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Genetic and Sociocultural Influence on Language Development

Lynn Harding Waterhouse

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Abstract
The present study was designed to assess the relative contribution of genetic and environmental variance to the phenotypic expression of language skills. The classical twin method is used, comparing intrapair similarity for identical and like-sexed fraternal twins on measures of phonological, morphological, syntactic and semantic development. In addition, the mother's interactions with her child are measured, both in terms of the verbal complexity of her speech and her speaking style. Comparisons will he made for all measures: one, between children reared by the . same mother but who differ in genetic relatedness (MZ vz. DZ pairs); and two, between children reared in different families whose mothers vary in I.Q., speaking styles, and speech complexity (between families).

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CHAPTER I

REVIEW OF RESEARCH

Recent advances in empirical and theoretical work in linguistics, psycholinguistics, and sociolinguistics have shed light on the process of language acquisition. Most current studies on the acquisition of language have been concerned with two central problems. The first problem or major consideration has been the possibility of invariant developmental sequences. Work has been done in relation to every level or aspect of linguistics: intonation (Menyuk, 1963), phonology (Winitz, 1958; Gruber, 1966), morphology (Berko, 1958, and Bellugi, 1964), lexicon (Bullowa, 1964; Ferguson, 1956, 1954; Casagrande, 1964; Weir, 1962), semantics (Ervin, 1961; Entwhistle, 1966; Bever, 1970), and syntax (Braine, 1963, 1965; Brown and Berko, 1960; Brown and Fraser, 1963; Ervin-Tripp, 1966, 1970; McNeill, 1966).

The second problem has been to provide a meaningful theoretical explanation for the observed evidence of invariant process in language acquisition. Surprisingly, although a number of theories have been put forth, including a mentalistic language acquisition device (McNeill, 1969), various learning scheme concepts (Braine, 1965; Staats and

Staats, 1963), invariant perceptual strategies (Bever, 1970), as well as the idea of innate language universals (Chomsky, 1968), there has been little or no exploration of two extremely relevant theoretical systems of explanation: the ethnography of communication and behavioral genetics.

As emergent sciences which examine the origins of pattern, generality, and individual variation in behavior within population groups--one from a purely cultural vantage point, and one from a biological stance--both theoretical systems can provide explanatory causal hypotheses for the development of language behavior in the child.

The genetic hypothesis as applied to language development would argue that (1) the course of development of language behavior is genetically determined (Lenneberg, 1967); (2) that individual variations in heretofore observed invariant general patterns of language development serve to express what are really genetic differences between individuals; and (3) that the heritability of perceived traits in the behavior of individuals can be determined comparatively between individuals where the traits appear proportionately in populations (Dobzhansky, 1967). Roughly then the causal situation is this: there is developmental unfolding of the genotype within the environment to produce resultant phenotypic language behavior in the child

An argument for language development coming from the ethnography of communication would state that (1) the course of development of language is socioculturally determined by communication between the child and its siblings, peers, parents, and other adults, with variations in effective influence differing with different cultures; (2) that individual differences are largely "a matter of recombination of separately acquired cultural patterns" (Pittenger, Hockett, Danahey, 1960); and (3) that the major determinant of a child's language behavior are the communicative behavior patterns posited as elements of culture, which are transmitted to the individual by enculturation from other members of his community. In general, the causal steps of this hypothesis are that cultural communication patterns, operating within individuals through speech acts and communication habits in the course of interaction serve to foster both language development and communication competence in the child.

Though separate and distinct, both the above systems share the underlying assumption central to evolutionary thinking, that the process of adapting is important for all human behaviors. According to Alland (1967):

> There is only one evolutionary process--adaptation. Furthermore, in any adaptive system, cultural and biological factors can each modify behavior and each other.[1]

For Alland, human cultural adaptation consists of two

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[1]A. Alland (1967), Evolution and Human Behavior, pp. 196-197.

factors: (1) a given string of innate responses, and (2) learning, where likely responses to stimuli become invariant patterns of behavior.

For Hebb (1953), Lehrman (1953), and Freedman (1968), Alland's two factors are so mixed in the actual development of an individual as to be indistinguishable. Hebb argues that the creation of any kind of distinction between innate and environmentally-determined behavior patterns can be misleading because the effects of heredity and environment are not really exerted on different units of a particular piece of behavior but are effective in differing ways, on the course and development of the <u>same</u> units of behavior. Freedman in turn, argues that there is no logical dividing line between environmentally controlled and learned behaviors, except for behaviors such as reflexes.

Lehrman's argument is almost Piagetian, being couched in terms of a stage interaction model:

> The interaction out of which the organism develops is not one, as is so often said, between heredity and environment. It is between organism and environment! And the organism is different at each different stage of its development.[2]

Clearly, it would seem that sociocultural factors and the child's linguistic environment feed into the child's genetically directed development to yield what appears to be a largely invariant (across and within cultures) process

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[2] D. S. Lehrman (1953), <u>A Critique of Konrad Lorenz's Theory</u>, p. 53.

of language acquisition. Of course, despite Lehrman's general statement, little is known about the nature of such an interaction.

Many behavior geneticists have agreed on the importance of studying both genetic and environmental effects on behavior (e.g. Vandenberg, 1965, 1967; Dobzhansky, 1967). However, the problem of possible system-within-system interactions has not been fully considered in terms of language, for many theorists have yet to realize (at least in publication) the essential falseness of the nature-nurture question (Morton, 1970). In fact, most theories constructed so far have taken one position or the other, arguing either that language development is triggered by some particular internal mechanism, or is fully learned by the child.

Chomsky (1965) and Lenneberg (1967) and McNeill (1969) believe that the child possesses specific innate predispositions for acquisition, including certain pro-syntactical neural substrates, pre-set attention for the frequency of human speech tones, and a mentalistic device, called LAD (language acquisition device) which does all the acquiring for the child. McNeill feels that the child is born with the concept of sentence somehow pre-imprinted. Support for this nativist hypothesis comes largely from the facts as follows: (1) the child acquires language rapidly, (2) there is a uniformity in such development across children, and (3) the child's actual input is so ungrammatical and unrevealing of the rules that it is hard to believe that such material allows the child to accurately infer the rules, something the child apparently does.

An opposing position is represented by theorists like Mowrer (1960) and Skinner (1957) who have suggested an imitation-reinforcement model, where the child imitates an adult speech model, and the reinforcement a child receives from an adult for such behavior serves to foster language development. Though Rheingold, et al. (1959) and Salzinger (1962) have been able to show evidence of some shaping by reinforcement for speech sounds, no work has been done with the complex patterns which supposedly are built on the base of such reinforcement. Braine (1965) has offered a theory of context generalization, which he found some empirical evidence for, in which he argues that a child learns primitive word classes. According to Braine, the child learns that a certain word is right in a certain context, and so through context generalization the child learns to use that word in that position in all further generated utterances.

Some linguists (Berko, Brown) have proposed a rule-learning model wherein the child is continually creating rules for the input which he hears, and from such rules is able to shape a grammar of his own. Support for such a model comes largely from work done which shows that in fact children do overgeneralize rules about the material which they hear. Berko's 1958 thesis on inflectional over-regularization has been the classic study. Weir's Language in the Crib suggests that rule-practice also takes place.

Staats and Staats (1963) have offered the only comprehensive learning theory model. Their theory serves to describe many types of language associations which they feel are important to the acquisition situation, and they employ the concepts of response hierarchies, word associations and complex environmental stimulus control to explain the process of language acquisition.

The cultural viewpoint is exemplified by the work of Bernstein. Bernstein (1967) hypothesizes that the form taken by social relations is often transmitted in terms of certain syntactic and lexical selections. The individual is socialized into using particular structures or codes, and the codes he has available in turn structure many of his cognitive and even emotional capabilities. Bernstein's work suggests the possibility that there are two types of acquisition taking place at the same time--the acquisition of grammar and the acquisition of the rules for speaking.

Although sociolinguistics has yet to discover exactly what the rules of speaking are in different cultures (not to mention American culture), it is nonetheless possible that those theorized rules may in fact be acquired differently than rules about the internal make-up of the code (Hymes, 1971). Of course both sets of rules would be interconnected, and thus developmental acquisition might be assumed to be so interconnected. If the acquisition processes can be isolated, it may be that one is directed by predominately genetic control, and the other might operate as predicted by learning theory models.

Some specific environmental variables that are hypothesized to affect rates and patterns of language acquisition are the complexity and intellectual coherence of maternal speech. While the mother may verbalize relevant attributes in a task situation, the complexity of simplicity of her utterance can contribute to the effectiveness of her teaching style. Bernstein (1964) concluded that the elaborateness of maternal speech elicits more "elaborated" or "restricted" code in the child. Maternal intelligence is also thought to be important for structuring the child's environment.

Brophy's work (1970), predicated on the work of Hess and Shipman (1965), claims that mothers may utilize verbal behavior in teaching situations in one of two ways: proactively or reactively. In assessing a structured teaching situation, two aspects of the mother's communication were coded: (1) verbalization of task-specific discriminations, and (2) focusing behavior, where the mother focuses the child's attention on salient attributes of the task object. Brophy found that middle class mothers operate proactively, using all their energies to orient the child conceptually and discriminate all salient features, whereas the lower class mothers operated reactively, criticizing their children for mistakes. Though these behaviors were not unilateral on either side, a significant difference between the groups was found. These forms of language behavior were correlated not only with socio-economic status, but also with mother's and child's I.Q.

Nelson (1971) has correlated mother-to-child speech in the second year of life with the child's facility in combining words in phrases. Mothers whose children showed relative ease with combinatorial skills spoke about objects more, were non-directive with their children, spoke in shorter and more coherent sentences, and addressed more questions to the child, as well as using fewer simple stereotyped routines of language (such as "D'you wanna?," or "How about"). The children of these mothers used phrases that seemed to be derived from productive rules rather than unanalyzed fragments. These patterns in the child's speech were correlated with both SES and child's birth order. Nelson concludes that early environmental input results in children learning language that differs in form as well as content.

It is obvious that none of these theories fully consider that both learning and genetic control operate to foster language development. Nonetheless, the relative contribution of genetic and environmental variance to individual differences in language acquisition has been studied.

The classical twin research method has been used by a number of researchers in various attempts to disambiguate genetic and environmental variance. In much research the central assumption is that the variance between identical, or monozygotic twins is environmental variance, while dizygotic twins reveal differences based on genetic and environmental variation.

Lenneberg (1967) has summarized the mostly anecdotal reports of twin similarity for onset of speech and speech development history. Over 90% of identical twins (monozygotic, or MZ) are reported to have the same speech development history, while only 40% of fraternal twins (dizygotic, or DZ) have the same history. Koch (1966) studied 90 twin pairs of 59 to 86 months of age. Speech form, as judged by teachers and the investigator, was more similar for MZ groups than for DZ groups. The studies previously reported on language acquisition in twins do not allow firm conclusions to be drawn because of methodological problems in the diagnosis of zygosity, use of retrospective data and possibilities of observer bias (Luchsinger, 1953, 1957, 1961; Seeman, 1937).

In recent research Bruggemann (1970) has studied two sets of two-year-old monozygotic twins. The co-twins differed in the words in their vocabulary, words forming the pivot class, as well as manner of negation formation. However, diagnosis of zygosity was based primarily upon examination of the placentas, and only one serological test was done.

Mittler (1969, 1970) has done a comparison of 200 twins and 100 singletons which has yielded more definitive findings on twin language abilities. Comparing MZ to DZ twins (where zygosity was determined by dermatoglyphic analysis), and twins to singletons, using the I.T.P.A. and the Peabody Picture Vocabulary Test, Mittler found that while MZ and DZ twins' language development is approximately six months behind that of singletons, there is no difference in the pattern of their development. Mittler also found that even as there was no significant difference between MZ and DZ intrapair variance on the Peabody and I.T.P.A., nonetheless the heritability of language skills (as measured by Holzinger's H) ranged between 44 and 56 percent of the total variance of the subtest of the I.T.P.A. Mittler's study is not definitive, however, in that the measures used did not test for phonological, morphophonemic, and syntactic language skills, but merely looked at vocabulary and auditory perception.

Genetic influence is not time-bound or static, but can be assumed to have a pattern of influence over an individual's development. Furthermore, estimating the genetic and environmental variance for trait at one point in time does not shed light on the substrates of patterns of development. For example, McCall (1970) found that

MZ twins in the Fels Longitudinal Study were more similar than DZ pairs on I.Q. measures taken at any point in time. However, patterns of change in I.Q. scores did not show significant heritabilities. Fraternal twins were no more dissimilar than identicals in patterns of change in intelligence test scores. However, more recently Wilson (1972) has found that there are genetic influences on patterns of development. Using the Bayley scale as a test of mental development, Wilson found that identical twins had patterns of change on the test which were significantly similar, whereas DZ twin pairs did not show similar patterns of change. This suggests, argues Wilsón, a genetic blueprint for the course of development.

The combination of genetic and environmental variance to language development is a complex problem with many unsolved questions. Factors in the child's environmental situation such as mother's language, I.Q., approach to the child, and the child's own endowment--memory, I.Q., personality characteristics and, possibly, a special language acquisition mechanism all may influence the course of development. Furthermore, different aspects of language (morphology, phonology, syntax) may be subject to genetic and cultural influences at different time periods within development. (For further discussion of the problem see Appendix A.)

CHAPTER II

RESEARCH HYPOTHESES

The present study was designed to assess the relative contribution of genetic and environmental variance to the phenotypic expression of language skills. The classical twin method is used, comparing intrapair similarity for identical and like-sexed fraternal twins on measures of phonological, morphological, syntactic and semantic development. In addition, the mother's interactions with her child are measured, both in terms of the verbal complexity of her speech and her speaking style. Comparisons will be made for all measures: one, between children reared by the same mother but who differ in genetic relatedness (MZ vz. DZ pairs); and two, between children reared in different families whose mothers vary in I.Q., speaking styles, and speech complexity (between families).

The central hypotheses of the twin research were as follows:

1) There are measurable aspects of language which are heritable, and thus identical twins will show significantly smaller intrapair variance than fraternals on the language development measures.

2) Not all aspects of language will show evidence of genetic control--rules for use of language and elements involved in the child's discourse operations are hypothesized to be under environmental control, and so identical twins will not show significantly smaller intrapair variance than fraternals on measures of such abilities.

3) While mothers may both respond to, as well as influence the development of differences and similarities in language skills between co-twins, mothers' influence on differential development--when disambiguated from responses to such development--will be shown to be significant. A critical test of the two implied hypotheses--one being that mothers adjust their language input to the child's general comprehension level (implying that the child's behavior cues the mother's behavior), and the other being that the mothers' differential stimulation to their children causes different levels of child comprehension and speech production (thus implying that the mothers' behavior cues the child's behavior)--is provided by an MZ-DZ twin study. Mothers are frequently incorrect in their assumptions of their twins' zygosity. Do mothers of identicals who mistakenly think they have DZ children, provide differential input to the two co-twins? If this is the case, do these genetically identical twins show language patterns similar to true MZ pairs, or is their language development--due to the mother's influence--discordant? A similar study can be made of

fraternal twins believed by the mother to be identical. Since over one fifth of twin pairs are misclassified by their mothers it can be determined if mothers automatically adjust their language input to the child's true genotype or provide variable input regardless of genotype (see Scarr, 1968).

Out of these three major hypotheses the following specific hypotheses were developed:

1. Monozygotic twins will be found to be significantly more similar in patterns of language development than same-sex dizygotic twins.

2. General intelligence, as measured by the Stanford-Binet will be significantly correlated with measures of language development.

3. Skill on tests of syntax, semantics, and morphology will be significantly correlated: tests of syntax (the Osser measure, Mehrabian's syntax measures), tests of morphophonemic skills (Berko's test, and Mehrabian's inflection test), and vocabulary measures (Peabody and Mehrabian) will have higher within test group correlations than between test group correlations.

4. Level of verbal complexity as measured by MLU (mean length of utterance) will show more intrapair variance between DZ than MZ co-twins.

5. MZ twins and DZ twins will show equal similarity in measures of "speech style." These are measures of

frequency of verbalizations, amount of verbalization, frequency of verbs, use of personal pronouns.

