaf	value	3.183	4.702	9.336	4.334	8.663	3.683
	prob.	0.605	0.370	0.092	0.423	0.122	0.537
	Df =	1/24	1/46	1/40	1/38	1/34	1/24
Hearing Status & Sex							
Hearing boys vs deaf boys	value	2.879	7.178	6.049	6.887	3.222	0.742
	prob.	0.712	0.221	0.329	0.236	0.624	0.957
	Df =	1/12	1/26	1/18	1/24	1/18	1/16
Hearing girls vs deaf girls	value	*	4.303	9.493	4.261	13.30	*
	prob.		0.492	0.137	0.557	0.093	
	Df =		1/18	1/20	1/12	1/14	
Deaf boys vs deaf girls	value	4.795	5.214	8.142	3.558	6.261	*
	prob.	0.522	0.374	0.195	0.581	0.331	
	Df =	1/11	1/22	1/19	1/18	1/16	
Hearing boys vs hearing girls	value	4.713	1.940	0.749	5.917	11.79	*
	prob.	0.530	0.795	0.954	0.339	0.103	
	Df =	1/11	1/22	1/19	1/18	1/16	

* = too few degrees of freedom to compute the Hotelling's T^2 probability.

TABLE 14. Results for the comparison of the groups representing hearing and deaf subjects within each grade level expressed in means ($\bar{X}$) and standard deviations (s).

	Grade	1	2	3	4	5	6
Figural Fluency							
Hearing	$\bar{X}$	19.7	21.4	24.7	21.2	21.9	19.3
	s	5.68	3.82	5.84	5.24	8.65	5.85
Deaf	$\bar{X}$	17.8	20.2	21.0	21.8	23.6	22.5
	s	6.50	6.40	6.76	6.12	6.46	6.05
Figural Flexibility							
Hearing	$\bar{X}$	13.9	14.3	17.2	13.4	15.6	13.7
	s	4.57	2.99	4.43	2.23	5.04	3.39
Deaf	$\bar{X}$	12.0	13.0	13.2	13.4	14.6	14.7
	s	4.60	2.89	4.18	2.91	3.96	3.59
Figural Originality							
Hearing	$\bar{X}$	16.2	22.3	23.5	21.8	23.1	18.5
	s	4.76	10.17	6.65	8.95	8.56	9.07
Deaf	$\bar{X}$	17.2	18.6	20.3	19.8	18.9	16.9
	s	6.77	6.74	11.13	7.74	6.07	8.17
Figural Elaboration							
Hearing	$\bar{X}$	77.3	93.0	95.1	108.4	103.2	98.1
	s	28.50	32.63	24.02	28.84	36.20	35.21
Deaf	$\bar{X}$	75.3	80.5	89.0	93.7	100.4	92.1
	s	41.25	33.80	41.68	28.40	45.40	37.08
N Hearing		13	24	21	20	18	13
Deaf		13	24	21	20	18	13

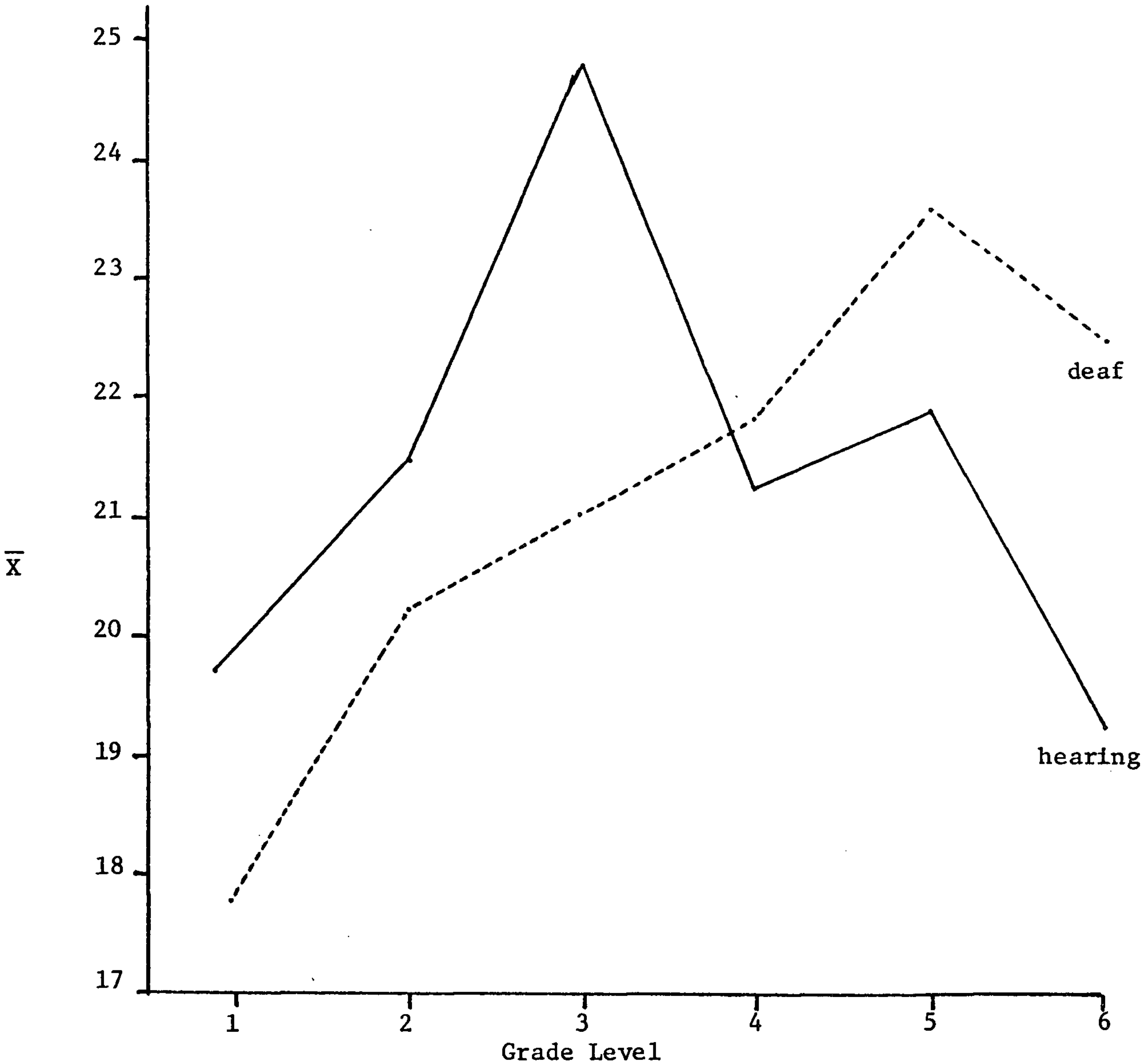


Figure 12. Figural fluency mean scores ($\overline{X}$) by grade of the groups representing hearing and deaf subjects as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data in Table 14.

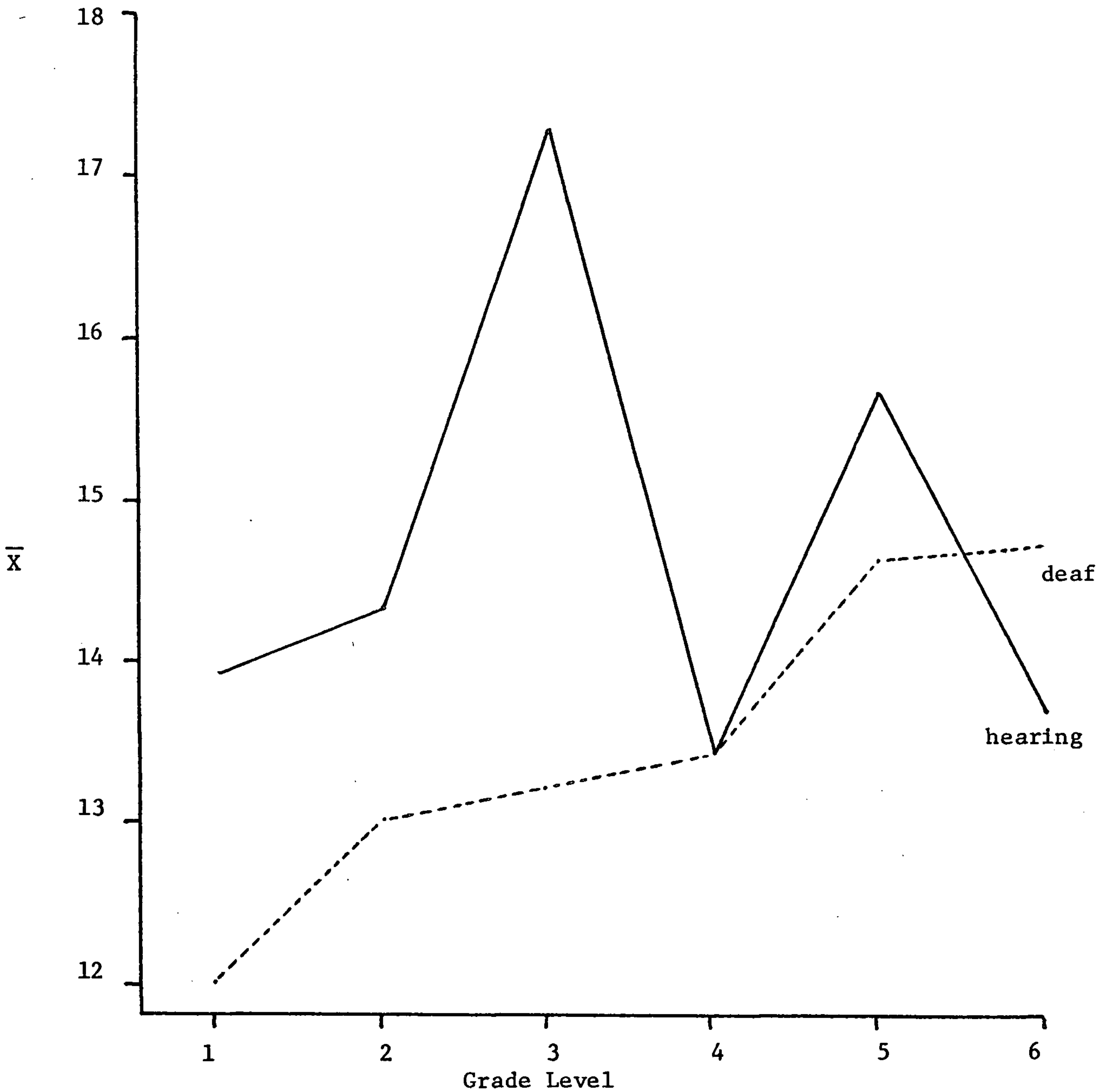


Figure 13. Figural flexibility mean scores (X̄) by grade of the groups representing hearing and deaf subjects as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data on Table 14.