6. Mother's speech style will be significantly correlated with her children's MLU (mean length of utterance) and aspects of her children's language behavior.

7. MZ twins whose mothers misperceived their twins will show more variation in verbal complexity and speech style than MZ's whose mothers correctly perceived their zygosities.

Possible Outcomes

Considering the above hypotheses, at the outset of the present study a number of different outcomes were possible. If MZ co-twins were found to be generally more similar than DZ pairs on measures of language acquisition, this would support a genetic hypothesis to account for individual differences in language development.

A second possibility was that both MZ and DZ co-twins would be found to be very similar in language performances but that large differences will be found among twin pairs. This outcome could support an environmental hypothesis based on within-family similarity versus between-family differences in language environment. In such case measures of maternal behavior would probably correlate with intra- and between-pair variances.

A third possibility was that little variability in language acquisition will be found either within or between families. It could be that language environments represented by a small twin pair sample would be sufficient to support similar patterns of language acquisition in all of the children, regardless of genotypic differences. Since individual variation is the general rule of behavioral development, this seemed a remote possibility, but such an outcome could lend support to the idea of a species-specific, genetically determined language acquisition pattern with little individual variation (Lenneberg, 1966, 1967).

A fourth possibility, also remote, was that a great deal of variation in language acquisition will be found both within and between families for both MZ and DZ pairs. If maternal behavior is also uncorrelated with variability within- and between-pairs then the standard measures of language acquisition might be said to be unreliable or, to have been unreliably used in this study.

A fifth possibility was that MZ pairs would show greater variability in language skills than DZ pairs. This finding, if correlated with a sample bias--more between-family variance in MZ than DZ groups--would suggest (1) that language is under environmental control, and (2) that parents nullify differences in DZs through environment, but, for psychological reasons allow MZ variability or encourage it.

Finally, it may be that different skills, morphology vs. syntax, phonology vs. semantics, will show different patterns of heritability and differentiable patterns of variance. This would support a Lorenz model of genetic cum environmental influence wherein different aspects of a behavior fall under different control. This would also lead to an understanding of language as a much more complex set of skills (Morton, 1970).

CHAPTER III

METHODOLOGY

Introduction

Given the problem of establishing the relative causality of (1) genotypic identity and (2) discourse features of the communication environment, in determining the course of language acquisition in a sample of children, there are not only substantive theoretical considerations, but there are important methodological issues as well.

The experimental design of this study incorporates a research paradigm from behavior genetics, the twin study method (Vandenberg, 1968) with a paradigm from communications research, content analysis (Holsti, 1969). In this study of children's language skills, an estimate of the heritability of individual behaviors is done by means of MZ and DZ co-twin analysis of variance, while the correlation of the mother's language behavior to such skills is estimated following a content analysis of her speech. Furthermore, examination of aspects of the children's particular skills on a given measure of language ability has been effected through a content analysis of the child's responses to the measures. The study presented here has thus combined the two distinct methodological paradigms into one design in order to obtain information about processes which affect language development. A third aspect of the design is the ethnography of communications, the study of rules in communication and interaction patterns. It provides a means to discuss the mother-child interaction situation.

Before the specifics of the research design are considered, it is important that the concept of heritability and the twin study method be fully explained, the technique of content analysis discussed, and the elements of the ethnography of communication be presented.

Heritability

Heritability, relative across environments and across populations, is the concept which represents the degree to which variance in a particular, quantitatively measured behavior may be accounted for as coming from a genetic rather than environmental component. Following Jensen (1969) the variance of the phenotypes, which is the outcome of genetic and environmental interaction, can be separated into a number of variance components, where each represents a source of variance. The components, taken together add up to the total variance. Thus,

$$V_P = \underbrace{\frac{(V_G+V_{AM})+V_D+V_i}{V_H}}_{\text{Heredity}} + \underbrace{\frac{V_E+2Cov_{HE}+V_I}{V_E}}_{\text{Environment}} + \underbrace{\underline{V_e}}_{\text{Error}}$$

where:

V_P = phenotypic variance in the population

V_G = genic (or additive) variance

V_{AM} = variance due to assortive mating. $V_{AM} = 0$ under random mating (panmixia)

V_D = dominance deviation variance

V_i = epistatis (interaction among genes at 2 or more loci)

V_E = environmental variance

Cov_{HE} = covariance of heredity and environment

V_I = true statistical interaction of genetic and environmental factors

V_e = error of measurement (unreliability) (Jensen, 1969).

Again, following Jensen, the technical formula definition of heritability is

$$H = \frac{(V_G + V_{AM}) + V_D + V_i}{V_P - V_e}$$

<u>The Twin Study Method</u>

Vandenberg (1966) states that while the twin study method cannot be used to trace genetic <u>mechanisms</u>, it does permit the investigation of the comparative contribution of hereditary components to the total variance on a set of variables, where those behavioral variables are all tested for on the same twin population.

The research design of twin studies involves the selection of a sample of same sex twins, whose zygosity is unknown to the experimenter. MZ (identical twins) share a common genetic trait endowment, while DZ (fraternal) twins have only 50% of their genes in common. It can thus be argued that measurable differences between two members of an MZ twin pair must result from environmental factors alone, while differences in the DZ pair are the result of environmental and genetic differences.

Blood typing (Gottesman, 1961) and fingerprint analysis (Nixon, 1952) are used to determine zygosity of the twins. (This information is not collected by the experimenter until after all analyses have been made).

The heritability measures often used in twin study research are Holzinger's h^2 based on within pair variance of the twins;

$$h^2 = \frac{{}_W DZ^2 - {}_W MZ^2}{{}_W DZ^2} ,$$

and Falconer's h^2;

$$h^2 = Z\,(r_{imz} - r_{idz})$$

based on the difference between MZ and DZ intraclass correlation.

Jensen's formula, discussed above, is a determination of total phenotypic variance in a population where heritability is considered in the broad sense, that is, all possible factors are included in the formula. In the present research heritability is determined in the narrow sense as an estimate of the proportion of genetic variance without any consideration of dominance, epistasis, or assortative mating.

The technical formulas used here estimate heritability in the narrow sense using $V_H \times V_E$, or the statistical interaction of environment and heredity, and V_E, or true environmental influence, in order to determine V_h, (heritability in the narrow sense). For Holzinger's h^2 statistic, and Falconer's h statistic, the assumptions are (1) that any differences between DZ co-twins' behaviors are the result of the interaction of heredity and environment, $V_H \times V_E$, and (2) differences between members of an identical or MZ twin pair are purely environmental or V_E. Thus any statistical test of the differences between the two variances should yield that portion of the variance which is accounted for by genetic control.

Holzinger's h^2 tests for the difference between MZ and DZ within-pair variances as a statistical measure of heritability, and Falconer's h tests for the difference between MZ and DZ intraclass correlations as a statistical measure of heritability. In terms of Jensen's formula, therefore, it can be seen that the broad factors are used in these statistics as they subsume the other factors, and no determination is made separately for the factors indicated above the line in the formula.

Where $h^2 = 1$, the effect is totally genetic, where $h^2 = 0$, the effect is wholly environmental. This formula holds where the following assumption can be met: that the amount of within-pair variance contributed by the environment to the trait under question is the same for the fraternal (DZ) and identical (MZ) twin pairs studied (Vandenberg, 1966). The question as to whether this assumption can be met has been discussed by Scarr (1968).

The corresponding F test for Holzinger's h^2 is

$$F = \frac{{}_{W}DZ^2}{{}_{W}MZ^2}$$

Also used in the analysis of co-twin data is the intraclass correlation. This statistic (Wilson, 1968)

$$r_i = \frac{\text{between family variance-within pair variance}}{\text{between family variance+within pair variance}}$$

compares the variance between co-twins with the variance expressed between twin pairs in the sample. The intraclass r_i is a one-way analysis of variance, and as such represents the proportion of the total variance which stems from differences between twin pairs. If co-twins' scores on a given measure are the same, the within-pair variance is zero, and thus r_i would be 1.00. Any variance between co-twins will lessen the r_i: if co-twins' scored behaviors are no more alike than that of random individuals, clearly $r_i = .00$ (Scarr, 1969).

A heritable behavior might then be expected to show a high intraclass correlation for MZ pairs, and a low intraclass correlation for DZ pairs, given the assumption of homogeneity of between-family variance for both MZ and DZ groups taken together. But if both MZ and DZ pairs show significant intraclass correlations it may turn out either that the particular trait is either highly heritable, or it may be under considerable environmental control.

The test for the significance of the difference between $r_{i\ mz}$ and $r_{i\ dz}$ is done by an F test of the within-pair variances.

Content Analysis

Important aspects of the methodology of content analysis of language behavior are the following: coding categories, or the scheme of labelling and isolating elements in the speech as data because of their participation in such a category; second, the units of speech which may be placed in such a category, whether morphemes, phonemes, words, phrases, sentences or units of discourse; and third, procedures of giving value or weight to coded units--frequency of presence, order of position, power of the coded units, etc.

Involved in the process of developing a content analytic scheme are the further questions of sampling, reliability, and validity (Holsti, 1969). A proper determination of coding categories will help to establish validity and reliability. If a coding scheme is not only exhaustive, and based on a unified principle of classification, but the categories are also mutually exclusive, independent and most importantly reflect the purposes of the research, and further, if the variables involved are clearly defined, not only in the researcher's mind, but stated, presentable and interpretable by others, then it may be that the researcher's ideas will be represented validly in the final data, and that coders may be able to do a reliable job (Holsti, 1969).

Ethnography of Communication

A third element in the present design--one which operates by means of content analytic methodology--is the ethnography of communication. Susan Ervin-Tripp in her discussion in the Ethnography of Communication (1964), states that sociolinguists study verbal behavior in terms of the relation between Hymes' (1962) categories which are:

(1) the setting
(2) the participants
(3) the topic
(4) the functions of the interaction
(5) the form
(6) the values held by the participants about each of these (Hymes, 1962).

In a more recent discussion of sociolinguistics in the *Handbook of Experimental Social Psychology*, Ervin-Tripp goes into somewhat greater detail in discussing the variables which may affect individual variation in daily speech: personnel, situation, speech acts, topic, message, functions of interaction, and rules for switching.

As Ervin-Tripp points out, there are a variety of interactions possible already (participant-form, function-setting). Many are known and more will be discovered.

Ethnography of Speaking

Hymes has offered a set of elements necessary for an adequate model of the rules for ways people speak. These elements are (1) message-form, (2) message-context, (3) setting, (4) scene, (5) speaker, (6) addressor, (7) hearer, or audience or receiver, (8) addressee, (9) outcomes, (10) goal (11) key, (12) channels, (13) forms of speech, (14) norms of interaction, (15) norms of interpretation, and (16) genre (Hymes, 1969).

Hymes states that generalizations about modes of speaking may take the form of relativity among the components, and he suggests that the method of discovery is to observe language behavior, considering any difference in a component as a possible point for application of a 'sociolinguistic' test: that being what relevant *contrast*, if any, is present (Hymes, 1969)?

In terms of this model the focus of the present research has been the examination of possible act sequences which serve the function of teaching the child to be communicationally competent in his own code. This has been examined in a set of situations where setting, scene, speaker, listener, outcome and message-content are controlled, while other elements are free to vary and co-vary.

Design

One group of forty-two children or twenty-one twin pairs was used, where each child was tested individually on a series of language measures (see Measure's section below). To control for bias in testing two E's were always present and only one twin per time was tested all measures by one E. Furthermore, as testing took place over separate visits, order of testing was randomized. At the time of testing all responses were coded onto test sheets specially arranged for such coding, and the child's speech was tape-recorded. The child was also placed in an interaction setting with his mother, where a set of two story books served as a basis for the mother-child interaction. IQ measures were taken on all forty-two children (Peabody Picture Vocabulary Test, and the Stanford-Binet I.Q. test), and a modified form of the Wexler Adult Intelligence Scale test was given to all mothers. The mothers were further interviewed on their attitudes toward each twin's language development, children's use of language in general, and they were asked a series of questions on the pregnancy and delivery of the twins. A questionnaire was also given to the mothers concerning socioeconomic factors, such as husband's education and husband's job, and the mothers were also requested to give an absolute judgement as to the zygosity of their twins.

At the close of data collection, mothers were requested to allow their children to be taken to the University of Pennsylvania Hospital for blood samples to be drawn for a serological estimate of zygosity. All those requested agreed. Four pairs were not brought in for analysis: two had been blood-typed privately previous to the study and this information was obtained from the families' physicians, one had been typed for a previous study (Scarr, unpub.), and another had been used in the same study as DZ because of markedly different eye color.

Blood samples were sent to the War Memorial Blood Bank in Minneapolis where antisera analysis was done on twenty factors (see Appendix D).

After the completion of data analysis, including all coding of responses on language measures, the results of the analysis were sent to Philadelphia, and final statistical analysis of the data was made.

Sample

At the beginning of testing the age range of the sample was from two and a half years to four years of age (see Table One). The sample was recruited from Philadelphia birth records, and from the greater Philadelphia Mothers of Twins Clubs who have a national policy of encouraging participation in research. Of approximately eighty possible pairs, twenty-three were obtained: black pairs were excluded, and those twin pairs with either or both twin of less than four pounds birthweight were excluded from the sample. Calls were made to mothers, following which an explicit letter detailing the research was sent. Of those twenty-three originally recruited, twenty-one stayed in the study. One set was dropped because of the mother's continual non-cooperation, the other set was dropped because one of the twins appeared to be autistic.

Of the remaining twenty-one pairs, there were fourteen same-sex female pairs, and seven same-sex male pairs. At the close of data analysis it was found that eight of the girl pairs were MZ and six were DZ, and that three of the boy pairs were MZ and four were DZ. The sample as a whole, however, despite a sex bias, is completely within statistical expectations for a group of same-sex, same eye color, same hair color twins: ten DZ and eleven MZ pairs, or roughly fifty percent MZ and

TABLE 1

BIRTHDAY AND BIRTHWEIGHTS OF THE TWINS

Twin pairs	Birthday	Birthweight
1.A	2/2/68	4 lbs.
1.B		3 lbs. 11 oz.
2.A	8/14/68	5 lbs. 8 oz.
2.B		5 lbs. 14 oz.
3.A	10/20/67	6 lbs. 12 oz.
3.B		5 lbs. 9 oz.
4.A	11/27/68	6 lbs. 12 oz.
4.B		4 lbs. 10 3/4 oz.
5.A	2/17/68	4 lbs. 11 1/2 oz.
5.B		5 lbs. 8 1/2 oz.
6.A	8/5/68	5 lbs. 2 oz.
6.B		5 lbs. 3 oz.
7.A	4/25/68	5 lbs. 3 oz.
7.B		5 lbs.
8.A	5/18/68	5 lbs. 7 oz.
8.B		5 lbs. 11 oz.
9.A	4/14/67	5 lbs. 6 oz.
9.B		6 lbs. 14 oz.
10.A	3/31/68	6 lbs. 9 oz.
10.B		5 lbs. 15 oz.
11.A	9/6/67	5 lbs. 6 oz.
11.B		4 lbs. 1 oz.
12.A	5/22/67	6 lbs. 12 1/2 oz.
12.B		6 lbs. 11 oz.
13.A	6/29/67	5 lbs. 8 oz.
13.B		6 lbs. 3 oz.
14.A	3/22/68	6 lbs. 6 1/2 oz.
14.B		4 lbs. 12 1/1 oz.
15.A	3/24/68	4 lbs. 15 oz.
15.B		4 lbs. 1 oz.
16.A	8/16/68	6 lbs. 2 oz.
16.B		6 lbs.
17.A	3/26/68	4 lbs. 6 oz.
17.B		4 lbs. 9 oz.
18.A	3/17/67	4 lbs. 8 oz.
18.B		4 lbs. 13 oz.
19.A	2/15/68	7 lbs. 7 oz.
19.B		7 lbs. 9 oz.
20.A	8/8/68	7 lbs. 4 oz.
20.B		6 lbs. 4 oz.
21.A	4/22/68	7 lbs. 3 oz.
21.B		7 lbs. 13 oz.

fifty percent DZ.