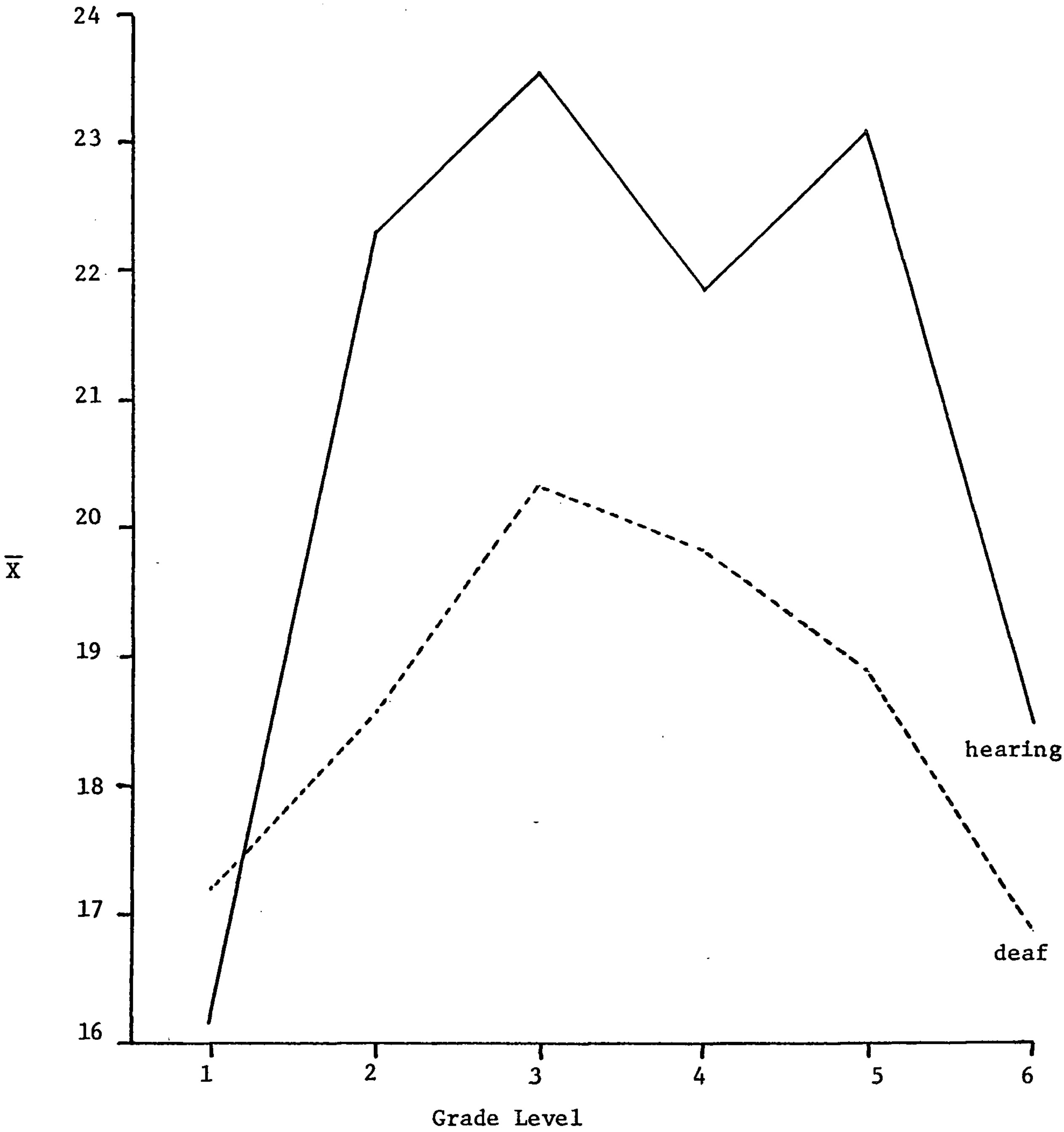


Figure 14. Figural originality mean scores ($\overline{X}$) by grade of the groups representing hearing and deaf subjects as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data on Table 14.

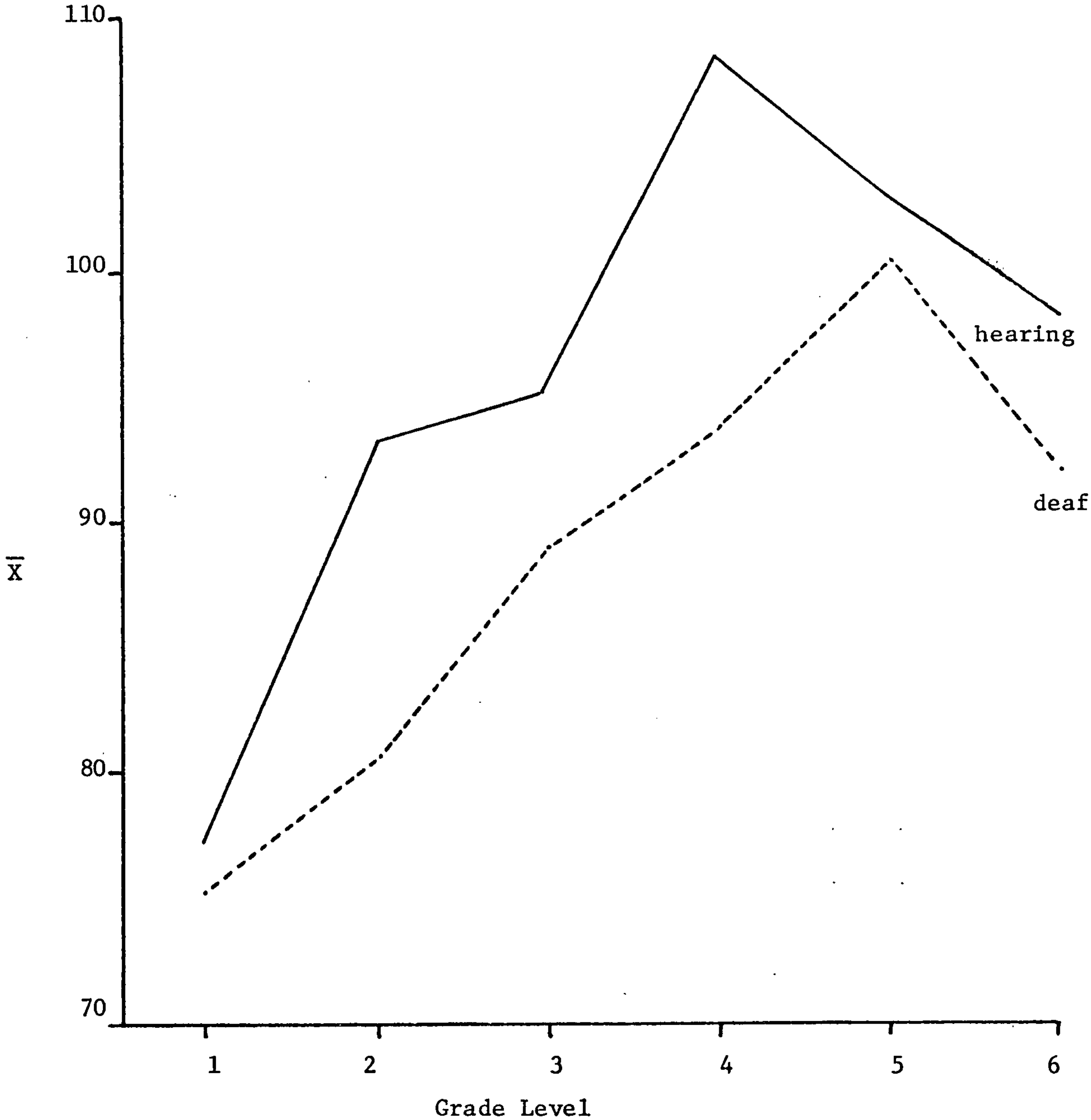


Figure 15. Figural elaboration mean scores ($\overline{X}$) by grade of the groups representing hearing and deaf subjects as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data on Table 14.

The deaf groups' mean scores tended to increase with grade but the hearing groups' mean scores initially increased with grade but declined after grade 3, with grade 6 being its minimum score.