The socioeconomic status of the families, as judged from the occupation of the fathers, was rated in terms of the socioeconomic scale reported in Reiss et al. (1961). This scale is based on a survey of the status value of jobs and occupations done by the National Opinion Research Center (NORC). While this survey was performed in 1947, and some shifts of the status of some jobs have taken place, this would not affect the present ranking significantly. The benefit of this scale for the present study is that it makes it possible to obtain a rating with a minimum of information. Furthermore, this ranking has been used by the Louisville Twin Study, aiding in later data comparisons (Vandenberg, 1968).

On the Population Decile Scale of the Bureau of the Census 1950 detailed classification, the sample is solidly middle class with an average of 8.2 on a ranking of one to ten, where the sample range is from 4 to 10. On the overall NORC transformation of the Census socioeconomic index (100 points), the sample average is 51.2, with a range of 67 points, from 18 to 85. Occupations represented by the fathers of the present twin sample range from bank vice president (85) to rampman on a conveyor belt (18). None of the mothers presently hold fulltime jobs, although four of them have part-time jobs.

The range of intelligence of the sample as measured by the Peabody Picture Vocabulary test and the Stanford-Binet IQ shows a great similarity in average IQ for DZ and MZ groups. On the PPVT, the average of DZ pairs is 88.8 and the average of MZ pairs is 85.6, where the standard deviations are 15.1 and 15.7 respectively. On the Stanford-Binet, however, while the average of all IQs is similar for both groups--102 for MZ and 100.4 for DZ--the standard deviation for the groups is extremely different: 21.0 for MZ and 14.0 for DZ. This extreme difference reflects the fact that the MZ IQ range was 70 points, from 66 to 136, while the DZ IQ range was only 49 points, from 74 to 123. This bias may affect intraclass r_is, which are computed with between-family variance, but would not affect estimates of heritability.

Another bias in the sample was the birth order of the twins within the family. Five of the MZ twin pairs are first born, and none of the DZ pairs were first born. The rest of the MZ's and all DZ's fall in 2, 3 or 5 position in the family. This most likely reflects the evidence so far gathered that MZ twinning is random and more likely to occur with first births, and that DZ twinning is both heritable and a function of increased maternal age, as well as previous fertility (Bulmer, 1970). The effects of such a bias may be to increase scores for both MZ co-twins, considering that birth order and number of siblings do have an effect on language development, however this again would not affect the estimate of heritability, which is based on within-pair variances.

Still another bias in the sample was that at the time of testing the average age of DZ pairs was greater than that of MZ pairs by about three months. CA adjustments to scores, however, should eliminate this bias.

Measures

The measures used in this study are of four distinct types: tester administered language skill measures, coded content analytic measures on test responses or transcriptions of tape recorded speech, interviews, and questionnaires. All four are described below.

Tester Administered Measures

All measures used in this study were previously developed and are reported in the literature (Berko, 1958; Fraser, 1963; Mehrabian, 1970; Osser, 1969; Manual for Administration Story sequences task, 1969; Peabody Picture Vocabulary Test, 1965). The tasks can be sorted on four general dimensions: the PPVT and test one of the Mehrabian sequence are tests concerned with vocabulary development; Osser, Fraser (from here on referred to as the Harvard measure), and Mehrabian text six are designed to test for development of comprehension and production of various aspects of syntactical operations; Berko and Mehrabian test four are designed to test for the child's acquisition of morphology; and the E.T.S. Picture story task sequence is designed to test for the child's operations with discourse (see Table 2).

All findings reported on these tests have been with singletons. The general age range of samples previously used with these measures is from two to five years --a range which encompasses the present sample.

Peabody Picture Vocabulary Test

This test is a series of four picture choices on a page wherein the tester presents the page to the child with the statement of a noun or verb pictured as one of the four items. No articles which would clue the child in to the picture are used. Instructions to the child follow the formula "Can you show me shoe?," "Can you show me sitting?" The child is questioned until he or she offers six wrong choices within a set of eight serial choices at which administration of the test is terminated.

Previous research has used the PPVT not only as a measure of vocabulary, but also as a measure of IQ (when raw score is transformed) and as a language developmental norm as well (Osser, 1969). In the present study it has been used as both a measure of vocabulary and a measure of intelligence.

TABLE 2

MEASURES USED IN THE STUDY

Name	Abbreviation	Description with Sample Instruction
Peabody Picture Vocabulary Test	PPVT	An age-graded vocabulary measure administered by showing 4 pictures on a page, giving a noun or verb lable for one: "Here is banana, show me banana."
Stanford-Binet Vocabulary Test	S-B Vocab.	Vocabulary measure for 2-3-year-olds where 18 pictures are shown, one to a card, and the child is asked to label: what is this? A subtest of the Stanford-Binet IQ test.
Mehrabian's Vocabulary Test	M1	Part of a set of six measures, it is a vocabulary test for 2-5-year-olds based partially on the S-B vocab. Administration identical to that of PPVT.
Berko Measure of Morphology	Berko	A measure of morphological rule-use. Nonsense pictures are shown, and the child is asked: "This is a niz, here are two ________?"
Mehrabian Measure of Morphology	M4	Measure of child's knowledge of morphology based on I.T.P.A. items. As with Berko, child is asked to fill in the blanks: "Here is a leaf, and here are some ________."
Fraser's test of comprehension	Harvard	Child is asked to point to the appropriate one of two pictures given a sentence which fits only one picture. "Show me the boy is pushed by the girl."

TABLE 2 (continued)

Name	Abbreviation	Description with Sample Instruction
Osser, Wang, Said Measure of syntax imitation	Osser	A set of thirteen sentences is read to the child, and he is asked to repeat the sentence exactly: "Father is doing some painting with a brush."
Mehrabian's Measure of syntax repetition	M6	The child is asked to repeat each of 18 sentences: "I want to play," "You have to drink milk to grow strong," etc.
E.T.S. Story Sequences Test	Story	Here the child is requested to make up a story about 4 pictures of animals (in various activities) which are placed before him. A sample story would be: "The bunny is eating and drinking coffee, and the turtle is going out. They're all playing," and on.
Morpho-phonemic trans-formation	MT	A form of coding for the Osser, M6, M4 and story which include all changes from correct syntax and morphology which appear to be an attempt to approximate the correct syntax or morphology: for example, "There isn't any more" repeated by the child as "There's not any more."
Syntactic deletion	Del.	A form of coding which counts number of words deleted from a repeated sentence.

TABLE 2 (continued)

Name	Abbreviation	Description with Sample Instruction
Syntactic insertion	Ins.	A form of coding which counts number of words inserted in a repeated sentence.
Verbs Correct	VC	A form of coding which counts number of verbs used correctly in ETS Story, Osser, and M6 repetition measures.
Story Personal Pronoun	PP	A form of coding which counts number of personal pronouns used in the ETS Story Sequence's last item.

Berko

This measure was designed to discover the level of a child's rule learning about the nature of morphological operations. A series of pictures are presented to the child, and questions are asked of the child following an identification of the object or objects in the picture--which is most often a nonsense character. These questions are intended to lead the child to express whatever rules about the word and its endings he has learned, or possibly had somehow as innate rules. A sample question is the first item: "This is a wug. Here is another one. Now there are two __________?" The argument implicit in the design is that if the child can operate with the morphological change to /z/, he will express his knowledge by filling in the tester's blank. There are twenty-eight items in the test, allowing for the development of plurals, verb tenses, and comparatives.

Fraser (Harvard)

In this test the child is presented with a series of two paired pictures. The child, after hearing the two possibilities unassociated by the tester with an individual picture, must then point to the picture which goes with the utterance. The test administrator will say: "One of these is some string and one of these is a string. Now show me a string. Now show me some string." There are fifty-two items in the test, which covers pictures showing difference in articles, adjectives, possessives, tense (past, present, future), transformation (active, passive) and negation (Fraser, 1963).

Osser

The Osser measure consists of thirteen sentences spoken to the child with the preceding instructions that he or she repeat the sentence exactly as it is spoken by the experimenter. The sentences are of almost the same length, and vary in terms of the complexity of the underlying structure. Samples of the sentences are: "Father does some painting with a brush; The boy sees that the girl sits; and A boy slides and another boy slides." Two variants of the test were offered in the original publication; only variant B is here analyzed.

Mehrabian

Mehrabian (1970) developed a set of six measures to test linguistic ability, particularly grammatical ability, in children aged two to five years. His tests, derived from items on the Stanford-Binet, Menyuk (1963), and I.T.P.A. (1961), were shown to have both high test-retest reliability (.82 for all measures) and high intercoder agreement (.72 to 1.00 for all six tests). Test one is a picture vocabulary test, test two is a test of comprehension of simple commands, test three is a test of the comprehension of meaningless commands (such as "Put the box into the ball"), test four is a test of inflection, test five is a test of the judgement of the grammaticalness of sentences, and test six is a test of verbal imitation, where the items are taken directly from Menyuk's 1963 test.

Of these six tests only three were used in the study (see Appendix D). In pretests with singletons, and in the initial testing of twins, tests two, three, and five were found to be confusing to the children in our samples, and consequently difficult to administer.

E.T.S. Picture Story Task

This test was taken from a current study being conducted by Dr. Virginia Shipman out of E.T.S. in Princeton. Specific test design was the work of Dr. Tanaka of that staff.

The test is constructed as a series of pictures offered to the child with a monologue on the part of the experimenter. The tester reads or memorizes the script, and presents a picture to the child in groups. The child's tasks are (1) to order an aggregate of pictures in terms of the order of the sentences in the story, (2) to repeat certain more complex stories in the face of pictures which partially illustrate the story, and finally, (3) the child is offered the opportunity to tell the tester his own story based on four pictures presented at the end of the other tasks. This last task was used as part of the present study.

<u>Coding Measures</u>

Category coding schemes had to be constructed for the test responses which were not to be scored as simply right or wrong. The PPVT and the Mehrabian vocabulary measure (hereafter referred to as M1) and the Berko were all scored simply as right or wrong, and the Harvard test of grammatical comprehension was also scored right or wrong. The Osser, M4 (inflectional test) M6 (production of grammatical repetitions), and E.T.S. Story task, however, were coded in a more complex fashion.

The Osser and M6 were coded according to a single coding scheme developed from the scheme used by Osser, <u>et al</u>. (1969). The child's responses were coded for deletions from each sentence, insertions to each sentence, number of verbs correctly used in the sentence, and number of morphophonemic changes made to the words in the sentence. The unit for deletions and insertions was the single word, the unit for correct verb use and morphophonemic change was variable. In the case of a plural, morph change would only involve a single word, but in the case of such change involved in the elaboration of a contraction two words would be involved, and further still, in the instance of a complex two-part auxiliary verb, three words might be involved in the morph change. Similarly with the judgement of correct verb use might involve one, two or three words. Enumeration was by frequency.

The M4 involved a three-category scheme: an individual answer was coded correct, incorrect, or a morphophonemic transformation of the correct answer. Definition for the third category was provided by an invariant list of possible answers for each test item. The unit here was the single word, and a child's response might then be coded as simply 1, 2, or 3.

The story sequence was coded across a number of dimensions. Decisions had to be made as to (1) number of utterances in the story, (2) number of words in the story, (3) number of verbs incorrect, (4) number of verbs correct, (5) number of personal pronouns, and (6) number of characters. This last item was dropped when the coding of it by a set of twenty coders proved to be unreliable. As with the coding of the Osser and M6, enumeration was by frequency within category.

Reliabilities for Child Test Coding Schemes

With these coding schemes, and with the right-wrong scoring, all coding was done separately by two coders, and then each disagreement was settled by reference to a written code-book and the data itself. For all tests intercoder agreement was raised to 1.00. For the complex coding schemes, a subset of the data was given to a sample of twenty college juniors to code with verbal and written instructions. Using Scott's intercoder agreement coefficient (Krippendorff, 1969), reliabilities for coding one decision from the Osser-M6 scheme (morphological transformation), one decision from the M4 scheme (morphological transformation), and all decisions on the story task were obtained. For the Osser-M6 item a = .76, for the M4 decision, a = .83, and for the elements of the story coding: (1) number of utterances a = .81, 1.00, .71; (2) number of words, a = 1.00, 1.00, .87; (3) number of verbs incorrect, a = .82; (4) number of verbs correct, a = .71, 1.00; (5) number of personal pronouns, a = 1.00, 1.00, .93; and (6) number of characters, a = .66, .75, .82. The high reliability of many tested samples is probably as much due to the brevity of the children's stories as to the power or clarity of the coding scheme. The samples for testing decisions were drawn at random from the data set using a random number table.

The mothers' language in interaction with each twin was also coded for use in analysis. This scheme involved a set of decisions on the first 100 utterances the mother used in telling a story to each of her twins. The scheme involved the non-hierarchical decision set: question, answer, reduction of what the child said, expansion of what the child said, repetition of what the child said, criticism of what the child said, confirmation of what the child said, assertion, and direction to the child to speak, perform or attend, with final category, "other." For the entire sample of utterances, the category of reduction was an empty category--no mother reduced anything which her child said. Reliabilities on three decisions using a small subsample of the data was twenty college juniors as coders showed reliabilities as follows: (1) questions, a = .92; (2) confirmations, a = .81; and (3) directions, a = .87.

For all measures and coding schemes employed in the present study two coders coded the data separately and then worked with the codes and published test manuals to raise intercoder agreement to 1.00. Special, or more complex coding schemes, those novel to this study, were tested for the reliability of individual decisions involved in coding the data.

Questionnaires and Interviews

The interview with each mother on her pregnancy and delivery with the twins had a double purpose. As data about the pre- and post-natal condition of the children was discovered, a sample of the mother's spontaneous speech to an adult was unobtrusively gathered. On this sample of speech a mean length of utterance for each mother was estimated.

The composite questionnaire given to each mother at one visit and collected at the next visit asked for socioeconomic information, data on the family, position of the twins in the family, attitudes toward each twin, attitudes toward child language development, and the mother's own estimate of her childrens' zygosity. For the present study use of this information has been limited to socioeconomic information, perception of the twins' zygosity, and a general determination of the mother's interest in her children's language development.

CHAPTER IV

PROCEDURE

Data collection was undertaken by the author in collaboration with Mrs. Karen Fischer of the Graduate School of Education, The University of Pennsylvania. Mrs. Fischer is using data from this sample for her dissertation under Dr. Sandra Scarr-Salapatek of the University of Minnesota. Mrs. Fischer has had primary responsibility for analysis of the PPVT and Berko measures, and is also concerned with a question of twin methodology. The author has had primary responsibility for the analysis of the E.T.S. story sequence, the three Mehrabian measures, and the analysis of factors in the mothers' speech.

Testing Procedure

The experimenters visited subjects in their homes over a period of ten months at approximately four to six week intervals. In the course of an average of five visits, all tests were administered at least once to each twin. Presentation of the tests was randomized, and in the course of a single visit, one experimenter tested only one twin of the pair, while the other experimenter tested the other twin. This is absolutely necessary to control for bias. If an experimenter perceives a pair of twins to be identical, then if he or she tests both twins, there is a possibility that this perception will influence coding of responses and tester behavior as well.

In most homes tests were administered with one twin and one experimenter in the living room on the sofa or on the floor, and the other twin and experimenter in the kitchen or dining room seated at a table. Mothers generally were present in either of the rooms at some point during the testing (they sometimes used our presence as a chance to do the laundry). Non-interruption by other siblings was requested by the experimenters, but no constraints were put on the mother's behavior lest she develop any anxiety about what was happening in the course of testing. Her presence was, of course, required in the story task, and here an effort was made by the experimenter to leave the immediate area where the story was being told.

Experimenter perception of zygosity fluctuated greatly in the course of the study. During the ten months of data collection the children did grow, and as height and weight changes took place, and as interaction led to greater familiarity, a number of decisions went back and forth. Table 3 shows a comparison of experimenter and mothers' zygosity estimates with true, serologically

TABLE 3

ACTUAL AND PERCEIVED ZYGOSITIES OF THE TWINS
BLOOD-GROUPED FOR THE PRESENT STUDY

Twin Pairs	Actual Zygosity	Exp. A	Exp. B	Mother
1.A,B	MZ	DZ	MZ	DZ
2.A,B	DZ	DZ	DZ	DZ
3.A,B	DZ	DZ	DZ	DZ
4.A,B	MZ	DZ	DZ	DZ
5.A,B	DZ	DZ	DZ	DZ
6.A,B	MZ	MZ	MZ	MZ
7.A,B	MZ	MZ	MZ	DZ
8.A,B	MZ	MZ	MZ	MZ
9.A,B	DZ	DZ	DZ	DZ
10.A,B	MZ	MZ	MZ	DZ
11.A,B	DZ	DZ	DZ	DZ
12.A,B	DZ	DZ	DZ	DZ
13.A,B	MZ	MZ	MZ	MZ
14.A,B	DZ	DZ	DZ	DZ
15.A,B	MZ	MZ	MZ	MZ
16.A,B	MZ	DZ	MZ	MZ
17.A,B	MZ	MZ	MZ	DZ

TABLE 4

CORRECTLY AND INCORRECTLY PERCEIVED ZYGOSITY, WHERE MISPERCEPTION IS BY MOTHER OR EXPERIMENTER

Perception	Actual Zygosity	
	Actual MZ Pairs	Actual DZ Pairs
Perceived as MZ	5	0
Perceived as DZ	6	10

determined zygosity. The experimenters' judgements are those recorded immediately after the last visit to the home, and, consequently are closer to true zygosity than earlier estimates were. Note the two cases in which both E and the mother are in accord, but wrongly so.

Note on Table 4 that five mothers of MZ children perceived their twins as dizygotic, while no DZ pairs were misperceived by either experimenters or the mother. One factor which may account for the misperception of the five mothers of MZ pairs is that the average birthweight difference of the wrongly perceived pairs is 10.4 ounces, while the average difference for correctly perceived pairs is 6.6 ounces. (This where the average DZ birthweight difference is 13.6 ounces.) It also may have been that greater birthweight difference was not the only influence on the mothers' first perceptions of her twins, but also that the attending obstetrician may have misjudged zygosity, and presented such a misjudgement to the mother.

As stated previously, data collection involved not only administration of the described language measures, but also involved giving the Stanford-Binet. This test alone occupied an entire morning or afternoon visit, and completion depended on the continued attention and good humor of the child. Only three tests of forty-two had to be redone for lack of attention to the task, however, and most children enjoyed many of the subtests.

Of the language measures, from the child's point of view, the Berko measure was clearly the most popular--the "wugs book of pictures" was asked for long after the testing had been done. Response to the Harvard measure of syntactical competence represents the opposite extreme. Perhaps because the pictures were black and white line drawings, or because the test had so many similar items (fifty-two pairs of pictures with pairs of sentences), and because in many cases subsets of items were not understood by the child, this test was most difficult to administer in entirety.

Midway through the testing visits a distinct tester bias began to be evident. One experimenter seemed to be getting a consistently higher response level on a number of measures (Berko, Harvard). Discussion and retraining, with consideration of possible hidden factors such as unconscious shaping, reinforcement, personality, persistence and the like, seemed to have a correcting effect on this situation, and in the latter half of the testing this bias disappeared. Unfortunately, this makes it difficult to adjust for tester bias in the data: during the levelling off of later visits, the earlier trend appeared to reverse itself, overall nullifying the pattern of earlier effects.

It should be noted that this bias affected only two measures in the first half of the visits, and was not a controllable bias of failure to use standard instructions or the like. Furthermore, the design of switching twins with each visit (which was difficult because the children tended to associate themselves with one tester or another) also distributed the bias.

An important point to note about tester interaction with the twins is a suggestion made by Hymes (1961), that an investigator of child language should know what the culture views as an appropriate situation for verbal behavior, or what verbal behavior is appropriate to a given setting. In these homes testers were seen not as casual visitors, but as instructors with whom the child must do his best, and meet and respond to all requests for verbal behavior. Most all the children responded with serious attention and a great deal of interest, and continued in a test situation even to the point of fatigue (missing a nap).

Mothers' perceptions of the experimenters throughout the study were fairly uniform: while most mothers presented the testers as "teachers" to the twins and siblings, comments and hints in conversations suggested that mothers perceived the testers as child psychologists, investigating not some general question, but something in particular about her children. Aside from a general statement of research aims and hypotheses in the beginning of the home visits, no effort was made to clarify or disambiguate these responses, except in cases where such responses seemed to impair the research setting (or researcher--one mother called one of the experimenters at six in the morning to ask for advice on treatment of a twin's persistent psychosomatic cough!).

Blood Grouping Procedure

At the close of the data collection, mothers of twins were asked whether or not serological analysis had been done on their children. For the seventeen cases where no previous analysis had been done, all mothers agreed to let their twins be brought in for blood samples to be drawn. Though not painful to the child, it was a situation which provoked anxiety for mother and twins alike. The twins and their mother were brought into the Hospital of the University of Pennsylvania Outpatient Blood Donor Lab, and blood samples were taken. These samples were then shipped to Dr. Herbert Polesky of the War Memorial Blood Bank for serological analysis. The antisera used are often difficult to obtain for research, but the Blood Bank was able to complete tests on all pairs with the same antisera. Furthermore, they were able to use the samples for medical research in blood physiology.

At the completion of data coding, results were sent from Minneapolis to Philadelphia, and all mothers were informed by letter of their twins' blood types on the A, B, O system, and the state (positive or negative) of the Rh system. For those mothers who requested further information on all the antisera tests, the details were sent to the family doctor or pediatrician.

The antisera which were used in doing the serological analysis of the seventeen pairs are as follows:

A_1A_2BO system

MNS_s system

Rhesus tests CcDEe (Rh factor)

Lewis a and b

Kell k

Cellano k

Kidd (Jk^a and Jk^b)

Duffy (Fy^a and Fy^b)

Mt^a Martin

Yt Cartwright.

In the present study twins were classified as MZ or monozygotic where there was no discordance on any of these serological tests. One or more differences marked the pair as DZ or dizygotic. With twenty antisera used in the analysis, a reliability of approximately .95 can be expected on decisions of zygosity with this method (Sutton, 1962; Vandenberg, 1968).

DZ differences in the sample covered a wide range of discordance from one to ten, with the average of DZ antisera discordances being 4.4. For a table of both MZ and DZ differences, see Appendix B.

One surprising outcome of the presentation of serological evidence to the parents of the twins was that in two cases, mothers of MZ's misperceived by them as DZ's refused to accept the serological evidence. Perhaps this is not so surprising, as the mothers must learn to undo three or more years of attribution of differences, differences which may, in fact, be correctly perceived, but wrongly attributed.

As a final outcome of the testing and visits, a series of talks to area mothers of twins clubs are planned in order that findings of value to mothers can be shared with them.

CHAPTER V

RESULTS

The discussion of results is divided into four sections: (1) the question of heritability; (2) the nature of language skills; (3) influences of the mother; and (4) influences of mother's perceptions. The first section of the discussion will be a consideration of differences between MZ and DZ variances on all language measures, and the statistics which can be established from those differences by means of intraclass correlations, Falconer's h^2, and F test on the within-pair variances, and Holzinger's h. The second section is an examination of the intercorrelations of twins' performance on all language measures. The third section is a discussion of factors in mothers' speech style which both correlate with and may influence children's language development, and the fourth section is a discussion of the differentiation of mothers' speech style to correctly and incorrectly perceived MZ pairs.

Section One: Heritabilities

Tables 5 through 12 show intraclass r_is, Falconer's h^2, a heritability estimate based on

$h^2 = 2(r_{imz} - r_{idz})$, and F tests of the significance of the difference between MZ and DZ within-pair variance ($\sigma^2 dz/\sigma^2 mz$). Further, for comparison, an estimate of heritability based on within-pair variance alone is also presented; Holzinger's h, or $h = \sigma^2 dz - \sigma^2 mz/\sigma^2 dz$.

The tables are organized in terms of a priori judgements about the nature of the particular language measures. All measures are presented as Z scores on raw scores, and Z scores on raw scores adjusted for chronological age.[3] Table 5 presents data on raw score and IQ derived from raw score for the PPVT, along with the mental age and IQ for the Stanford-Binet. Table 6 presents Z on raw score, and Z on raw score adjusted for chronological age (here referred to as CA) of the child at the time of testing for measures of vocabulary; the PPVT, the vocabulary measure which is a subtest of the Stanford-Binet, and the M1 test of vocabulary. Table 7 presents two measures of the child's development of morphology--M4, and Berko.

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[3]A subset of the data was checked for correlation between age of the child and performance on the tests. Although a positive correlation might be expected, nonetheless for both heritable and non-heritable measures there was one significant positive correlation between age and test score. The only significant correlations were a negative correlation between Osser and M6 total error scores and age: Osser, $r = -.34$; and M6, $r = -.39$, significant at the .05 and .01 levels respectively; and a significant positive correlation between age and child's mean length of utterance: $r = .60$, $p \quad .001$.

TABLE 5

MEASURES OF INTELLIGENCE
BASED ON RAW SCORES (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(O^2dz/O^2mz)$	Falconer's h^2	Holzinger's h
Peabody Picture Vocabulary Test	.80**	.50	1.90	.60	.47
PPVT IQ	.77**	.48	2.10	.58	.53
Stanford-Binet Mental Age	.98**	.83**	6.91**	.30	.86
Stanford-Binet IQ	.97**	.57*	5.89**	.80	.83

*p = .05
**p = .01

TABLE 6

MEASURES OF VOCABULARY (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(\sigma^2_{dz}/\sigma^2_{mz})$	Falconer's h^2	Holzinger's h
Peabody Picture Vocabulary Test	.80**	.50	1.90	.60	.47
Stanford Vocabulary	.95**	.66**	3.16*	.58	.83
Stanford Vocab/CA	.91**	.44*	2.90*	.94	.68
Mehrabian 1	.77**	.22	2.89*	1.00	.65
Mehrabian 1/CA	.73**	.03	3.88**	1.00	.74

*p = .05
**p = .01

TABLE 7

MEASURES OF MORPHOLOGY (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(\sigma^2 dz/\sigma^2 mz)$	Falconer's h^2	Holzinger's h
Mehrabian 4	.47	.68*	(1.32)	-.42	.24
Mehrabian 4/CA	.25	.54*	(1.02)	-.58	-.02
Berko[a]	.43	.65*	(1.58)	-.44	-.58
Berko/CA[a]	.35	.61*	(2.00)	-.52	-.99

[a]N = 40
*p = .05

TABLE 8

MEASURES OF ABILITY TO DEAL WITH SYNTAX (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(\sigma^2 dz/\sigma^2 mz)$	Falconer's h^2	Holzinger's h
Harvard	.29	.31	2.13	.04	.53
Harvard/CA	.41	-.36	3.11*	1.00	.68
Osser	.91**	.81**	1.02	.20	-.02
Osser/CA	.88**	.86**	2.23	.04	-1.23
Mehrabian 6	.90**	.49	4.07*	.82	.75
Mehrabian 6/CA	.90**	.30	3.91*	1.00	.74

*p = .05
**p = .01

TABLE 9

MEASURES OF MORPHOPHONEMIC TRANSFORMATION (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(^2dz/\ ^2mz)$	Falconer's h^2	Holzinger's h
Osser MT	.71**	-.28	3.14*	1.00	.68
Osser MT/CA	.71**	-.24	2.89*	1.00	.65
Story VerbMT[a]	.90**	-.18	8.38**	1.00	.88
Story VerbMT/CA[a]	.90**	-.19	6.58**	1.00	.85
Mehrabian 6 MT	.39	.27	1.19	.24	.16
Mehrabian 6 MT/CA	.38	.28	1.17	.20	.14
Mehrabian 4 MT	.34	.05	2.55	.58	.61
Mehrabian 4 MT/CA	.33	.23	1.80	.20	.44

[a]N = 40
*p = .05
**p = .01

TABLE 10

MEASURES OF SYNTACTICAL DELETIONS AND INSERTIONS (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(\sigma^2 dz/\sigma^2 mz)$	Falconer's h^2	Holzinger's h
Osser Insertions	.44	.13	2.48	.62	.60
Osser Insertions/CA	.63*	.10	4.74**	1.00	.79
M6 Insertions	.76**	.40	4.07*	.72	.75
M6 Insertions/CA	.80**	.39	3.99*	.82	.75
M6 Deletions	.95**	.85**	2.99*	.20	.66
M6 Deletions/CA	.96**	.87**	2.89*	.18	.65
Osser Deletions	.85**	.90**	(2.48)	-.10	-1.48
Osser Deletions/CA	.86**	.91**	(2.86)	-.10	-1.86

*p = .05
**p = .01

TABLE 11

MEASURES OF THE CORRECT USE OF VERBS (N = 42)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(\sigma^2 dz/\sigma^2 mz)$	Falconer's h^2	Holzinger's h
Osser Verbs Cor.	.88**	.84**	1.54	.08	.35
Osser VC/CA	.84**	.72**	1.35	.24	.26
Story VerbsCor.[a]	.38	.24	1.27	.28	.21
Story VC/CA[a]	.38	.32	1.04	.12	.04
Mehrabian 6 VC	.85**	.82**	1.20	.02	.17
Mehrabian 6 VC	.85**	.84**	.93	.02	-.07

[a]N = 40
*p = .05
**p = .01

TABLE 12

MEASURES BASED ON THE CHILD'S BEHAVIOR ON E.T.S. STORY SEQUENCE (N = 40)

Measures	Intraclass Correlations, F Test, Heritability Statistics				
	r_{imz}	r_{idz}	$F(\sigma^2 dz/\sigma^2 mz)$	Falconer's h^2	Holzinger's h
Story No. Wds.	.19	.16	1.00	.06	.01
Story Wds/CA	.24	.24	.96	.00	-.04
Story Utterances	.12	.16	1.84	-.08	.46
Story Utt./CA	.24	.29	1.46	-.10	.31
Story Personal Pronouns	.45	.15	.97	.60	-.03
Story PP/CA	.50*	.10	.80	.80	-.27
Child's Mean Length of Utt.	.61*	.05	3.31*	1.00	.70
Child's Mean Length of Utt./CA	.35	.18	1.46	.34	.32

*p = .05

Table 8 aggregates three measures of syntactical competence, the Harvard, Osser and M6, and shows all three as Z scores, as well as Z scores on raw score adjusted for CA. Table 9 includes four measures of spontaneous morphophonemic transformation, the Osser coded morphophonemic change, incorrect morphophonemic operations on verbs shown in the story sequence, morphological change as coded for the M6, and child transformations of morphology on the M4.

Table 10 shows syntactical deletions and insertions as coded from the Osser and M6 repetition tasks. Table 11 presents the child's correct use of verbs, as measured on the Osser, M6, and Story task, and finally, Table 12 includes four factors involved in the child's telling of a story: the number of words, the number of sentences, the number of personal pronouns, and the mean length of utterance (MLU).

In all there are twenty-three measures of child language skills. On the tables there are two representations of these twenty-three measures, one as straight Z score, and one as Z score taken on raw score adjusted for chronological age at time of testing. Of these twenty-three measures, the number of measures which show a heritability over .50 is

	Falconer's h^2	Holzinger's h
Z scores	11	11
Age adjusted Z scores	10	10

or roughly half the total number of measures.

Taken separately, the statistics on these measures disclose an interesting pattern of results, as will be discussed immediately below.

Measures of IQ

The findings presented here for heritability and intraclass correlations on IQ measures are comparable with findings from larger samples. For the Stanford-Binet, the intraclass correlations for this sample, .97 for MZ and .57 for DZ, compare with the findings of Burt (1958, 1966) which were .89 for MZ pairs and .56 for DZ pairs. The intraclass correlations on the Stanford-Binet and the PPVT, .77 for MZ pairs and .48 for DZ pairs, compare with findings for a wide range of mental tests (Erlenmeyer-Kimling and Jarvik, 1963). The resultant h^2 of .80, and h of .83 for the Stanford-Binet are exactly the heritabilities which have been established for intelligence.

These findings, while not initially of direct relevance to the analysis of language skills for heritability, are important as they establish that this small sample falls within the pattern of previous results on the dimension of heritability of IQ. Any other findings would have led to a questioning of the sample, and an investigation of testing procedures. Furthermore, such findings establish a reliable base for the discovery of intercorrelations of IQ and language measures.

Measures of Vocabulary

All measures of vocabulary showed high intraclass correlations for MZ pairs, and moderate to low correlations for DZ pairs. As can be seen in Table 6, the PPVT and the Stanford vocabulary measure yielded significant MZ and DZ intraclass correlations, while the Ml showed only significant MZ intraclass correlations. The F test of the difference between the MZ and DZ within-pair variance was significant for the Stanford vocabulary measure, and the Ml, but not for the PPVT.