Figural flexibility (Figure 13). On figural flexibility the hearing subjects produced greater mean scores than the deaf subjects in all grades except grades 4 and 6. Deaf subjects' mean scores were greater in grade 6 only. The hearing subjects' mean scores increased to grade 3 and then slumped to a minimum at grade 4. Their mean scores then improved but declined again at grade 6. The deaf subjects' mean scores steadily increased from grade 1 through 5 and then declined only slightly, 0.1 of a mark at grade 6.

Figural originality (Figure 14). The hearing subjects' mean scores were definitely greater than the deaf subjects' on figural originality in all grades except grade 1. Both groups followed a similar pattern whereby their mean scores increased to a maximum at grade 3, and then declined rapidly towards grade 6. However, the hearing group showed a temporary decline at grade 4.

Figural elaboration (Figure 15). On figural elaboration the hearing subjects scored higher than the deaf subjects in all grades. Both hearing and deaf subjects' mean scores increased steadily to grade 4. The hearing subjects' mean scores then declined to grade 6 whereas the deaf subjects' continued to increase to grade 5 before declining at grade 6.

Hearing and deaf boys and girls

Figural fluency (Figure 16, Table 15). On figural fluency the hearing boys' and girls' mean scores increased to grade 3 and then declined at grade 4. At grade 5 the hearing boys' mean score continued to decline whereas the hearing girls' increased sharply.

The deaf boys and girls revealed a different pattern of development. Both deaf groups tended to increase their mean scores with grade level although the deaf girls' showed a more rapid increase than the deaf boys. The deaf girls' mean scores were greater than the deaf boys' in all grades except grade 2 where the deaf boys' showed a temporary peak.

At the grade 5 level both hearing and deaf girls produced definitely higher mean scores than did the boys.

Figural flexibility (Figure 17, Table 16). The groups representing hearing and deaf boys and girls followed similar patterns of development on figural flexibility as on figural fluency. [This was expected due to nature of the test instrument and the high correlation between the two factors (Table 6).]

The hearing boys' and girls' mean scores increased together to a maximum at grade 3 then both slumped at grade 4. At grade 5 the hearing girls' mean score increased greatly but the hearing boys' only slightly.

The deaf boys' and girls' mean scores tended to increase with grade level although the boys' declined at grade 4. The deaf girls' mean scores did not show the same rapid increase on figural flexibility as they did on figural fluency (Figure 16).

Figural originality (Figure 18, Table 17). The hearing girls' and deaf boys' mean scores on figural originality followed similar patterns of development. Both groups reached maximum mean scores at grade 3, slumped at grade 4, and increased again at grade 5. The deaf girls' mean scores showed a minimum at grade 3, maximum at grade 4, and a decline to grade 5.

The hearing boys' mean scores were higher than the other three groups in all grades except grade 3 when the deaf boys' mean score equalled the hearing boys'. The deaf boys' mean scores were greater than the deaf girls' in all grades except grade 4. The hearing and deaf boys, therefore, exhibited a tendency to produce higher mean scores than their corresponding groups of girls.

Figural elaboration (Figure 19, Table 18). On figural elaboration the groups revealed two distinct patterns of development. All four groups' mean scores increased almost linearly with grade level until grade 4, with the hearing boys showing the greatest increase and the deaf boys the smallest. However, at grade 5 the girls, both hearing and deaf, continued to increase their mean scores whereas the boys' mean scores declined to below their grade 2 mean scores. The hearing and deaf boys' mean scores increased again at grade 6.

The deaf girls displayed the greatest overall increase and the deaf boys the least. The deaf girls' mean scores were higher than the deaf boys' in all grades except grade 1, and the hearing girls' mean scores were higher than the hearing boys' in all grades except grade 4. The girls thus showed a tendency to produce higher mean scores on figural elaboration than the corresponding groups of boys.

4.4 Summary of Results

Of the ten hypotheses only two were rejected. Hypothesis 1 for the comparison of the groups representing hearing and deaf subjects, and hypothesis 5 for the comparison of the groups representing hearing boys and girls were both statistically significant on the MANOVA tests at the $\alpha < .05$ level on a two-tailed test. On the univariate F-tests the only significant differences occurred under Hypothesis 1 where the hearing subjects were significantly superior to the deaf on figural flexibility and originality.

Discriminant analysis of the rejected hypotheses revealed the groups of hearing and deaf subjects to be discriminated along a figural fluency/flexibility dimension and figural flexibility to be the factor distinguishing between the groups. The hearing boys and girls were also discriminated along a figural fluency/flexibility dimension and figural flexibility was also the discriminating factor.

On a visual comparison of mean scores the hearing subjects' were greater than the deaf subjects' on all figural factors. Hearing girls' mean scores were higher than the deaf girls' on all figural factors, and the hearing boys' mean scores higher than the deaf boys' on all figural factors except figural fluency.

On figural originality the hearing and the deaf boys' mean scores exceeded the girls', and on figural elaboration the girls' exceeded the boys'.

By grade on figural fluency, the hearing subjects' mean scores increased to grade 3, declined sharply at grade 4, and increased slightly at grade 5. The deaf subjects' mean scores increased to grade 5 and decreased at grade 6. The same patterns were followed by both groups on figural flexibility and by the hearing subjects on figural originality. The deaf subjects' mean scores on figural originality reached a maximum at grade 3 and then declined until grade 6. On figural elaboration the hearing subjects increased their mean scores to grade 4 and declined to grade 6 whereas the deaf subjects increased theirs to grade 5 before declining.

The hearing and deaf boys' and girls' mean scores followed similar patterns to the above but with notable differences. On figural fluency the hearing girls' mean scores increased greatly at grade 5 while the hearing boys' continued to decline. The deaf boys' mean scores showed a temporary peak at grade 2.

On figural flexibility the hearing boys' and girls' mean scores followed similar patterns to figural fluency but the deaf girls' declined at grade 3 and peaked at grade 4, and the deaf boys' temporarily declined at grade 4.

On figural originality the hearing boys showed no "Grade Four Slump" whereas the girls' mean scores fell greatly. The deaf girls' mean scores were maximum at grade 4 while the deaf boys' were at a minimum. The groups of boys tended to produce higher mean scores than the corresponding groups of girls.

On figural elaboration the hearing and deaf girls increased their mean scores almost linearly with grade level but the boys' mean scores declined at grade 5. The girls' mean scores tended to be greater than the corresponding boys' mean scores.

TABLE 15. Figural Fluency mean scores ($\overline{X}$) and standard deviations (s) for the groups representing hearing and deaf boys and girls within each grade level as measured on the TTCT, Figural Form B, using the modified protocols.

		Grade Level					
		1	2	3	4	5	6
Hearing Boys	$\overline{X}$	18.7	20.7	24.8	21.6	19.5	20.2
	s	7.72	3.81	4.92	5.39	8.75	6.18
	N	7	14	10	13	10	9
Hearing Girls	$\overline{X}$	20.8	22.3	24.6	20.3	25.0	*
	s	1.72	3.83	6.82	5.25	8.00	
	N	6	10	11	7	8	
Deaf Boys	$\overline{X}$	17.0	21.2	19.9	21.3	21.8	22.0
	s	4.83	6.95	4.75	5.71	4.26	6.20
	N	7	14	10	13	10	9
Deaf Girls	$\overline{X}$	18.8	18.8	22.1	22.7	25.9	*
	s	8.45	5.83	8.29	7.20	8.22	
	N	6	10	11	7	8	

* = N too few for reliable computations.