The heritabilities associated with the intraclass correlations and the within-pair variance resulted in moderate to high heritability for all measures of vocabulary, whether corrected for chronological age or not. The range of h^2 was from .58 for the unadjusted Stanford vocabulary measure, to 1.00 for the Ml, adjusted and not adjusted for CA. The range of heritabilities found with Holzinger's h was more compressed--from .47 for the PPVT to .83 for the unadjusted Stanford vocabulary.

Measures of Morphology

Both measures of morphology showed the distinct and unexpected pattern of higher intraclass correlations for DZ pairs than for MZ pairs, whether r_is were based on adjusted or non-adjusted scores. [Though such a finding is unusual, a similar finding has been reported previously by Osborne (1967) but in that instance the abilities measured were skills of visual perception.]

The intraclass correlations were all significant for DZ pairs, and non-significant for MZ pairs. Falconer's h^2 showed identical negative heritabilities: M4, -.42, and -.58, and Berko -.44, and -.52. Holzinger's h, however, revealed a wider ranging pattern: M4, .24, -.02; Berko, -.58, -.99. None of the F tests of the difference between within-pair variances were significant.

Measures of Syntactical Competence

With the three measures of syntactical competence, a complex pattern of results emerged. While the Harvard measure and M6 measure both yielded heritabilities of 1.00 for h^2 on adjusted scores, and also showed moderately high heritabilities for h (.53 and .68 for the Harvard measure, and .75 and .74 for the M6), nonetheless the h^2 on the unadjusted Harvard Z scores is very low, .04. And while the MZ intraclass correlations for Osser and M6 were significant, for the Osser, the DZ intracorrelations were also highly significant, making the h^2 extremely low--.20 and .04 for Z scores and adjusted Z scores respectively. Holzinger's h on the Osser showed negative heritability.

The F tests of the within-pair variance were significant for the adjusted Harvard, and for the adjusted and unadjusted M6.

Measures of Spontaneous Morphophonemic Transformations

Two of the measures of morphophonemic transformation resulted in high heritability, and two of the measures resulted in low heritability. The Osser MT (morph transformation) and the Story VT (verb transformation) both revealed consistent heritabilities of 1.00 on h^2. For both measures, all MZ intraclass correlations were high and significant at the .01 level, and all DZ intraclass correlations were negative, and not significant. The F test of the within-pair differences was significant in all cases.

The measures of morphophonemic transformation in the M4 and M6 described a very different pattern. None of the MZ or DZ intraclass r_is were significant, and none of the F test of within-pair variance were significant. All heritabilities on h^2 and h were low-moderate: .24, .20, .58, .20 for h^2; and .16, .14, .61, .44 for h. On both h^2 and h, age adjustment of the M4 measure decreased heritability.

Measures of Syntactical Deletion and Insertion

Osser and M6 offered identical patterns of results of a measure of insertions into a repeated sentence: high significant r_is for MZ pairs, and low-moderate, non-significant intraclass correlations for DZ pairs. Heritabilities for both measures on h^2 ranged from .62 to 1.00, and on h ranged from .60 to .79. Three of the four F tests were significant.

Intraclass correlations for MZ and DZ pairs on the deletions measure however were high; significant at the .01 level. Heritabilities on the h^2 ranged around .00--but Holzinger's h showed a marked contrast: Osser deletions had a negative heritability, and M6 deletions had a moderate to high heritability: .66 and .65.

Measures of Correct Use of Verbs

For all measures, children's correct use of verbs showed little genetic contribution to phenotypic variance when measured either on Holzinger's or Falconer's h. Intraclass correlations for the Osser measure and the M6 measure were high and significant for both MZ and DZ groups. For all three measures, F tests on within-pair variance were not significant.

Measures of the Child's

Story Telling

Intraclass correlations for all measures of the child's competence in telling a story were low to moderate, with only two MZ r_is achieving significance, that for child's mean length of utterance, and that for CA adjusted number of personal pronouns used in the story. For those particular cases, the h^2 was .80 and 1.00 respectively. All other heritabilities were shown to be low, and the F test on all measures was non-significant, with the exception of unadjusted child's mean length of utterance.

Summary: IQ, all measures of vocabulary, all measures of syntactical insertion, the child's use of personal pronouns, two of three measures of syntactical competence, two of four measures of morphophonemic transformation, and one of the measures of syntactical deletion all show high heritability in this sample. Two of the measures of vocabulary, and the measures of insertion and syntactical competence which do show heritability in this population show heritabilities which are completely comparable to the heritabilities associated with IQ.

Of the measures which show little contributions to phenotypic variance, only three--Osser deletions, and Berko and M4 morphology--show the unusual pattern of marked negative heritability on both Falconer's and

Holzinger's h statistics for deriving heritability. The other non-heritable measures, which show patterns within expectations, are Osser syntactical competence, M6 and M4 morphophonemic change, all measures of correct verb use, and features of story-telling other than child's use of personal pronouns, and mean length of utterance.

Section Two: Intercorrelations of Skills

A correlation matrix of CA and non CA adjusted Z scores on all measures used in the study with twins taken as individuals yielded three types of significant correlations: (1) correlations of language measures with the Stanford-Binet measure of IQ; (2) intercorrelations among many of the tests presumed to measure the same skill; and (3) intercorrelations among the distinct language measures. Unless otherwise noted, further discussion of the correlations is based on CA adjusted Z scores only (see footnote 3, page 58).

Correlations of Measures with IQ

Ten of twenty-three measures were significantly correlated with IQ.

All measures of vocabulary, both measures of morphology, the Osser measure of syntactical competence, the Osser measure of correct verb use, the child's mean length of utterance were positively and significantly correlated with the child's performance on the Stanford-Binet. Osser and M6 deletions showed significant negative correlation with the Stanford-Binet (see Table 13).

Of the measures which did show significant correlation with IQ, only the vocabulary measures, and the child's mean length of utterance had yielded statistical evidence of heritability in this population. The others had shown trivial, or statistically unintelligible (i.e., negative) heritabilities.

Intercorrelations of Related Measures (see Table 14)

Vocabulary. The M1 and PPVT measures were both significantly correlated with the Stanford-Binet measure of vocabulary, but the M1 and PPVT were not significantly correlated with one another.

Morphology. The Berko and M4 measures of the child's ability to operate with morphology were significantly correlated at the .01 level.

Syntactical Competence. The Osser and M6 measures were significantly correlated, but neither measure correlated with the Harvard measure.

Morphophonemic Transformation. The M6 measure showed positive significant correlation with two of the other measures: Osser MT, and MAMT, and the M4 MT was positively correlated with the Story MT. No other possible

TABLE 13

CORRELATION OF LANGUAGE MEASURES WITH CHILD AND MOTHER'S IQ WHERE SCORES USED ARE Z SCORES OF C. A. ADJUSTED RAW SCORES (N = 42)

Measures	Child's IQ Stanford-Binet	Mother's IQ Wais
Peabody Vocab.	.62***	-.09
Stanford Vocab.	.73***	.03
Mehrabian Vocab.	.30*	.23
Berko Morphology[a]	.39**	.25
Mehrabian 4 Morphology	.40**	.17
Harvard	.21	-.03
Osser	.39**	.24
Mehrabian 6	.24	.34*
Osser Morph. Trans.	-.23	-.34*
Story Morph. Trans.[a]	-.19	.21
Mehrabian 6 MT	-.23	.05
Mehrabian 4 MT	-.26	.09
Osser Insertions	.12	-.13
Meh. 6 Insertions	-.10	-.43***
Osser Deletions	-.47***	-.39**
Meh. 6 Deletions	-.38**	-.43**
Osser Verbs Correct	.39**	.30*
Story Verbs Correct[a]	.03	-.31*
Meh. 6 Verbs Correct	.05	.26*
Story Words[a]	.14	-.15
Story Utterances[a]	-.07	-.28*
Story Personal Pronoun[a]	-.13	-.08
Child's Mean length of Utterance[a]	.53***	.12

[a]N = 40

*p = .05

**p = .01

***p = .005

TABLE 14

THE INTERCORRELATIONS OF THE MEASURES FOR CA-ADJUSTED Z SCORES (N = 42[a])

Measures	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
1. PPVT	1.00	.48	.20	.39	.47	.12	.41	.29	.23	.36	.06	.44	.07	.09	.50	.37	.27	.04	.07	.06	.25	.11	.28
2. S-B Vocab.		1.00	.50	.12	.28	.06	.31	.31	.10	.17	.09	.16	.27	.13	.34	.08	.20	.14	.27	.31	.14	.13	.30
3. M1 Vocab.			1.00	.02	.29	.22	.21	.10	.09	.11	.12	.13	.27	.20	.07	.06	.16	.11	.06	.15	.06	.02	.15
4. M4				1.00	.48	.19	.44	.42	.40	.14	.42	.19	.10	.16	.46	.47	.56	.05	.32	.04	.19	.18	.34
5. Berko[a]					1.00	.31	.72	.65	.45	.15	.50	.23	.11	.36	.59	.57	.69	.22	.29	.14	.14	.17	.32
6. Harvard						1.00	.21	.21	.07	.09	.26	.09	.07	.00	.01	.16	.23	.13	.08	.12	.15	.13	.29
7. Osser							1.00	.81	.59	.21	.56	.36	.41	.43	.72	.62	.83	.29	.48	.22	.08	.34	.41
8. M6								1.00	.65	.14	.57	.29	.42	.54	.63	.69	.82	.22	.50	.13	.13	.44	.43
9. Osser Morph. Trans.									1.00	.14	.59	.23	.57	.43	.58	.58	.69	.15	.44	.19	.25	.28	.10
10. Story Morph. Trans.[a]										1.00	.16	.25	.03	.15	.34	.38	.33	.29	.05	.11	.15	.13	.08
11. M6 Morph. Trans.											1.00	.27	.46	.29	.49	.44	.58	.10	.24	.03	.16	.28	.18
12. M4 Morph. Trans.												1.00	.18	.10	.46	.44	.31	.06	.12	.05	.12	.34	.12
13. Osser Insertions													1.00	.52	.33	.26	.40	.10	.33	.18	.21	.14	.15
14. M6 Insertions														1.00	.52	.66	.46	.12	.48	.15	.40	.11	.28
15. Osser Deletions															1.00	.85	.76	.03	.31	.08	.36	.15	.38
16. M6 Deletions																1.00	.74	.03	.46	.14	.47	.21	.44
17. Osser Verbs Correct																	1.00	.23	.45	.11	.12	.29	.44
18. Story Verbs Correct[a]																		1.00	.17	.77	.65	.46	.30
19. M6 Verbs Correct																			1.00	.01	.12	.48	.14
20. Story Words[a]																				1.00	.81	.41	.38
21. Story Utterances[a]																					1.00	.36	.06
22. Story Personal Pronouns[a]																						1.00	.13
23. Child mean length of utterance[a]																							1.00

[a] N = 40

($r = .26$, $p = .05$)

($r = .365$, $p = .01$)

($r = .40$, $p = .005$)

correlations within this group of measures reached significance.

Insertions and Deletions. All measures in this group were positively and significantly correlated: Osser I with M6 I, M6 D and Osser D; M6 I with M6 D and Osser D; and M6 D with Osser D. All the correlations, with the exception of Osser I and M6 D were at the .01 level of significance.

Verb Usage. M6 and Osser showed a positive correlation, while the story form of verbs correct did not correlate with either measure.

Story Task. Relations between the child's number of words, number of utterances, and use of personal pronouns all were significant positive correlations. The child's mean length of utterance showed a significant correlation only with number of words in the story.

For all language measures, all intercorrelations of related measures were positive and most groups of measures showed significant correlations with one another.

Intercorrelations of All Language Measures

The first important set of correlations to note is that of child's mean length of utterance with PPVT, Stanford vocabulary, M4 and Berko measures of morphology, with all three measures of syntactical competence, as well as with correct verb usage for the story and Osser measures. The mean length of utterance has been argued as a reasonable indicator of child's level of development. This set of correlations on forty-two children would support that argument.

The second observation which can be made on the correlation matrix is that most measures which had been grouped together as presumably testing the same language skill <u>did</u> show similar patterns of significant serial correlation with the other measures. The Berko and M4 measures of the child's competence in morphology both showed significant positive correlations with the Osser and M6, Osser and M6 verbs correct measure, the child's mean length of utterance, as well as the PPVT and the Stanford Vocabulary. The two measures further showed significant negative correlations with Osser and M6 morphophonemic transformations, and Osser and M6 deletions.

The vocabulary measures showed a pattern of some similarity. PPVT and the Stanford vocabulary measures were positively correlated with Berko, Osser, M6, and Child's mean length of utterance. M1 and the Stanford vocabulary were correlated with insertions coded for the Osser.

Of the measures of syntactical competence, clearly the M6 and Osser formed a set--all but one of their matched correlations with the other measures are in the same direction, and of the same magnitude; eleven of their matched correlations are significant. Both measures showed significant positive correlations with Osser and M6 verbs correct, number of pronouns in the child's story, and child's mean length of utterance. Both measures showed significant negative correlation with Osser MT, M6 MT, M4 MT, Osser and M6 insertions measures, and Osser and M6 deletions.

All four measures of morphological transformation showed significant positive correlation with both the Osser and M6 measures of deletions. Osser and M6 MT measures also showed significant positive correlation with the Osser and M6 measures of syntactical insertion.

The Osser and M6 verb correct measures showed a pattern of significant negative correlations with all measures of deletion and insertion, and one measure of morph transformation (Osser). Both measures, however, showed a significant positive correlation with both the Berko and the M4.

Elements of the child's story telling did not show as much similarity of pattern as the other sets of measures did. Number of words was postively correlated with deletions, and the M6 insertion measure, and number of personal pronouns used correlated significantly with all measure of correct verb usage, as well as the Osser and M6 measures of syntactical competence.

Summary. Of twenty-three measures organized into groups according to presumed ability to measure the same language skill, less than half are significantly correlated with I.Q. Of this number, only two complete groups of measures are represented--measures of vocabulary, and measures of the child's ability to deal with rules of morphology--the first of which has shown statistical evidence of high heritability, and the second of which has shown evidence of negative heritability.

The six presumed groups of measures were shown to have significant intercorrelations, with the exception of two items--the Harvard measure of syntactical competence, and the story sequence measure of correct verb usage, neither of which correlated with the other two measures in its group.

Furthermore, these group distinctions held up in terms of correlations among all the test measures. Patterns of test-matched correlations (as can be seen in Table 14) were very similar for measures of the same group.

Section Three: Mothers' Speech Style

Mothers' speech was coded into nine categories: questions to the child, answers to the child's questions, expansion of the child's statements, assertions to the child about the world, exact repetitions of what the child said, criticisms of what the child said, or the way in which he said it, confirmation of the child's own assertion, reduction of the child's statement, and direction to the child for behavior, speech or attention. Of these nine categories, only one was an empty category--no mothers sampled in this study reduced their children's statements.

Of the eight remaining categories, all except confirmation showed at least one significant positive or negative correlation with the child's language behavior, as measured on the present language tests (see Tables 15 and 16).

Furthermore, these nominally scaled factors also showed some significant intercorrelations (see Table 17).

Despite earlier findings of the relationship between factors of mothers' style of speaking to her children and the socioeconomic class of the family, only two positive significant correlations were found for SES. Mothers' answers and directions to the child were positively correlated with rank in the sample ($r = .32$, $r = .32$). There were, however, negative correlations for mothers' directions to the child with decile rank and rank as measured by a Bureau of the Census scale ($r = -.35$, $r = -.35$). Another significant negative correlation with SES is that of mothers' assertion with family position on the Bureau of the Census scale ($r = -.35$).