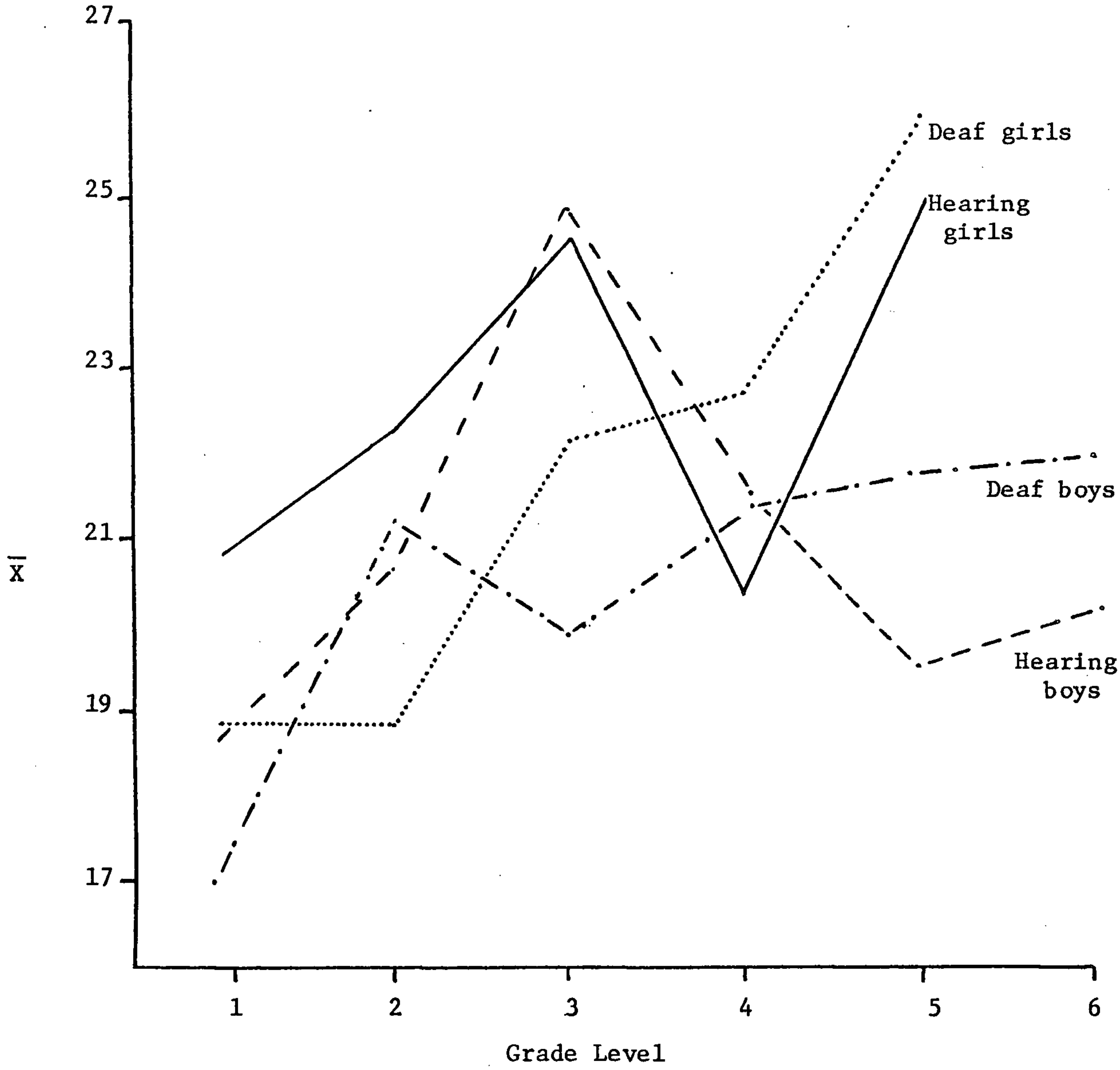


Figure 16. Figural fluency mean scores ($\overline{X}$) by grade of the groups representing hearing and deaf boys and girls as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data on Table 15.

TABLE 16. Figural Flexibility mean scores ($\overline{X}$) and standard deviations (s) for the groups representing hearing and deaf boys and girls within each grade level as measured on the TTCT, Figural Form B, using the modified protocols.

		Grade Level					
		1	2	3	4	5	6
Hearing Boys	$\overline{X}$	14.0	14.4	17.0	13.4	14.1	13.1
	s	5.80	3.34	3.71	2.14	5.99	3.44
	N	7	14	10	13	10	9
Hearing Girls	$\overline{X}$	13.8	14.2	17.5	13.3	17.4	*
	s	3.13	2.57	5.16	2.56	2.97	
	N	6	10	11	7	8	
Deaf Boys	$\overline{X}$	11.4	13.1	13.9	12.7	14.6	14.2
	s	3.41	3.44	4.63	2.63	2.84	3.27
	N	7	14	10	13	10	9
Deaf Girls	$\overline{X}$	12.7	12.8	12.6	14.7	14.5	*
	s	5.99	2.04	3.85	3.15	5.26	
	N	6	10	11	7	8	

* = N too few for reliable computations.

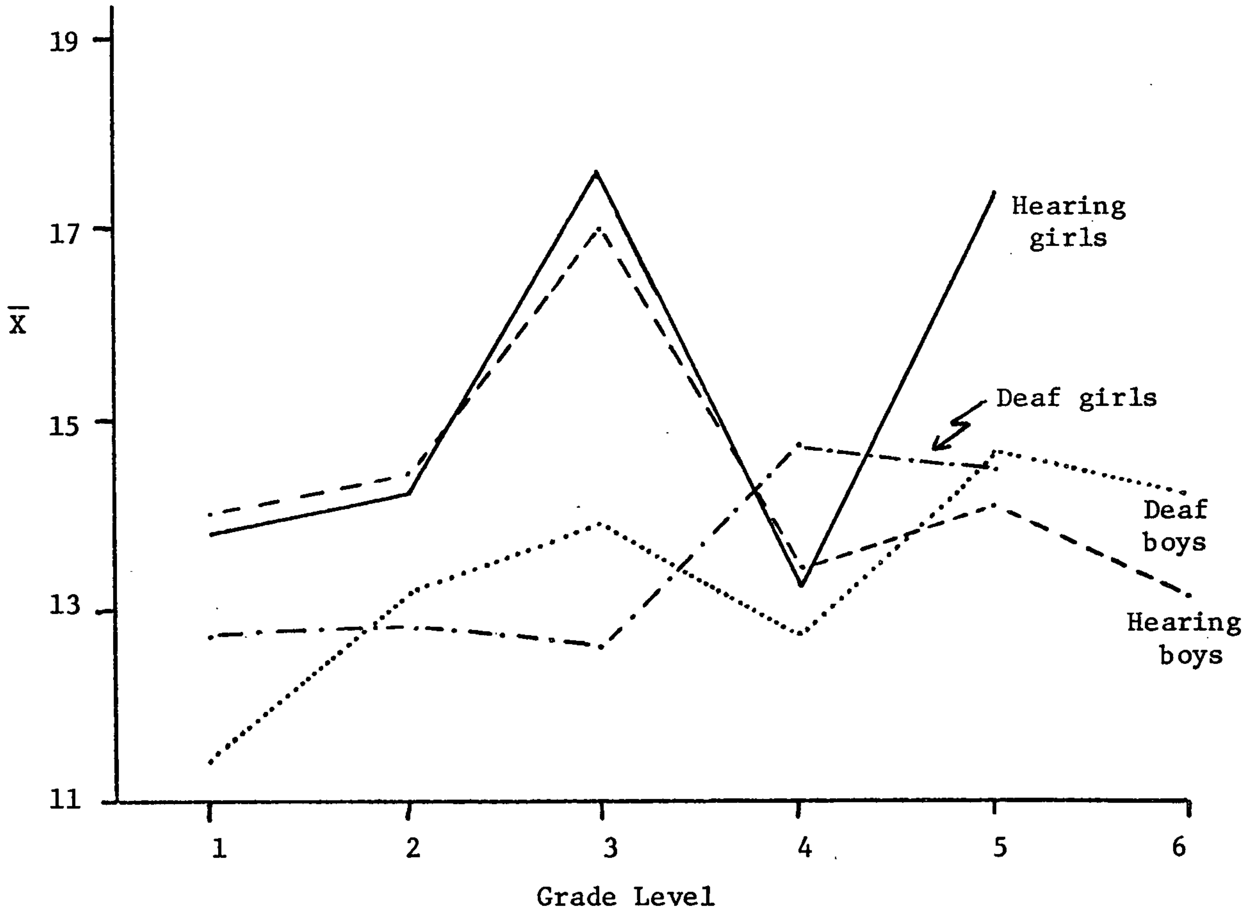


Figure 17. Figural flexibility mean scores (X̄) by grade of the groups representing hearing and deaf boys and girls as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data on Table 16.

TABLE 17. Figural Originality mean scores ($\bar{X}$) and standard deviations (s) for the groups representing hearing and deaf boys and girls within each grade level as measured on the TTCT, Figural Form B, using the modified protocols.

		Grade Level					
		1	2	3	4	5	6
Hearing Boys	$\bar{X}$	18.0	22.9	24.2	24.8	23.4	19.6
	s	3.56	10.99	5.33	8.81	7.90	9.88
	N	7	14	10	13	10	9
Hearing Girls	$\bar{X}$	14.2	21.4	22.0	16.1	22.6	*
	s	5.46	9.41	7.88	6.47	9.87	
	N	6	10	11	7	8	
Deaf Boys	$\bar{X}$	17.7	19.1	24.2	18.4	20.0	18.2
	s	6.37	8.04	12.85	6.14	7.02	9.34
	N	7	14	10	13	10	9
Deaf Girls	$\bar{X}$	16.7	17.9	16.8	22.4	17.6	*
	s	7.79	4.68	8.40	10.09	4.75	
	N	6	10	11	7	8	

* = N too few for reliable computations.