TABLE 15

POSITIVE CORRELATIONS OF FACTORS IN MOTHERS' SPEECH WITH CHILD'S LANGUAGE BEHAVIOR (Raw Scores) (N = 30)

Measures	Factors in Mothers' Speech								
	Ques.	Answ.	Exps.	Repe.	Crit.	Conf.	Dirc.	MMLU	Assr.
PPVT	.33								
S-B Vocab					.33				
S-B Vocab/CA					.45				
Osser MT							.40		.31
Osser MT/CA							.42		.35
Story MT		.55							
Story MT/CA		.51							
M6 MT	.34		.30						
M6 MT/CA	.33		.30						.32
M4 MT	.33								
M4 MT/CA	.39								
Osser syntax				.39					
Osser syntax/CA				.39					
M6 syntax				.35					
M6 syntax/CA				.35					
Osser Deletions							.46		.49
Osser Deletions/CA							.45		.49
M6 Insertions		.51							
M6 Insertions/CA		.44							

(r = .31, p = .05)
(r = .42, p = .01)

TABLE 16

SIGNIFICANT NEGATIVE CORRELATIONS OF FACTORS IN MOTHERS' SPEECH WITH CHILD'S LANGUAGE BEHAVIOR (Raw Scores) (N = 30)

Measures	Factors in Mothers' Speech								
	Ques.	Ans.	Exp.	Rep.	Crit.	Conf.	Dir.	MMLU	Assr.
PPVT							-.38		
S-B Vocab.							-.58		-.52
S-B Vocab./CA							-.53		-.44
Osser Morph. Trans.				-.32					
Osser MT/CA				-.33					
M6 MT				-.46					
M6 MT/CA				-.44					
Story MT	-.42								
Story MT/CA	-.43								
M4 MT/CA				-.34					
Osser Verbs Cor.							-.43	-.28	-.35
Osser VC/CA							-.41	-.35	-.35
Story VC		-.40	-.48					-.30	
Story VC/CA		-.39	-.46					-.32	
M6 VC								-.28	
M6 VC/CA								-.29	
M6 syntax							-.43		
M6 syntax/CA							-.40		
Story Words	-.33								
Story Utts.	-.39								
Story Utt./CA	-.32								
Story PerPro.								-.38	
Story PP/CA								-.38	
Child's MLU					-.34				

(r = .31, p .05) (r = .42, p = .01)

TABLE 17

SIGNIFICANT INTERCORRELATION OF FACTORS IN MOTHERS' SPEECH STYLE (N = 30)

Factors	Factors								
	MLU	Ques.	Ans.	Exp.	Asr.	Rep.	Cri.	Con.	Dir.
Mean length of Utterance					-.37*				-.37*
Questions			-.41*			-.76**			
Answers				.31*					
Expansions					.31*				
Assertions						-.36*			
Repetitions								-.33*	-.44**
Criticisms									
Confirmations									.32*
Directions									

*p .05

**p .01

On Table 15 positive correlations of the factors in mothers' speech with the children's language behavior are shown. Of all language measures, the child's morphophonemic transformations appear to show the most relationship with a variety of aspects of the mother's speech. The questions a mother asks of her child are correlated with M6 MT and M4 MT; answers that she gives are correlated significantly with Story MT; her MLU or mean length of utterance is correlated with M6 MT; number of assertions in her speech is correlated with Osser MT and M6 MT; and the number of directions she issues to the child is correlated with Osser MT.

The child's performance on vocabulary measures appears to be positively affected by questions and criticisms of his or her performance. Deletions in the child's tested speech are positively correlated with assertions and directions on the part of the mother, whereas insertions show a significant correlation with the number of answers the mother gives the child. Measures of syntactical competence--M6 and Osser--show similar significant correlations with the mother's exact repetitions of the child's statements. This is of special interest, considering that the actual task in both the Osser and M6 tests is the exact repetition of sentences. Repetitions on the part of the mother are also correlated with the number of personal pronouns used by the child in his story.

Table 16 shows all the significant negative correlations which were found for mother's speech and child language behavior. Mother's assertions and directions are negatively correlated with the child's performance on all aspects of the Stanford-Binet and PPVT.

Mother's mean length of utterance was negatively correlated with all three measures of the child's correct use of verbs. Mother's repetition, even though positively correlated with measures of syntactical competence, is negatively correlated with all measures of morphophonemic transformation.

Child's mean length of utterance was negatively correlated with mothers' criticisms.

Aspects of the child's story telling showed significant negative correlation with mothers' questions, expansions, answers, and overall mean length of utterance.

Summary. Factors in mothers' speech revealed a variety of significant correlations with aspects of the child's measured language behavior. As would be expected, factors in the mothers' speech showed correlation not only with individual tests, but also showed correlation with groups of measures. There was no clear pattern of correlation of mothers' speech factors with either measures statistically determined to have high or low genetic contribution to phenotypic variance

--correlations are distributed among both sets of measures.

Section Four: Influence of the Mother's Perception

One of the questions in twin research is that of the nature of the mother's influence on the twins' behavior. Is the mother building in differences, or is she responding to the child's zygosity? In the case of speech style to the child, it would seem that an interesting analysis might be made. For MZ mothers who misperceived their twins' zygosity (N = 5), do they in fact show a differentiated speech style to their twins? For that matter, do mothers of DZ pairs differentiate their speech to each twin?

Table 18 shows F tests of the significance of the absolute difference between DZ and MZ mothers' speech style factors, first for DZ and MZ as a group, then for DZ with MZR, or those mothers of MZ twins who were correct in perceiving their children's zygosity, and finally for DZ with MZW, or those mothers of MZ twins who were incorrect in their perception of zygosity. Six of the eight F(dz/mzw) are significant, as opposed to only one of the eight F(dz/mzr). The pattern of significance is not, however, consistently in the direction of greater speech style variance among MZW mothers, but in fact, varies considerably from measure to measure. For answers, expansions, and criticisms of

TABLE 18

FACTORS IN MOTHER'S STYLE: SIGNIFICANT DIFFERENCES
FOR DZ WITH MZ, MZR, AND MZW PAIRS
(with greater variance group indicated) (N = 30)

Factors	Significance Tests		
	F(dz and mz)	F(dz and mzr)	F(dz and mzw)
Questions	1.50 dz	1.50 dz	1.50 dz
Answers	3.27*dz	2.45 dz	4.91**dz
Expansions	1.42 dz	1.04 mzr	5.00**dz
Assertions	1.78 mz	2.23 mzr	3.77*mzw
Repetitions	5.20**mz	5.00**dz	11.48***mzw
Criticisms	1.46 mz	2.81 mzr	4.68**dz
Confirmations	3.54*mz	2.00 dz	5.28**mzw
Directions	2.08 dz	3.15 dz	1.53 dz

*p = .10

**p = .05

***p = .001

the child, mothers who misperceived their MZ pairs showed significantly <u>less</u> variance than DZ mothers on the same factors, where mothers who had correctly perceived their twins' zygosity did not show a significant difference from the DZ mothers' variance.

For assertions, repetitions, confirmations, and directions, however, MZW mothers show <u>more</u> within-pair variance than MZR mothers. This greater variance is, in fact, greater than the variance found for DZ mothers on three of these factors, and is in three cases a significant difference. Thus for three of eight measures MZW mothers show both significantly <u>less</u> variance than DZ mothers (criticism, answers, expansion), while on three other factors MZW mothers show significantly <u>more</u> variance than DZ mothers (assertions, repetitions, and confirmations).

The results are not clear. Is this significant variability in the speech style of MZW mothers a problem of confused attribution, is it an artifact of the testing situation, or does it represent some pattern of differentiated response?

<u>Birth Order of Pairs and MZ Mothers' Speech Style Factors</u>

Among the nine MZ twin pairs whose mothers' speech was examined for various factors (questions, answers, assertions, repetitions, etc.), there were four sets of twins who were first-born in the family, and five sets who were later-born. While many aspects of development such as I.Q., dependency, affiliation (Schacter, 1959), and achievement have been shown to correlate with birth order, little work has been done to see if the context for language acquisition is affected by a birth-order specific environment provided by the mother.

In a study of first-born versus later-born children, McAlister (1965) found that mothers' speech to first-borns was more involving and corrective than mothers' speech to second-borns, whereas mothers' speech to second-borns was more positive and consistently more supportive.

In the present study, as can be seen on Table 19, the only significant difference of mothers' speech to first-borns as compared to mothers' speech to later-borns is that between questions, repetitions, and directions. MZ mothers of first-borns pose significantly more questions to their children, but do less repeating and directing than do mothers of second-borns. This fits in well with McAlister's finding, if repetition can be seen as supportive, which it can (as per supportive therapy where the support consists of simple repetition of the patient's utterances), and directions may also be considered as supportive. Questions clearly are--in this context of story-telling--involving and, often, corrective.

TABLE 19

T TESTS ON MEANS OF FACTORS IN MZ MOTHERS' SPEECH TO FIRST AND LATER BORN TWIN PAIRS

Factors	MZ Mothers Speech to First Born Pairs (N=8)	MZ Mothers Speech to Later Born Pairs (N=10)	
	$\bar{X}$	$\bar{X}$	
Questions	51.33	38.71	t= 2.38**
Answers	0.90	1.14	N.S.
Expansions	1.90	1.14	N.S.
Repetitions	1.44	5.70	t= 1.78*
Assertions	26.22	26.28	N.S.
Criticisms	1.33	1.00	N.S.
Confirmations	10.33	15.33	N.S.
Directions	5.33	9.84	t= 1.86*

*p = .10, two-tailed test

**p = .05, two-tailed test

Furthermore, the greater mean number of confirmations on the part of MZ mothers of later-borns, again indicating greater supportive behavior, also fits the pattern suggested by McAlister's data.

Given that this is a very small sample, it does however suggest that McAlister's findings would be replicated on a larger twin sample of first and second borns, and it also suggests that mothers of first-borns tend here to involve the child in the story with questions, while mothers of later-born twin pairs tend to keep the child on the track with directions, repetitions, and confirmations more often.

Sections One, Two, Three and Four have been a description of the results of the study. In the next chapter the significance of these findings will be discussed.

CHAPTER VI

DISCUSSION

Overview

The general findings of this study are (1) that certain language skills, as measured by tests used here show statistical evidence of high heritability, (2) that language skills do intercorrelate with one another in patterns which suggest that tests designed to measure the same skill do, in fact, measure that skill, (3) that only two groups of skills--one showing a high genetic contribution to phenotypic variance, and one a low contribution--are significantly and positively correlated with IQ, i.e. vocabulary and morphology, (4) that factors in mothers' speech style significantly correlate with aspects of their children's use of language, and (5) that mothers' perceptions of their twins' zygosity appear to influence variability in speech style to their twins.

Two further findings not presented in the results section are, first, that mothers' mean length of utterance to her twins was exactly half that of her MLU in adult conversation--9.1 words per sentence with adults, and

4.5 words per sentence with the twins; and second, that mothers' attitudes toward language acquisition show little correlation with measures of aspects of the child's story-telling. Such attitudes, measured indirectly as completeness of response to eleven questions of language development derived from Slobin's cross-cultural workbook in acquisition (1967), showed no correlation with any aspect of the child's telling of a story, with the exception that the number of words in the child's story was significantly negatively correlated with the mother's total response to the questionnaire ($r = -.32$, p .05). That is, the greater the mother's overall response to the set of questions, the fewer sentences her children used in telling their stories.

While these distinct findings require a great deal of individual discussion, taken together they suggest that the process of acquisition is a very complex one, the source of which cannot here be clearly defined as nurture or nature--solely dependent on the mother's behavior or coming entirely from some internal language acquisition device. Nor can language development be seen simply as a function of the child's IQ, or his socioeconomic class.

Whether or not the skills tested here represent that set of skills essential for language acquisition cannot be answered by this study. However, the character of the language which the child is acquiring here appears to be a package of distinct skills--skills which show greater and lesser degrees of genetic contribution to phenotypic variance.

A central element in the child's environment at this age is his mother, and it was found here that mothers do adjust their speech (MLU) to communicate with their children. Furthermore, factors involved in this adjusted style do correlate with the child's behavior on many of the measures, and groups of measures studied here. Mothers' adjustment of speech style, however, does not really seem to be further divided into speech style adjustment to each twin, except in the case of misperceived MZ zygosity, where style appears to be significantly more variable (see pages 126-127).

This has been an empirical and observational piece of research; less than complete confirmation of the hypotheses does not disprove that portion of the data which does support them. By this rationale it may be said that of the seven initial hypotheses of this study, six have been supported by some section of the data.

MZ twins were hypothesized to be more similar in patterns of language behavior than DZ twins. This was true for measures of vocabulary, syntax, morphophonemic transformation, syntactical insertion, number of personal pronouns in a story, as well as for the child's mean length of utterance. But it was not true for measures of morphology, correct verb use, or for measures involved in the child's telling of a story.

General intelligence as measured by the Stanford-Binet was expected to be significantly correlated with all measures of language development. Child's IQ, in fact, was positively correlated with only two complete groups of measures: measures of vocabulary, and measures of morphology. IQ was negatively correlated with measures of syntactical deletion.

A third hypothesis was that the child's performance on tests of syntax, semantics, and morphology would be significantly intercorrelated. This did prove to be the case. The PPVT vocabulary measure was correlated with the Berko and M4 measures of morphology; both the Berko and M4 were correlated with the Osser and M6 syntax measures; the PPVT and Stanford vocaculary measure correlated with the Osser and M6 measures; and the Berko measure correlated with the M4, the M1 measure of vocabulary, the Stanford measure of vocabulary, and the Harvard measure of syntax. (For details, see Table 14.)

The child's mean length of utterance was hypothesized to show high heritability. Uncorrected for age, MLU did show heritability in this population ($h^2 = 1.00$; $h = .70$). However, when a correction for the chronological age of the child is introduced, the heritability was reduced to that of $h^2 = .34$, $h = .32$. The age adjustment reduced within-pair variance for the DZ group, which affected the measures of heritability. Furthermore, there was a positive significant correlation between CMLU and child's age ($r = .60$). This correlation indicates that CA adjustment reduces variability for both groups. The two factors combine to reduce the F ratio from a significant to a non-significant ratio (Table 10). Thus this hypothesis is supported, but only when chronological age is not corrected for in the sample.

The fifth hypothesis was that a number of sentences in the story, correct verb usage, and use of personal pronouns in the story would not show a high genetic variance-component. This hypothesis was supported by the data from the child's number of sentences, and number of words in the story, but it was not supported by the data from the child's use of personal pronouns in the story. For frequency of personal pronouns, while an F test of the within-pair differences was not significant, there was so much between-family variability that the small difference between MZ and DZ variances led to a high heritability--$h^2 = .80$ for CA adjusted scores. Note that this heritability was not found where only within-pair variance is considered (see Table 10).

Mother's speech style was hypothesized to be significantly correlated with her children's mean length of utterance, and with aspects of her child's language behavior. As mother's speech style was broken down into factors, the hypothesis then becomes that of a correlation between factors in the mother's speech and specific behaviors in the child. The first finding here was that only one aspect of the mother's style correlated with the child's mean length of utterance--her criticism to the child showed an r of -.34 (p .05).

Other aspects of the child's measured language behavior which suggested influence by factors in the mother's style were morphophonemic transformations, measures of syntax, deletions, insertions, and personal pronouns in the story. With these measures there were a number of significant positive correlations, (see Table 15), with factors in mother's speech style.

Mother's speech style factors also showed many significant negative correlations with aspects of the child's language behavior. The mother's questions, assertions, expansions, repetition, her own mean length of utterance, and her directions to the child were all negatively correlated with various measures of the child's language ability. Many of the negative correlations however were with measures, such as morphophonemic transformation measures, which indicate that the child is making his own transformations of correct structures. Here the negative correlation suggests that mothers' speech style is composed of a patterned frequency of these factors, increased frequency of such factors goes along with decreased errors on the child's part.

The seventh and last hypothesis of this study was that MZ twins misperceived as DZ by their mothers would show more variation in language behavior than MZ twins whose mothers had correctly perceived their zygosities. F tests of the within-pair variance for MZR pairs (where mothers had correctly estimated zygosity) and MZW pairs (where mothers were wrong) on all measures reached significance in seventeen out of forty-six of the tests--where there are twenty-three tests, each with an adjustment for CA. Of the seventeen significant differences, fifteen were cases where the MZR pairs showed greater within-pair variance than that of the MZW co-twins (see Table 20). Furthermore, for all forty-six measures, thirty-five showed the MZR pairs to have greater within-pair variance. The importance of this increases somewhat with the addition of the information that there is no significant difference between MZR and MZW groups on the Stanford-Binet, and that mean within-pair difference on the Stanford-Binet mental age is less for MZW pairs than for MZR pairs: a difference of 1.6 months for MZW pairs, and 2.2 for MZR pairs.