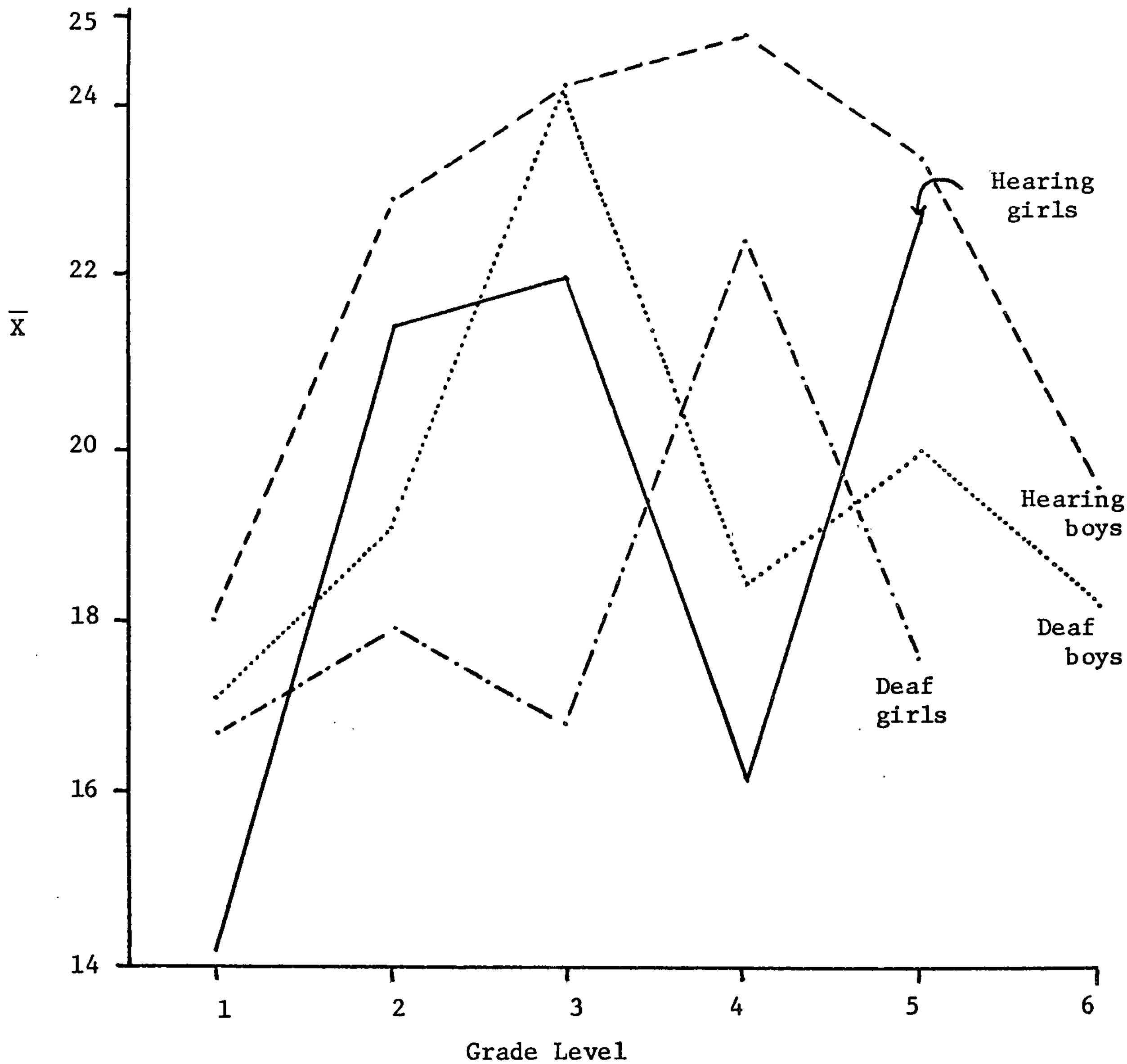


Figure 18. Figural originality mean scores (X̄) by grade of the groups representing hearing and deaf boys and girls as measured on the TTCT, Figural Form B, using the modified protocols. Drawn from data on Table 17.

TABLE 18. Figural Elaboration mean scores ($\overline{X}$) and standard deviations (s) for the groups representing hearing and deaf boys and girls within each grade level as measured on the TTCT, Figural Form B, using the modified protocols.

		Grade Level					
		1	2	3	4	5	6
Hearing Boys	$\overline{X}$	73.6	92.5	94.9	111.5	87.9	99.2
	s	31.03	36.24	23.81	27.39	21.43	41.33
	N	7	14	10	13	10	9
Hearing Girls	$\overline{X}$	81.7	93.6	95.3	102.7	122.4	*
	s	27.41	28.68	25.37	32.80	42.86	
	N	6	10	11	7	8	
Deaf Boys	$\overline{X}$	77.7	77.4	85.2	88.6	83.5	95.4
	s	42.83	35.82	39.61	22.70	28.64	40.59
	N	7	14	10	13	10	9
Deaf Girls	$\overline{X}$	72.5	84.9	92.5	103.0	121.5	*
	s	43.19	32.06	45.11	36.97	55.09	
	N	6	10	11	7	8	

* = N too few for reliable computations.

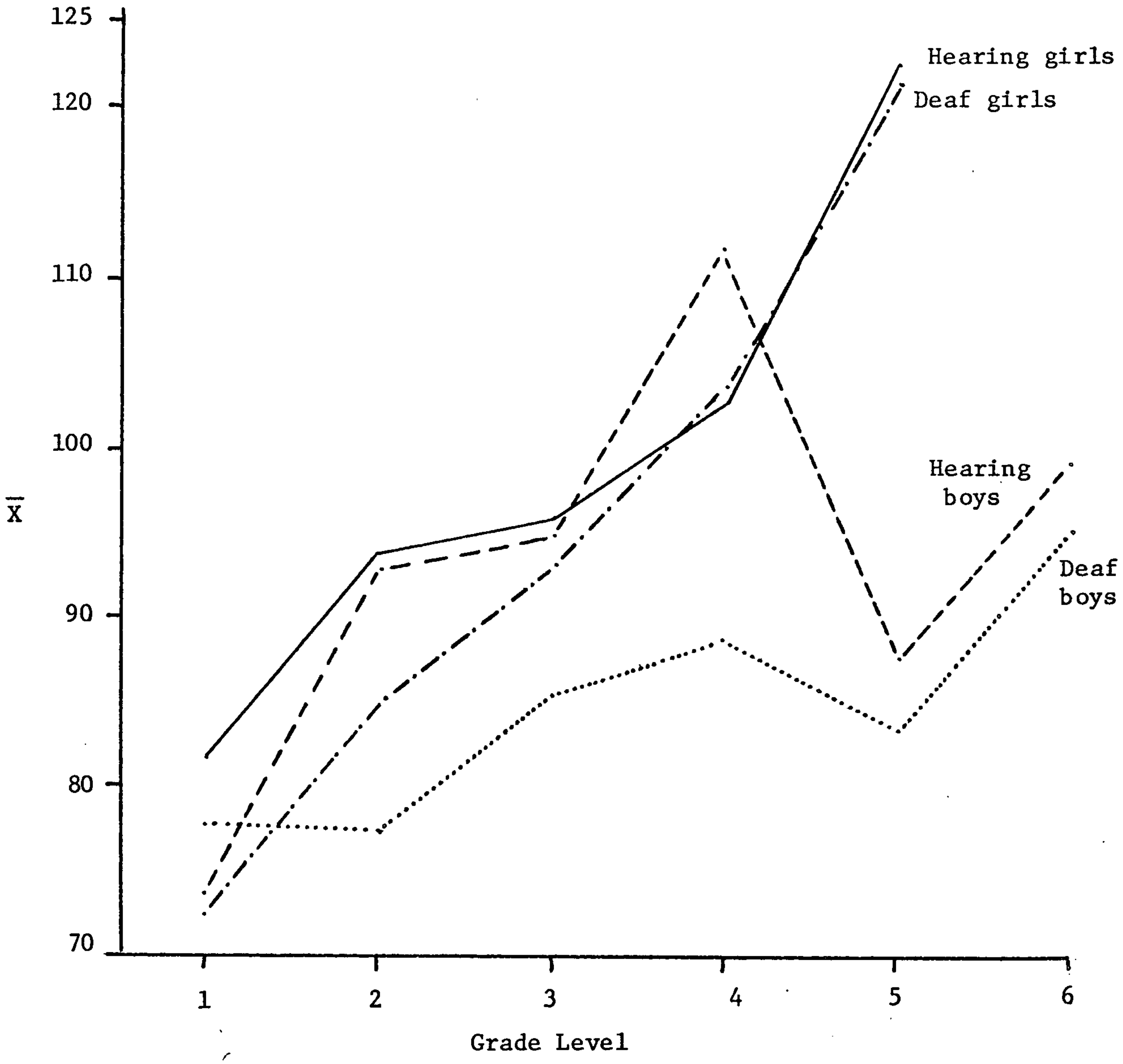


Figure 19. Figural elaboration mean scores ($\overline{X}$) by grade of the groups representing hearing and deaf boys and girls as measured on the TTCT, Figural Form B, using modified protocols. Drawn from data on Table 18.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND SUMMARY

5.1 Introduction

In this chapter the results are compared with those surveyed in the Review of the Literature. Similarities and differences between the studies are noted. This is followed by discussion on limitations, methods, implications, and the conclusions. The conclusion advances possible reasons for the differences between the results of the hearing and deaf subjects of this study, and between the results of this study and those of Kaltsounis (1970). This is followed by a summary of the study and recommendations for further research.

5.2 Comparison of Results with other Studies

Hearing and deaf subjects. The studies of Rogers (1968) and Torrance (1964) indicated a tendency for culturally disadvantaged children who had a poor verbal input to produce higher mean scores than advantaged children as measured on the TTCT, Figural Forms A and B. If deaf children are considered to be disadvantaged from a verbal input aspect the results of Kaltsounis (1970) strengthen Rogers' and Torrance's conclusions.

The mean scores on creativity (divergent production) by the deaf subjects of Kaltsounis' study were significantly superior statistically at the $\alpha < .01$ level on a two-tailed test. On the divergent production factors taken individually, Kaltsounis found the deaf subjects were also significantly superior to the hearing subjects.

The results of this study were opposite to the above. The hearing subjects' mean scores were statistically superior at the $\alpha < .05$ level of significance on a two-tailed test. On the individual figural factors the hearing subjects' mean scores were significantly superior over the deaf subjects' on figural flexibility and originality, and higher on figural fluency and elaboration.

Hearing and deaf boys. The results of Kaltsounis showed the deaf boys' mean scores on figural fluency and elaboration were greater than the hearing boys', and significantly superior on figural flexibility and originality. In this study on figural fluency, the deaf boys' mean score was slightly higher than the hearing boys', but on the other three figural factors the hearing boys' mean scores were higher although not significantly.

Hearing and deaf girls. The results of Kaltsounis showed the deaf girls' mean scores to be significantly superior over-all to the hearing girls' but not significantly superior on any of the figural factors taken individually.

In this study the hearing girls' mean scores were greater than the deaf girls' both on the individual factors and over-all but not significantly.

Hearing boys and girls, and deaf boys and girls. Torrance and Alliotti (1969) and Torrance (1967) have shown that on the TTCT, Figural Forms A and B, boys tend to score higher than girls on figural originality, and girls higher than boys on figural elaboration. The examples of Torrance (1967), Figures 6 and 7, clearly illustrate this. The results of Kaltsounis also followed this pattern, his deaf boys scoring higher on figural originality and his girls higher on figural elaboration. However, his hearing groups departed slightly from Torrance's reported pattern. Kaltsounis' hearing boys' mean score was significantly superior to the hearing girls on figural originality, and also slightly higher on figural elaboration.

The results of this study followed the same pattern as described by Torrance for both hearing and deaf subjects. On figural originality the hearing boys' mean score was greater than the hearing girls', and the deaf boys' greater than the deaf girls'. On figural elaboration the deaf and hearing groups of girls scored higher than the respective groups of boys. None of these differences reached the chosen .05 level of significance on a two-tailed test.

Hearing and deaf subjects by grade. The hypothesis that there are no significant differences between hearing and deaf children (total groups) as measured on the TTCT, Figural Form B, was rejected in favour of the hearing children. Kaltsounis rejected his hypothesis in favour of the deaf children. In this study the hearing subjects' mean scores were significantly superior on figural flexibility and originality, and in Kaltsounis' study the deaf subjects were significantly superior on figural flexibility, originality, and elaboration. The similarities and differences between the studies are further clarified when the grade by grade patterns of development are considered. These patterns are presented on Table 1 and Figures 12, 13, 14, and 15.

The patterns of development of the hearing subjects in this and Kaltsounis' studies are similar for figural fluency and flexibility even though this study's mean scores by grade tended to be higher. (This may be due to the educative effect of the modified protocols.) On figural originality the mean scores of the subjects in both studies increased to grade 2, slumped at grade 4, and recovered at grade 5, before declining at grade 6. However, the mean scores of Kaltsounis' subjects exhibited much greater variation between high and low mean scores. On figural elaboration there were no apparent similarities.

The mean scores of the deaf subjects of both studies tended to increase with grade level. Only on figural originality did they vary greatly from this pattern. In this study the deaf subjects' mean scores rose sharply to grade 3 and then declined to below their grade 1 mean scores at grade 6. The mean socres of the deaf subjects in Kaltsounis' study showed only slight declines at grades 3 and 6.

In both studies the subjects exhibited temporary declines across the factors. Kaltsounis' deaf subjects' mean scores declined at the grade 3 level on figural fluency, flexibility, and originality, whereas in this study the only common decline in the deaf subjects' mean scores occurred on figural fluency and elaboration at grade 6, and figural originality at grades 3 to 6.

Deaf boys and girls by grade. The results of Kaltsounis (1970) indicated a tendency for deaf girls to score higher than deaf boys in grade 1, 2, and 3, and the deaf boys higher in grade 4 (Table 2). The results of the study as graphed in Figures 16, 17, 18, and 19 revealed an opposite tendency; on figural fluency deaf boys scored higher at grade 2 only, on figural flexibility in grades 2 and 3, on figural originality in grades 1, 2, and 3, and on figural elaboration in grade 1 only. The deaf boys showed higher mean scores than the deaf girls in grades 1, 2, and 3 only, but not in grade 4.

Although this study and Kaltsounis' agreed on the overall trends, i.e. deaf boys as a group scored higher than deaf girls on figural originality, and deaf girls higher on figural elaboration, the developmental patterns as described above showed underlying differences. The deaf boys in Kaltsounis' study gained their overall superiority at grade 4 and above, and his deaf girls their superiority on figural elaboration below grade 4. In this study the deaf boys gained their overall superiority on figural originality in all grades except grade 4, and the deaf girls on figural elaboration in all grades except grade 1.

Hearing boys and girls by grade. Torrance (1967) claimed on all figural factors both hearing boys' and girls' mean scores increased to grades 2 or 3 then dropped sharply at grade 4. He named this the "Grade Four Slump" (Figures 4, 5, 6, and 7). He also added that there was no trend for either boys or girls to score higher on figural fluency and flexibility, but in grades 1 through 6 boys' mean scores were higher on figural originality, and girls' on figural elaboration.

In this study (Table 15, Figures 16, 17, 18 and 19) the hearing boys and girls followed the same patterns as described by Torrance. The "Grade Four Slump" was clearly evident on figural fluency, flexibility, and originality, but not on figural elaboration. In the comparison of hearing boys with girls by grade there were no appreciable differences on figural fluency and flexibility but for figural originality the hearing boys' mean scores were higher in grades 1 to 5 (grade 6 girls scores not calculated due to degrees of freedom being too small), and on figural elaboration the hearing girls' mean scores by grade were greater in all grades except grade 4.

5.3 Discussion of Limitations

The hearing and deaf children of this study were not subject to controls for intellectual and psychological status. The assumption was made that the hearing and deaf groups were intellectually and psychologically normal. However, one teacher of the deaf commented, "All deaf children are emotionally disturbed simply because deafness restricts communication, and therefore causes frustrations." Furthermore, schools for hearing children separate the highly intelligent, the less intelligent, and the emotionally disturbed into special classes. Deaf children are already in special classes and are only further subdivided for extreme psychological and physiological problem cases. Whereas the hearing subjects of this study could be described as normal hearing children, and the deaf subjects as normal deaf children an error may occur if 'normal hearing subjects' is equated with 'normal deaf subjects.' This study was an attempt to measure the divergent production ability of groups representing children typical of normal hearing and normal deaf.

For best results, Torrance (1968) recommended the TTCT, Figural Form B, be administered to classes of between 15 and 35 pupils, and preferably smaller classes for younger children (p. 2). In this study the hearing subjects were tested in groups of approximately 35 per classroom and the deaf in groups of approximately 8 per classroom. Although the researcher observed no apparent differences in the test behaviour of the subjects due to the various class sizes, Torrance's recommendations above suggest a possible bias in favour of the deaf subjects.

Hearing and deaf children live in different cultural environments. This is partly due to the deaf children's disability, deafness, but also due to the forced segregation of deaf children for educational purposes. Torrance's scoring guide (Torrance 1968) based the scoring norms on the responses from hearing children. Perhaps these scoring methods are not appropriate to deaf children's responses. The experience gained in this study led the researcher to believe that the scoring methods for figural fluency, flexibility, and elaboration were appropriate for both groups but possibly not the scoring method for figural originality. The adjective "original" has cultural connotations; what is statistically original for a hearing child might not be for a deaf child, and vice versa. This problem could be overcome by statistically setting the originality scores to the data gathered by the frequency of each class of responses.

5.4 Discussion of Methods

During the administration of the modified protocols, the hearing children were requested to pretend to be deaf. The deaf children were simply given the modified instructions. The hearing children tackled the divergent production activities as a game of pretending to be deaf whereas the deaf children treated the activities as a test. The responses on the TTCT, Figural Form B, are effected by the classroom atmosphere.

Torrance (1966) reported that a game atmosphere encourages higher responses.

The modified protocols were designed to minimize verbal content. However, when the researcher administered the modified protocols he observed verbal biases against the deaf children. Some deaf children realized they would have to give titles to their drawing so they drew pictures for which they had words; and, most deaf children after completing their drawings had a smaller vocabulary from which to create titles. This latter bias caused at least two possible difficulties. The deaf children with small vocabularies either chose non-original titles such as 'man' (score = 0 points) rather than 'clown' (score = 1 point), or they changed their mental impressions of the produced pictures from, for example, a snail (score = 1 point) to a number six (score = 0 points). From observation the researcher believed that this latter bias was encountered by some deaf children in all grades and hearing children in grades 1 and 2.

Associated with the above verbal biases was memory failure. While helping the children to write their titles, the researcher observed that a few children, both hearing and deaf, forgot what they had drawn. This was more evident with the younger children. However, the researcher could not ascertain how many children invented titles for forgotten titles.

When necessary, the researcher and class teachers assisted both hearing and deaf children to write their titles. Care was taken not to suggest titles by such questioning as "Is it an apple?" or "Is it a pear?" Some children would reply "Yes" to both questions. The extent of the teachers' and researcher's influence by unintentional title suggestion and subsequent bias on the scores can not be determined. However, since more deaf than hearing children were helped any bias would have a greater effect on the statistics of the deaf children.

5.5 Discussion of Implications

5.51 Educational implications

The results of this study revealed the hearing subjects to be significantly superior to the deaf subjects on figural flexibility and originality but not on figural fluency and elaboration. This means although the deaf subjects produced many ideas (not a statistically different number from the hearing subjects) the ideas lacked variety of classes and statistical originality. In comparison to the hearing subjects, the deaf subjects produced mostly common ideas. This implied shallow thought and mimicry on the part of the deaf subjects in that they reproduced inputs without greatly modifying them. The cause of the deaf subjects' low figural flexibility and originality ability was probably due to their aural deficiency since the researcher observed no evidence of stark classrooms or unimaginative teaching.

5.52 Research implications

The points raised so far in this chapter direct attention to possible sources of bias (mostly against the deaf children) in the modified protocols and the scoring techniques. Future research on divergent production of deaf children will need to allow for such biases either statistically or by employing more strict experimental controls as restricting the ranges of hearing ability and IQ.

The great disparity between the results of this study and that of Kaltsounis (1970) poses an obvious question: Which study's results best describe the differences between hearing and deaf children? These two studies have laid the groundwork for future investigation into an important topic: divergent production ability.

5.53 Theoretical implications

There is a close relationship between divergent production and creativity with perhaps the major differentiating factor being utility. Divergent production contains the factors fluency, flexibility, originality, and elaboration, i.e. the number of ideas produced, their classes, their statistical unusualness, and the embellishments on the ideas. However, consider a person who produced a house-size plastic replica of a hamburger. He may warrant maximum marks for statistical originality because his idea was unique but to describe the product as creative would be highly questionable because the product is probably useless (unless used as an advertising gimmick).