If MZ birthweight differences are taken to have a significant effect on later development (Kaelber and

TABLE 20

TESTS OF LANGUAGE ABILITY WHERE MZR WITHIN-PAIR VARIANCE DIFFERED SIGNIFICANTLY FROM THAT OF MZW WITHIN-PAIR VARIANCE (N = 42)

Measures	Significance Tests			
	F(mzr and mzw		F(mz and dz)	
Harvard	4.88*	mzw	2.13	dz
Harvard/CA	4.55*	mzw	3.11*	dz
Osser Insertions	6.27*	mzr	2.48	dz
Story Utterances[a]	4.82*	mzr	1.84	dz
Story Utterances/CA[a]	4.52*	mzr	1.46	dz
Story Words[a]	9.41**	mzr	1.00	dz
Story Words/CA[a]	8.97**	mzr	.96	dz
Story Verbs Cor.[a]	4.52*	mzr	1.27	dz
Story Verbs Cor./CA[a]	4.39*	mzr	1.04	dz
Story Morph Trans[a]	7.33*	mzr	8.38***	dz
Story MT/CA[a]	7.87*	mzr	6.58***	dz
Osser Total Error	5.70*	mzr	-	
Osser TE/CA	6.66*	mzr	-	
M6 Morph Trans	11.03**	mzr	1.19	dz
M6 Morph Trans	10.45**	mzr	1.17	dz
M6 Verbs Cor.	15.83**	mzr	1.20	dz
M6 Verbs Cor./CA	16.51**	mzr	.93	dz

[a]N = 40

*p = .05

**p = .01

***p = .001

Pugh, 1969), then the MZW group should show greater differences in IQ and language development. Yet this was not the case--because mean difference between co-twins was 6.6 oz. for MZR and 10.4 oz. for MZW. What these findings suggest then is that, not only is the original hypothesis disconfirmed, but there is tentative evidence for the operation of some other phenomenon, one perhaps best considered in terms of mother's influence on development.

The Question of Heritability

Mittler (1969, 1970) had found that language skills as measured by the Illinois Test of Psycholinguistic Ability showed heritability at an h of between .56 to .65. The present study, which includes more specific measures of language skills, has found a variation in heritability of between -1.86 for Osser deletions to 1.00 for measures of vocabulary and syntax. Albeit negative heritabilities are statistically meaningless, the range is nonetheless extreme: measures of morphology suggest that all of the variance between individuals on that test is due to environmental factors, while several measures of both vocabulary and syntax suggest that those abilities show variance attributable only to genetic factors.

A comparison of Falconer's h^2 with Holzinger's h for all measures suggests that there was an extensive range of between-family variance for both the MZ and the

DZ groups, on many measures. Where the between-family variance is much greater in the MZ group than the DZ group and the MZ 2 is higher than DZ 2, then the MZ intraclass correlation will be greater in relation to the DZ intraclass correlation than the MZ 2 is to the DZ 2, and thus h^2 will be greater than h, which does not use between-family variance in its formula. This pattern of results appeared with the following measures: M6, Osser MT, Story MT, M1, Osser Deletions, and Story Personal Pronouns. Of these measures only the M1 was significantly and positively correlated with IQ. If all had been, then it might have been argued that because there is a greater range of IQ in the MZ group (see Chapter III, Sample, for discussion), the greater range of between-family variance on these language measures is a function of the IQ range (see Table 21).

However, this was not the case. Alternative explanations include the fact that the Osser, M1, M6 and Story measures may have been better designed to test for variance within the age range of our sample, hence more between-family variance was expressed for MZ pairs. It may also be that scores on such measures are more easily affected by elements in the child's personality such as perseverance, whimsy, game-playing and the like, factors which may show greater variability across families.

Derived heritabilities in this population also

TABLE 21

THE MZ AND DZ BETWEEN-FAMILY VARIANCE ON ALL MEASURES (Z SCORES ADJUSTED FOR CA)

Measures	Between-Family Variance	
	MZ Group	DZ Group
PPVT	547.7	356.0
S-B Vocab.	669.0	236.7
M1 Vocab.	430.7	275.8
M4 Morphology	240.8	472.4
Berko	382.2	380.5
Harvard	283.7	172.6
Osser	714.6	269.4
M6	566.8	205.8
Osser MT	535.6	158.2
Story MT	622.3	148.5
M6 MT	347.8	322.7
M4 MT	258.2	356.1
Osser Insertions	288.1	387.2
M6 Insertions	397.7	397.3
Osser Deletions	632.9	369.3
M6 Deletions	569.8	449.9
Osser Verbs Correct	553.1	418.0
Story Verbs Correct	374.8	337.5
M6 Verbs Correct	415.8	371.8
Story Words	337.7	321.2
Story Utterances	253.4	413.8
Story Personal Pr.	533.4	172.4
Child's MLU	323.7	329.5

showed marked increases from h^2 to h. This indicates that the DZ between-family variance was considerably greater than that of the MZ group. This pattern appeared with the Harvard (unadjusted for CA), the M4 measures of morphology and morphophonemic transformation, and number of utterances in the child's story. Since all of these measures show low-moderate heritabilities on Holzinger's h^2 (.53, .44, .24, .46 and .31 (CA) respectively), it might be argued that such skills are open to the environment sufficiently to be expressed within a wider range of variance generally, by means of the interaction of several influences on development. Furthermore, as h^2 is an indication of the heritability accounting for the present sample, while Holzinger's h does not account for the between-family variance in the present sample, many of the findings here may be seen as random error in the sample--error which might be corrected by selection of a larger sample.

In one case of greater between-family variance for DZ however--the M4 measure of morphology--the DZ intraclass correlation is significant and higher than that of the MZ group. The resultant difference between h^2 and h is not only the outcome of greater between-family variance, but clearly is a function of both the between-family variance and the high within-pair variance.

Adjustment for chronological age also affected many of the h^2 heritabilities presented here. The Harvard and M6 measures of syntax, as well as the Stanford-Binet vocabulary measure showed marked gains in genetic contribution to phenotypic variance with the CA adjustment: .04 to 1.00; .82 to 1.00; and .58 to .94. There was only one decrement in genetic contribution with adjustment for CA, and that was with the child's mean length of utterance, where h^2 went from 1.00 to .34. As the scores were leveled by CA adjustment for age difference, so the between-family variance was reduced, and the amount of within-pair variance should have shown an even higher ratio relationship to between-family variance. However, because of the greater mean age in DZ pairs tested for CMLU (45.6 months at time of testing as compared with 42.2 months for MZ pairs), the reduction of between-family variance caused the DZ within-to-between ratio to increase, yielding a reduction in heritability.

In addition, of a subset of all measures tested for correlation with child's age, child's mean length of utterance showed the only positive and significant correlation (r = .60, p .001). Thus when CA adjustment is made, the significant variability is reduced, enhancing the effects described above.

The increases in statistical measures of heritability in this population are a function of an overall reduction in the between-family variance, combined with an adjusted increase in the ratio of MZ within-pair variance to DZ within-pair variance. The Harvard measure, for example, showed a DZ between-family shift of 452 to 172 when CA adjustment was made, while the DZ/MZ within-pair ratio changed from two-to-one to roughly three-to-one.

In general, the change in between-family variance for the CA adjustment made the most effect on the DZ group, as there was a greater mean age of DZ pairs for most of the tests, and in several of the cases the DZ range of ages was also greater than the MZ range. The reason for this greater mean age of DZ's was that they were older at the beginning of the study (DZ mean age = 3 years and 3 months; MZ mean age = 2 years and 10 months), and were also often older than MZ pairs at the time of testing. As DZ co-twins could only be tested when both co-twins were able to understand the instructions for the test, their performance was then keyed to the slower of the two, and testing could only be carried out later in the study. This, of course, added to the age differences between MZ and DZ groups. (That is not to say, however, that MZ co-twins did not exhibit such differences. There were differences, but these were largely matters of won't do, rather than can't do.)

Clusters of Heritabilities

Considering now only Falconer's h^2 on CA-adjusted Z scores, four groups of heritabilities appear:

Very High	h^2	Very Low	h^2	Moderate	h^2
Harvard	1.00	Osser Syn.	.04	CMLU	.34
M6 Syn.	1.00	M6 MT	.20	PPVT	.60
Osser MT	1.00	M4 MT	.20		
Story MT	1.00	M6 Del.	.18		
S-B Vocab.	.94	Osser Del.	-.10	Marked	
M1 Vocab.	1.00	Osser V.C.	.24	Negative	h^2
M6 Inser.	.82	Story V.C.	.12		
Osser Inser.	1.00	M6 V.C.	.02	Berko	-.52
Story P.P.	.80	Story Wds.	.00	M4	-.58
		Story Utts.	-.10		

The range of heritabilities in each of the groups is as follows: Very High--from .80 to 1.00; Very Low--from -.10 to .24; Moderate--.34 and .60; and Negative---.52 and -.58.

Negative

Only the moderate grouping of heritabilities, with two cases, CMLU and PPVT, shows any relationship to Mittler's findings. In fact, the M4 measure of morphology, drawn in part from the auditory vocal automatic subtest of the I.T.P.A. (Mehrabian, 1970) used by Mittler, showed a strong negative heritability, as did the other measure of morphology. For the matching measure of morphology Mittler had found an h^2 of .46 and .54 on a sample of four-year-olds. He had further found that this particular subtest of the I.T.P.A. was correlated with other biological variables such as length of the twins' gestation, and children's history of later speech onset (Mittler, 1969).

An isolated result of such a marked negative heritability on the M4 measure, in light of Mittler's finding, might indicate that the test here was unreliably given. However, a test designed to investigate the same question, the Berko measure of the child's understanding of the rules of morphology, showed an identical pattern of results. The M4 (see Appendix D) is a test of eleven items constructed to examine the child's ability to form regular and irregular plurals, past and present tense comparatives and superlatives. The Berko measure is a 28-item test of the child's ability to form regular and irregular plurals, past and present tense, and comparatives and superlatives, the only difference being that a large portion of the Berko items are designed on a base of nonsense words (Berko, 1958). The argument for the Berko test construction was that if the child's rule forming ability were present, it would be an ability which could operate on new words, and not only on those which were present in the child's repertoire.

Both the Berko and the M4 showed a significant, positive correlation with the S-B IQ. The more intelligent a child, the better his performance on these measures, suggesting that although the twins' behavior in relation to these tests showed negative heritability, nonetheless such behavior may be affected by another aspect of the child's behavior, one for which there is a marked genetic contribution to phenotypic variance.

On both measures, the mean raw scores of the MZ group was higher than that of the DZ group: for the M4 MZ mean raw score was 4.2 and DZ mean raw score was 3.6; for the Berko the MZ mean raw score was 10.3 and the DZ was 8.6. This fits the correlation with IQ. One aspect of the raw scores which must be noted, however, is that for both tests mean raw scores represented only one-third of the entire test. This means that while there was a great deal of room (number of items) on which variance may be expressed, the test, in fact, may have been too difficult for the age groups used in the study. Given that many of the answers the children gave on both tests were guesses and silly answers with an aim to extricate themselves from a slightly uncomfortable situation (the children always got restless when items on tests began to be too hard for them), it might be that scores on these measures at this stage represent more of personality and family factors. If this is the case, and if MZ pairs, despite their greater similarity in personality as reported by mothers on the attitude questionnaires, are responding to a pressure to differentiate themselves from one another, a pressure not felt by the DZ group with their many self-perceived differences, then it may be that MZ co-twins' lower intraclass correlation for these behaviors is an outcome of such a situation.

One check which can be done is simply a repetition of these measures when the sample, still intact, has a mean age of slightly over four years old. If the interaction of personality and social needs has been the factor influencing findings obtained when children cannot fully respond to the tests, then perhaps at a point when mean scores represent at least two-thirds of the test, the MZ and DZ group variances may fit the picture described by Mittler. (The sample is intact, and the check has been arranged.)

High Heritability

Returning again to the four groups of heritabilities it can be seen that the very high heritability group subsumes five categories of measures: syntax tests of the child's ability to perfectly repeat increasingly complex sentences; morphophonemic transformation, or a measure of the regular errors the child makes in plurals and verb use; vocabulary measure, the child's ability to recognize and name pictures of objects and actions; insertions to syntax, a measure of the additions to a repeated sentence which the child makes in the course of repetition; and the child's frequency of use of personal pronouns in telling a free-form story. In this cluster of measures h^2 ranges from .80 to 1.00, all of which are equal to or higher than that found for IQ (Erlenmeyer-Kimling, 1963), indicating that variance across individuals within this population for these measures may stem from a genetic component.

Of these measures, only the two vocabulary measures are significantly correlated with IQ, but this was expected: The S-B vocabulary is a subtest of the IQ test, and the Ml measure of vocabulary, while entirely different in administration from the Stanford vocabulary measure, derives one-third of its items from the Stanford-Binet (Mehrabian, 1970).

The presence of so many h^2 of 1.00 within the high heritabilities group, where all heritabilities are as high or higher than that found for IQ, provides strong evidence for the Chomskyian thesis that there is a genetically determined mechanism which controls the process of language acquisition. The mechanism which would be supported by the pattern of these findings would, however, be one which does not control every aspect of acquisition, but, in fact, controls selective aspects of the process, here namely operations with syntax, morphophonemic transformation, vocabulary, insertions to syntax and number of personal pronouns used in self-expression. The question of a possible selective mechanism opens still another important question: what are the aspects of language a child must acquire before he can be considered an acceptable speaker of the language? This question cannot be answered within the framework of the present study. One of two kinds of judgements would have to be made on the child's language performance. Either a series of scores on a selected set of subtests would arbitrarily be chosen as criterial for marking the achievement of some standard of performance, or independent judges might be brought in to say that a child is or is not performing in language as would be expected. In the latter case, internalization of some norms or standards by judges would still not benefit more complete understanding of exactly what skills are important and necessary.

The measures used in the present study were selected as covering a range of both rule-bound and non-rule-bound behavior with language, where rule-bound is tagged for grammar alone. In terms of this, the highly heritable measures form a package containing both rule-bound and non-rule-bound behaviors, the former being syntax, morphophonemic transformations, and insertions; the latter here defined as vocabulary and frequency of personal pronoun use.

The high heritability group might be explained as a function of memory, or some other cognitive process as opposed to the invocation of a language mechanism.

If this were the case, however, then the measures included here might be expected to show strong correlation with IQ, which has been shown to have a correlation with individual measures of separately tested cognitive abilities.

Low Heritability

The cluster of measures which show low heritability in this population are the Osser measure of syntax, the M6 and M4 morphophonemic transformations, the M6 and Osser Deletions from syntax, the Osser, M6 and Story correct use of verbs, number of words in the child's story, and number of utterances in that story.

In this group heritabilities ranged from -.10 to .24. What this suggests is that for these behaviors, on the average only ten percent of the phenotypic variance that is shown here within the population can be accounted for by genetic variance. These behaviors are not heritable, at least not in this sample.

Of the group of behaviors where there is little genetic contribution to phenotypic variance only Osser syntax and M6 MT and M4 MT have been included as members of groups of measures whose other members have been shown to be highly heritable. With these measures, furthermore, the intercorrelations among measures in these groups were positive and significant, suggesting that they are measuring the same or similar behaviors. The only explanation of these results which can be made is that Osser syntax, and M6 and M4 MT measures are measuring skills which are related to, but not fully consonant with the other measures showing high heritability that they were grouped with originally. Another problem to be considered is that there may have been systematic coding errors, however (1) the Osser, Harvard, and M6 were coded 1 or 0 and agreement was settled at r = 1.00 for two coders, (2) M6 and Osser MT were both coded using identical xeroxed coding instructions, and (3) the M4 MT was coded with instructions which included a list of all those, and only those answers acceptable in each category.

For the other language skills which showed low heritabilities in this population--deletions, verbs correct, and story words and utterances the pattern is simpler and clearer. These data do not support the idea that there is a mechanism for the acquisition of language. For these measures, variance in this population is almost entirely under environmental control.