Creativity is at least the divergent production factors plus utility. To claim from the results of this study that the hearing subjects were more creative than the deaf subjects would be erroneous since utility of the products was not measured. However, since the factors flexibility, originality, elaboration, and utility are dependent on fluency then it is reasonable to claim that the hearing subjects would probably be superior to the deaf subjects on creativity.

Levine (1960) claimed deaf children exhibit a 3 to 4 year lag behind hearing children in intellectual abilities. The results of this study revealed that the hearing subjects produced the characteristic "Grade Four Slump" whereas the deaf subjects did not. From Levine's claim the deaf subjects should show a Grade 7 or 8 Slump. In this study the deaf subjects' mean scores declined only at grade 6 for figural fluency and elaboration (Figures 12 and 15). Perhaps deaf children exhibit a "Grade 6 Slump." Further research over a greater age range may substantiate Levine's claim.

The most important implication arises if the results of this study are accepted as an accurate description of the divergent production ability differences between hearing and deaf children. If the results are accepted then educators of the deaf must face the following questions:

1. Of what educational importance for the deaf is divergent production ability?
2. To what extent is there a need to improve the divergent production ability of the deaf?
3. How can the divergent production ability of the deaf be improved?

5.6 Conclusions

5.61 Discussion with Respect to Kaltsounis (1970)

The univariate analysis of variance of this study (Table 8) showed the difference between the hearing and deaf subjects did not reach statistical significance for figural fluency. The univariate

F-probability of .909 indicates a strong likelihood that the groups originated from the same population. This was so as both groups were elementary school children, living in Western Canadian cities, having similar social and cultural backgrounds. Thus, this research believes that deafness was the major cause for the overall difference between the hearing and deaf subjects on the multivariate test and for figural flexibility and originality on the univariate test.

The deaf sample described by Kaltsounis (1970, p. 44) was similar to the deaf subjects employed in this study. The major difference appeared to be geographical location (Kaltsounis' subjects were in the State of Georgia, U.S.A.). An assumption could be made that Kaltsounis' hearing and deaf subjects were drawn from the same population. If this were so then the following question must be considered: "Why were Kaltsounis' deaf subjects statistically superior to their hearing counterparts on figural fluency (and figural flexibility, originality, and elaboration)?" Either (1) the above assumption is invalid, (2) his methods of test administration were invalid, or (3) his results did accurately describe the differences between his groups. This researcher believes (1) and (2) above are questionable. As stated in 2.5, Review of Kaltsounis 1970, his hearing sample was from another study carried out two years previously to his deaf/hearing study, and, further, the test protocols for each group differed. The hearing subjects were administered the ordinary protocols in regular class sizes whereas the deaf used natural, and finger sign, language protocols individually. Because of these two suspect experimental procedures Kaltsounis' overall results, (3) above, are open to suspicion. This researcher therefore believes that the results as detailed in Chapter IV are a more reliable description of the divergent production differences between deaf and hearing children than are Kaltsounis'.

5.62 Discussion with Respect to Fluency and Deafness

In this study the hearing subjects were statistically superior overall. However, on the individual figural factors hearing subjects were significantly superior only on figural flexibility and originality, with figural flexibility being the major discriminating factor (Figure 10).

Figural fluency was defined as the ready flow of ideas, i.e. the quantitative production of ideas, whereas figural flexibility was defined as the number of classes under which the ideas could be placed.

The results reveal that the deaf subjects obviously do not lack figural ideas (fluency) but seem to lack flexibility (changing from one class to another). Either flexibility depends upon range of usable language for classification purposes, or the test instrument used in this study was not sensitive to the deaf subjects' classification system. The latter possibility that deaf children possess a different classification system from hearing children is in itself an interesting field for psychological research.

In 1.1, Statement of the Problem, this researcher noted, in classrooms for deaf children, ideas seemed to be disseminated by mimicry. Mimicry tends to focus upon the first idea put forward thus limiting the mimic in terms of classes of ideas. The low figural flexibility scores produced by the deaf subjects in this study may be explained by learning situations based on mimicry. Furthermore, the low figural originality scores produced by the deaf subjects indicates the ideas produced were not substantially modified from their first input. This once again may be explained by mimicry perpetuating unoriginal ideas.

Perhaps a leading concern for educators of the deaf should be to identify teaching methods and learning atmospheres that supplement mimicry with alternate approaches in order to encourage greater flexibility and originality of thought. Educational research might profitably explore possibilities of an optimal mix of learning strategies based on mimicry and abstract concept assimilation.

5.7 Summary of the Study

This study was designed to ascertain the similarities and differences between groups representing hearing and deaf children on measures for divergent production. A review of the literature revealed studies with conflicting results, especially Levine (1960) who claimed deaf children on most tests exhibited a 3 to 4 year lag behind hearing children, and Kaltsounis (1970) who claimed deaf children to be superior on creativity.

To study the divergent production ability, 114 deaf subjects representing deaf children and 114 hearing subjects representing hearing children were chosen. Null hypotheses were tested to determine if the variables of hearing status, sex, and within-grade level, were discriminating factors. The TTCT, Figural Form B, was chosen as the measuring instrument because it required non-verbal responses. The regular instructions were modified by the researcher to a non-verbal form in order to enable the instrument to be presented to both hearing and deaf subjects. A pilot study was performed employing two groups of hearing boys and girls, 34 in each group, to trial test the modified protocols. The modified protocols were found to have a high educative effect. However, the assumption was made that the educative effect would be equal for both the hearing and deaf subjects of the main study.

Using the TTCT, Figural Form B, the subjects produced four sets of raw data: figural fluency, flexibility, originality, and elaboration. This data was analysed by univariate and multivariate F-tests for hearing status and sex effects, discriminant analysis for significant F-tests, and Hotelling's T^2 routine for the within-grade effects.

The analysis of the data showed the hearing subjects to be significantly superior statistically to the deaf subjects on a composite factor of the four divergent production factors with a multivariate F-value of 4.555 and associated probability of .001 on a two-tailed test. Hearing boys were also significantly superior to hearing girls with an F-probability of .029 associated with an F-value of 2.764.

The univariate F-tests reached statistical significance for only figural flexibility and originality on the comparison of hearing and deaf subjects. However, discriminant analysis revealed that the underlying difference amongst the dependent figural factors was at the flexibility end of a figural fluency/flexibility discriminant dimension.

None of the other comparisons by hearing status, sex, and within-grade effects reached statistical significance. However, grade by grade developmental patterns and boy or girl dominance on the individual figural factors compared favourably with other studies. Boys tended to score higher than girls on figural originality, and girls higher on figural elaboration. By grade, the hearing subjects exhibited the characteristic "Grade Four Slump" but the deaf subjects did not.

The only major difference between this study's results and those of Kaltsounis (1970) was on the comparison of the hearing and deaf subjects. Kaltsounis found his deaf subjects to be significantly superior at the .01 level on a two-tailed test whereas in this study the hearing subjects were superior at the .05 level (computed $\alpha < .001$) also on a two-tailed test.

The researcher noted several possible causes of the above major difference suggesting that in this study biases in the modified protocols may have favoured the hearing subjects, and in Kaltsounis' study biases in his protocols and sample selection may have favoured his deaf subjects. Possible reasons for accepting this study's results rather than the opposing results of Kaltsounis (1970) were debated. This was followed by discussion on mimicry by deaf children and its effect on flexibility. Finally, questions were posed enquiring into the importance of divergent production in the education of the deaf.

5.8 Recommendations

1. Continued research comparing the divergent production ability of hearing and deaf children should be encouraged in order to gain further knowledge on the subject.

2. Further research comparing hearing and deaf children should include experimental controls for cultural, intellectual, psychological, and social factors.

3. Future research data from measures of divergent production should include discriminant analysis statistical techniques in order to study the underlying psychological dimensions rather than just discover possible significant differences.

4. Further research with deaf children using the TTCT, Figural Form B, should endeavour to minimize all verbal biases in the instructions, the test activities, and the scoring methods.

5. Since 'original' is a culturally determined concept, new TTCT norms should be set for the deaf society.

6. To further enrich the children's concrete experiences, use of the ESS and SCIS science unit approach in teaching science to the deaf should be encouraged.

7. Research into the classification systems of the deaf should determine whether they differ from those of hearing children.

8. Further research should be encouraged in order to determine the role of mimicry in deaf education and its relation to concept learning and problem solving.

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APPENDIX A

An Explanation of the Terms of the Illinois Tests of Psycholinguistic Abilities

(Figure 2)

The Illinois Test of Psycholinguistic Abilities (ITPA) is a series of diagnostic tests rather than a classifying technique. The tests are designed to delineate specific abilities or disabilities in children so that a base can be set from which remedial programmes can be developed. The ITPA is used to check specific learning channels from reception (decoding) of information, through internal processes (association), to the output (encoding).

The following is condensed from:

> Illinois Test of Psycholinguistic Abilities, by Kirk, Samuel, McCarthy, James, and Kirk. In Examiner's Manual 1968, U. of Ill., pp. 5-14. Also in Learning Disorders in Children, prepared by Dr. Peggy Koopman, Assis. Prof., Dept. of Ed. Psycho., Univ. of B. C., Canada.

Reception

1. Auditory decoding is the ability to derive meaning from given sounds. A child is asked a question that requires minimal response such as 'yes', or 'no', or head nodding.
2. Visual decoding is the ability to derive meaning from visual stimuli in the form of pictures or figures. A child is given such instructions as 'find a pair' or 'chose a picture related to this one.'

Internal Organizing Processes

3. Auditory vocal association. The child's ability to relate concepts is checked by presenting oral statements such as 'a dog has hair, a fish has ?'
4. Visual motor association. The child is presented with visual analogues to the auditory vocal association tasks, i.e. 'if this does that, then this does ?' No aural questions are used. All questions are posed by pointing. The ability to associate pictures and understand the body movements as questions is therefore tested.

External Expression

5. Vocal encoding. The child is checked for his ability to vocally express his ideas, e.g. he is shown a ball and requested to "tell me about it." He is scored on relevant responses.
6. Motor encoding. The child is checked for his manual expression ability. He is given an object and requested to "show me what to do with this."

From the profiles of Figure 2, page 14, it can be seen that both the hard-of-hearing and the culturally disadvantaged children show lower scores on abilities that involve the use of aural and oral channels.

APPENDIX B

Tables Relevant to Review of Literature

and Results

TABLE I. Data to illustrate the "Grade Four Slump." Means ($\overline{X}$) and standard deviations (s) by grade and sex of boys and girls in the U.S.A. as measured on figural factor tests of creative thinking. (From Torrance 1967, p. 47.)

Factor	Grade		1	2	3	4	5	6
Figural Fluency	Girls	$\overline{X}$	13.75	17.38	17.26	15.94	17.45	17.72
		s	4.28	5.36	4.28	4.77	5.68	5.62
	Boys	$\overline{X}$	13.86	17.28	17.14	15.71	16.35	17.21
		s	4.01	5.27	6.26	3.65	5.29	4.18
Figural Flexibility	Girls	$\overline{X}$	11.39	13.26	12.79	12.47	14.03	13.23
		s	3.36	3.11	2.80	3.59	4.38	3.75
	Boys	$\overline{X}$	10.78	12.69	12.56	12.80	13.25	14.10
		s	2.93	3.22	3.63	2.84	3.97	3.41
Figural Originality	Girls	$\overline{X}$	10.11	12.37	13.62	11.44	17.71	15.43
		s	5.84	6.81	6.40	6.56	7.04	8.28
	Boys	$\overline{X}$	13.14	17.41	16.07	14.68	20.92	20.76
		s	10.11	7.92	8.36	7.08	9.48	7.34
Figural Elaboration	Girls	$\overline{X}$	54.08	56.65	53.11	51.28	58.40	69.91
		s	17.71	17.20	18.01	15.43	18.31	17.95
	Boys	$\overline{X}$	37.75	56.03	44.25	42.33	53.22	62.58
		s	14.16	18.25	15.92	13.77	18.18	19.51
N	Girls		36	65	72	36	73	35
	Boys		36	58	59	35	71	38

TABLE II. Principal-Components analysis of the divergent production factors (unrotated) for the comparison of the groups representing hearing and deaf children.

	Components			
Factor	I	II	III	IV
Fluency	-.88	.31	.13	.32
Flexibility	-.81	.46	-.23	-.27
Originality	-.68	-.55	-.48	.06
Elaboration	-.74	-.37	.53	-.15
Dominant Scale	X			
Bipolar Scale		X	X	X

TABLE III. Latent roots (eigenvalues) from the comparison of the groups representing hearing and deaf children.

Root Number	Root	Cummulative % of trace
1	2.450	61.26
2	.754	80.10
3	.595	94.97
4	.201	100.00
Trace =	3.950	

TABLE IV. Mean squares and error terms associated with the comparison by univariate analysis of variance of deaf and hearing children as measured on the TTCT, Figural Form B (Table 8 in text).

Source of Variance	Df	Fluency	Flexibility	Originality	Elaboration
Hearing vs deaf	1	0.53	83.53	334.10	3327.34
Hearing boys vs deaf girls	1	41.47	16.43	185.46	803.40
Hearing girls vs deaf girls	1	18.34	1.08	92.06	2645.84
Deaf boys vs deaf girls	1	2.67	57.04	94.01	625.24
Hearing boys vs hearing girls	1	0.19	31.03	248.19	2968.76
Error terms	224	40.78	15.14	66.53	1208.92

APPENDIX C

Results of Phase 1, The Pilot Study, for the Comparison of the Groups A and B using the Modified and Ordinary Protocols Respectively

Group A was composed of 16 boys and 16 girls due to two absentees, and Group B 17 boys and 17 girls.

For the univariate and multivariate analysis of variance, a 2 x 2 design was run as a one way layout with 4 groups (modified protocols boys and girls, and ordinary protocols boys and girls). However, for the purposes of this study, only protocol effects are given below.

TABLE A. The means ($\overline{X}$) and standard deviations (s) for the four figural factors of groups A and B.

		Figural Fluency	Figural Flexi-bility	Figural Origi-nality	Figural Elabo-ration
Group A Modified protocols N = 32	$\overline{X}$	23.59	16.41	23.56	96.75
	s	6.16	4.55	7.07	25.33
Group B Ordinary protocols N = 34	$\overline{X}$	18.53	14.29	20.53	67.53
	s	5.44	4.11	9.55	22.60

TABLE B. Intercorrelations of the figural divergent production factors of all subjects (groups A and B combined, N = 66).

	Figural Fluency	Figural Flexi-bility	Figural Origi-nality	Figural Elabo-ration
Figural Fluency	1.00			
Figural Flexibility	0.68	1.00		
Figural Originality	0.36	0.34	1.00	
Figural Elaboration	0.35	0.11	0.42	1.00

TABLE C. Comparison of groups A and B on univariate F-tests of hypothesis of equal means.

Source of Variance	Df	Mean square	F-ratio	p
Fluency				
Between	1	422.80	12.42	.0009*
Within	62	34.05		
Flexibility				
Between	1	73.54	3.80	.0557
Within	62	19.33		
Originality				
Between	1	151.66	2.07	.1551
Within	62	73.21		
Elaboration				
Between	1	14057.51	23.95	.0001*
Within	62	587.65		

*significant on a two-tailed test at $\alpha < .05$.

TABLE D. Comparison of group A and group B on a multivariate F-test of hypothesis of equal means.

Multiv-F	Degrees of freedom	p <
7.006	4 & 59	.0002*

* significant on a two-tailed test at $\alpha < .05$.

TABLE E. Principal-Components analysis of the divergent production factors (unrotated) for the comparison of subjects in groups A and B.

Figural Factor	Components I	II	III	IV
Fluency	-.85	-.29	-.26	.35
Flexibility	-.77	-.55	-.05	-.33
Originality	-.71	.37	-.59	.07
Elaboration	-.59	.69	.40	-.16
Dominant scale	X			
Bipolar scales		X	X	X

TABLE F. Latent roots (eigenvalues) from the comparison of subjects in groups A and B.

Root Number	Root	Cummulative % of trace
1	2.157	53.92
2	.997	78.85
3	.582	93.41
4	.264	100.00
Total trace	4.000	

TABLE G. Discriminant function weights for the groups A and B as measured on the figural factors, fluency, flexibility, originality, and elaboration.

Variable	Raw score weight	Standardized weight
Fluency	0.064	0.375
Flexibility	0.024	0.104
Originality	-0.033	-0.280 *
Elaboration	0.036	0.879 *

* Note this is mainly an originality/elaboration scale.

TABLE H. Discriminant analysis - Group means ($\overline{X}_k$) and group centroids ($\overline{Y}$) for the groups A and B.

	Figural Fluency $\overline{X}_1$	Figural Flexibility $\overline{X}_2$	Figural Originality $\overline{X}_3$	Figural Elaboration $\overline{X}$	Centroid $\overline{Y}$
Group A	23.59	16.41	23.56	96.75	4.61
Group B	18.53	14.29	20.53	67.53	3.28

$$\overline{Y} = v_1\overline{X}_1 + v_2\overline{X}_2 + v_3\overline{X}_3 + v_4\overline{X}_4$$

where v_k = the raw score weight (Table 9).

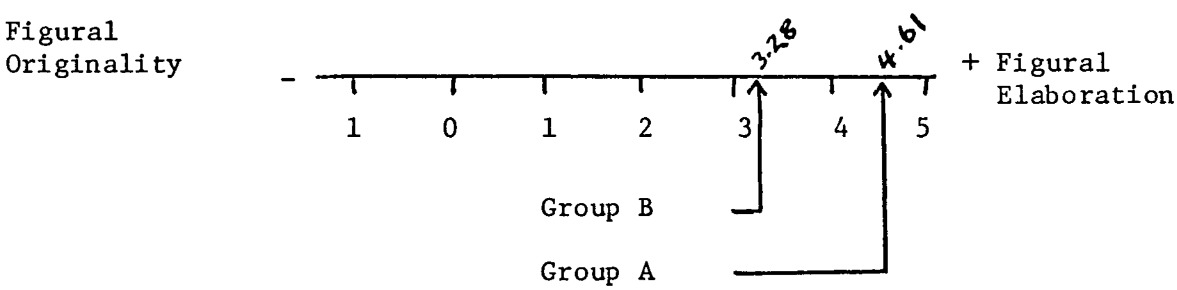

Figure A. Group centroids along the discriminant dimension for groups A and B.

Clearly the bipolar dimension figural originality/elaboration separates group A (modified protocols) from group B (ordinary protocols). The groups are distinguished at the elaboration end of the dimension and even though figural fluency was statistically highly significant ($p < .0009$) on the F-tests (Table C), figural fluency has relatively little discriminating power between the groups (Table G).