Moderate Heritability

The findings of h^2 of .34 for child's mean length of utterance, and an h^2 of .60 for child's vocabulary as measured by the Peabody Picture Vocabulary Test are results more aligned with Mittler's findings on the I.T.P.A.

However, they form a small subset of h^2 in this study, falling between the very high and very low heritability groups. Interestingly, even as the components for the child's mean length of utterance showed no heritability within this population, the ratio of those two components, the CMLU, does show heritability. Furthermore, when not adjusted for chronological age of the child, the CMLU is highly heritable: $h^2 = 1.00$. As discussed in the introduction to this chapter, the reason for this drop in derived heritability is the high correlation ($r = .60$) of child's age with performance on this measure. This suggests that perhaps CMLU then should be more correctly placed in the high heritability group of measures.

The Peabody Picture Vocabulary Test also might be shifted into the high heritability group. One problem of the test was that there were very few items in the test for the age range of our sample, and thus there was very little range on which to differentiate co-twins for the expression of variance. This was not so for the other vocabulary measures. The high genetic contribution to phenotypic variance in these other two measures, combined with the fact that all three of the measures show positive significant intercorrelations suggest that perhaps an age appropriate extension of the PPVT might indeed show a higher heritability within the sample.

Summary

Taken as a whole, heritability statistics for all measures together suggest that language behavior is in fact a very complex set of intercorrelated behaviors, i.e., a set which is divided in terms of the amount of genetic and environmental control exerted on members of that set. Roughly one-half the measures show high genetic contribution to phenotypic variance, and the other half shows little or no such contribution. The remaining two measures, M4 and Berko morphology, despite proposed explanations remain something of a puzzle.

The pattern of these data does not show any relationship to the findings of Mittler (1969, 1970), the only partially comparable study. Nor does the pattern of these data lend clear-cut evidence for a model of innately controlled language development, at least as the models have so far been expressed (Chomsky, 1968; MacNeill, 1969). Rule-bound behaviors in relation to grammatical operations were found as part of the very low and very high heritability groups. While it may be that the cornerstone skills of acquisition are those described by the high-heritability measures, it may also be that language acquisition is based on the contributions of all the measures studied here. If the latter is the case, then current models of an innate device are not supported by these data.

Examination of the measures showing low genetic contribution to phenotypic variance, however, does suggest that they are, for the most part, concerned with discourse operations, or the shaping of discourse rather than rules for the structure of sentences. The measures, showing high genetic contribution, on the other hand, do, for the most part include measures which test for rule-use in terms of grammar.

If this rough division is made, and the exceptions are ignored, then perhaps it may be tentatively argued that an innate genetic mechanism is a possibility, one which might be supported by another study, involving another set of measures of the child's language behavior. An addition to this possibility, the group of measures which showed little evidence of genetic contribution to phenotypic variance, relating to discourse operations, would need some cohesive definition in terms of the influence presumably exerted by aspects of the environment on such behaviors.

A rough division of skills such as this would certainly be a logical pattern for the construction of the complex system of interlinked behaviors which language appears to be. If rule-bound and structural aspects of using language are somehow cued, triggered or fomented by the force of an innate genetic mechanism, and yet the broad pattern of the language which ensues is controlled by the environment within the family and within the culture, then the transmission of language as a system is insured from generation to generation, while the shape and character of that language is free to vary with differing cultural needs and requirements.

The Nature of Language Skills

Hymes has argued (Huxley and Ingram, 1971) that the word language is used much too loosely, and should be broken down into two or more terms which more exactly apply to those aspects of language which are separately studied. His suggestions included language as a term for structural aspects with verbal behavior as the term to be employed for language use.

In the present study there is too a question of finding appropriate labels for the behaviors tested. The a priori determination of sets of skills as measuring the same aspect of language has been shown, by means of patterns of intercorrelation of the measures, to be largely true, at least at the level of categorization of those skills. Whether or not those categories are measuring a quantifiable and significant aspect of language behavior cannot be ascertained by the comparison of correlations. The fact of clusters of heritabilities, however, does lend authority to the "tested-for" aspects of behavior--as clusters of skills which show the same patterns of correlation with other skills also are shown to have similar patterns of heritability.

Furthermore, in viewing these patterns of heritability, solutions for the questions concerning such a sharp distinction of skills must come from a better understanding of what those skills are, and what they mean in terms of language acquisition.

It was earlier argued that the findings for h^2 and h pointed to two clear groups of skills, those surrounding the child's operations with discourse, and those which represented the child's ability to deal with rules of the language, or with structural rules of the organization of language as a system. Morton (1970) has argued that an innate mechanism for acquiring language should reflect only those aspects of the structure of language which are biologically necessary for man to know. Chomsky (1968) outlined a mechanism for acquiring language, called a "universal grammar," which has the function of specifying a set of rules which will be able to provide a rough structure for any language, under any number of conditions. McNeill (1966) has proposed a mechanism which is able to control the induction of the structure hidden in language by means of a hierarchical system of categories. All of these proposals for innate abilities to deal with language specify only that the structural aspects of language be so determined.

The findings for heritability here include language skills which fit these theoretical requirements, but they also include skills which do not fit these specifications. While the child's ability to deal with syntax, syntactical insertions and morphophonemic transformation all reflect functions which are clearly rule-bound and structural, among the same group of skills which show a high proportion of genetic variance, there are also the skills of vocabulary and use of personal pronouns. To what extent can these be said to be components of the child's ability to use rules?

If an argument is made for the frequency of the use of personal pronouns as being either validly representative of some rule of substitution, and vocabulary size is seen as rule-bound in terms of the linkage of words with meanings and objects, then it must be further argued that many of the skills discussed here, where contribution of genetic variance to phenotypic variance is low, are rule-bound behaviors as well. Certainly the use of verbs correctly in sentences must be a rule-bound function. Then too, for syntax, and morphophonemic transformations, both categories are represented in both the group of measures with high h and h^2 and the group of measures where h and h^2 was low. This last finding cannot be easily resolved when it is noted that syntax measures where genetic contribution to the total variance is both high and low are significantly intercorrelated, with the same being true for measures of morphophonemic transformation.

There are two general avenues of conjecture: either there is, in fact, some innate language-acquiring mechanism which operates as the theorists have modelled it, in which case, the tests used here would need reconsideration and re-evaluation; or, there is no particular language acquisition device, but there are two sets of language behaviors--those which are determined by an unknown genetic component, and those which are controlled by aspects of the environment.

In either case it becomes very important to be able to classify measures for the exact aspect of language behavior which they purport to test. Mittler (1969) suggested that children of four or younger might not have differentiated skills, but in fact might operate by means of a single determining language ability. His findings on a factor analysis of scores for singletons indicate that there is indeed a single factor. Likewise, Mehrabian's (1970) analysis of his own set of six measures revealed a single language ability in a sample of children from two and one-half to five years of age. These two sets of findings were for analyses done across a wide variety of types of tests.

Unfortunately the size of the present sample ruled out factor analysis of the various measures used.

However despite this, a table of intercorrelations of the measures suggests that there would be more than one factor if the data were subjected to factor analysis (see Table 12). What can be noted on the table are the significant intercorrelations of vocabulary, morphology and syntax measures, the significant intercorrelation of measures of morphophonemic transformation, insertion and deletion, and the significant intercorrelation of correct verb use with measures of syntax, morphology, and story personal pronouns. A pattern of significant negative correlations can be seen for measures of syntax in relation to measures of morphophonemic transformation, insertion, and deletion. According to these groupings of intercorrelations there might be seen to be three factors of language behavior: (1) vocabulary, morphology, syntax and pronoun use; (2) morphophonemic transformation, insertion, and deletion; and (3) behavior involved in the child's story telling.

It should be noted that all three hypothesized factors include measures with both high and low genetic contributions to phenotypic variance. If these factors were supported by data from a factor analysis of all scores on all measures, then the question of acquisition would become an increasingly complex one. If there is a language acquisition device, might it influence a portion of every factor? How might aspects under genetic and environmental control interact to operate as a single factor?

This study has not claimed to include all those and only those aspects of language behavior which are central to the child's acquisition of language. There are many more things which a child needs to learn to do with language before he is considered to be an acceptable speaker of the language. Certainly the child's use of rules about place, situation, speaker, topic, and code have not been considered. (As explained in Chapter III briefly, these rules could not be examined within the frame of this study, as the situation and act of testing imposed constraints, thereby reducing the variability which might reveal contrasts.)

What can be examined, however, is a small portion of the environment which may influence the child's acquisition of all types of rules: the mother and her speech style to her child.

Influence of the Mother

Mother's speech style has been hypothesized to have many wide-ranging effects on the child's language behavior and the child's performance on other sorts of tests as well (Hess, 1965; Brophy, 1970; Dickie, 1972; Wachs, 1972; Ervin-Tripp, 1970). In all cases the agruments are based on an interpretation of the mother's style which varies from a word-count coding of the mother's speech to a single statement by the mother taken as symbolic of some further pattern of interaction (Wachs, 1972) to a full-scale interpretation of all aspects of the mother's behavior in the presence of the child: speech, emotionality, gestures, movements, and the like.

The present study has isolated only nine factors from the mother's speech to the child, and one from the mother's speech to the experimenters. Mean length of utterance was coded for both the mother's speech to child and to experimenter, and in the mother's speech to each of her twins the following factors were selected for a simple frequency count: questions to the child, answers to the child's questions, expansions of assertions made by the child, repetitions exactly of what the child had stated, criticisms of what the child said--whether for content or structure, confirmations of assertions by the child, and directions to the child to behave, speak or attend.

These simple frequency counts (presence in 200 utterances of the mother) yielded some interesting correlations. Out of twenty-nine significant positive correlations, thirteen were with measures of the child's use of morphophonemic transformation (see Table 13). Questions, answers, assertions, mother's MLU and directions from the mother to the child all correlated positively and significantly with the child's morphophonemic transformations. Also correlated with mother's speech style were insertions and deletions to syntax. Mother's repetitions to her child correlated with the Osser and M6 measures of syntax, as well as with the child's use of personal pronouns. Criticisms of the mother were positively correlated with the child's performance on the Stanford-Binet vocabulary measure.

There were many more negative correlations than positive correlations with mother's speech style (see Table 14). As with the significant positive correlations, however, there were no relationships between mother's confirmation and any aspect of the child's language behavior. This supports an earlier finding of Cazden and Brown (Huzley, 1971) which was that mother's approval was not related to child's performance in terms of syntax.

Of the forty-one negative correlations, most are connected with the child's behavior in story telling, and correct verb use (nineteen). Questions, answers, expansions, assertions, directions and mother's mean length of utterance all showed significant negative correlation with various of that group of measures. Two measures of vocabulary were negatively correlated with directions from the mother, and assertions too showed negative correlation with the Stanford vocabulary measure.

What these correlations appear to suggest is that mother's speech style to her children may be more of a response to the child, than a determinant of the child's language development. The strong pattern of correlation with morphophonemic transformation indicates that mothers whose children make many changes in the tense and case structure of language are more frequently asserting, questioning, and directing their children, a pattern of behavior which may well be a response to the child's range of changes in language behavior. However, despite this, it may also be that patterns of speech style are part of a repertoire which the mother employs no matter what the child's behavior.

The greater number of negative correlations than positive would support this, as would the fact that all factors show both negative and positive correlations with the child's performance. If the mother were responding to her child's particular language behavior, it might be imagined that such adaptation would lead to a pattern of enhancing or positive correlations. In fact, Brown's original contention about the positive aspect of the mother's expansion of the child's speech was not supported here (1964, 1970). There was no positive correlation for expansion with any aspect of the child's behavior, and only one negative correlation reaching significance, that with Story Verbs Correct. It may be, however, that these expansions were important earlier on in the child's development--perhaps at the point of one and two word utterances. (Brown's argument was set at that point.)

One way to test for the responsiveness of the mother's style is to examine mother's speech style to MZ and DZ twin pairs, and two correctly and incorrectly perceived MZ pairs (MZR and MZW). As reported in the results section, and as can be seen on Table 16, for half of the factors, MZ mothers showed greater differences in style to each child than DZ mothers, and for the other half of the factors--questions, answers, expansions and directions--DZ mothers showed greater speech style factor variance.

When MZR and MZW mothers' speech style factors are compared, however, a more interesting pattern appears. For all factors except questions and directions MZW mothers show a speech style variance significantly different from that of DZ mothers: for answers and expansions, DZ mothers vary their style more with each child, but for assertions, repetitions, criticisms and confirmations, MZW mothers vary their style significantly more with each of the MZ co-twins.

When DZ and MZR mothers are compared, out of eight factors, five show clear evidence of greater (though only in one case significantly greater) variability of speech style factors by DZ mothers--the expected pattern if mothers are responding to their children rather than shaping them.

Turning back to Table 18, it can be seen that six out of the eight DZ/MZW comparisons are significant, while only one DZ/MZR comparison is significant. What this suggests is that the behavior of mothers to their MZR or DZ twins, as measured in terms of these eight speech factors, is not significantly different. While there is a tendency for DZ mothers' speech style to show more within-pair variation, in only one case, repetitions, is it a significant difference.

For MZW mothers, however, the pattern is different. When mothers' within-pair speech style variance for MZW and DZ co-twins is compared, nearly all the comparisons are significant (6/8), though not all in the same direction of difference. What this suggests is that the fact of misperception, or the state of misperceiving MZ twins as DZ twins, has some effect on a mother's speech style to her twins. From these data, it appears that mothers of MZ twins who misperceive them as DZ tend to treat the twins either in a significantly more similar manner than DZ pairs are treated here, or in significantly less the same manner. For confirmations, assertions and repetitions, such mothers treat misperceived MZ pairs more alike; and for answers, expansions and criticisms, mothers of misperceived MZ pairs treat them less alike than DZ pairs.

These extreme and significant style shifts suggest that the uncertainty of misperception (none of the mothers said they were more than sure at the two level, on a scale from one to three, with one being absolute certainty about zygosity), may represent a response to an ambiguous situation on the part of the mother.

Taken together these findings suggest that, to some extent, when mothers are sure of their children's zygosity, mothers of DZ twins do show a tendency for differentiated speech style response, in contrast to mothers of MZ twins. However, when mothers (here only MZ mothers) are unsure of their twins' zygosity, or rather, are incorrect in their perception of zygosity--significant style shifts toward greater and lesser variance occur. These shifts are not consonant with the idea of responsiveness to the child, but instead appear to mark the characteristics of extreme behavior which attend serious problems of attribution.

A further question of outcomes for the child may be studied by comparing MZR and MZW twin pairs' behaviors on the language measures. Though birthweight differences were greater among the MZW group, the S-B mental ages of both groups are equivalent, and so it may be assumed that if extremes in mother's style had a significant effect on the child's language behavior, it might appear as a tendency toward greater differentiation of behavior between MZW co-twins.

In fact, just the opposite proved to be true, (see Table 17). Of forty-six measures, seventeen showed significant difference between MZR and MZW pairs. However, all but two of the significant differences were in the direction of MZR co-twins having greater within-pair variance.

Given the IQ and birthweight range of the sample, if mother's speech had no influence on the child, and if mother's perceptions had no influence on the course of development, then it would be expected that greater variance might be distributed randomly among those tests wherein significant differences occurred. What Table 17 suggests, however, is that twins whose mothers correctly perceived their zygosities showed significantly greater variation more of the time (15/17).

If this variation is due to the fact that the MZR sample is especially different in language development, then no argument may be made. If however, this finding represents increased similarity of MZW pairs, which increases the MZR/MZW ratio, then it might be concluded that MZW pairs show increased similarity of language behavior as a response to extreme shifts in variability of maternal speech style. Only a long-term longitudinal study can disambiguate this problem.

Aspects of the mothers' speech styles beyond frequency of individual factors certainly must be studied in order to more fully examine the mother's influence on the child's language development. The important question is really the same as that asked about measures designed to test for patterns of acquisition in the child: what aspects of mother's style, when coded, will prove to the quantifiable, measurable and significant aspects of her speech and pattern of interaction?

A very rough set of nine categories has shown many significant correlations with child language behavior, and it may be that a coding based on pattern of style would show even more significant correlations.

In a small attempt to look at these more complex aspects of style, a set of four twin pairs was selected from the sample and divided into two sets of two pairs each. Both samples of two pairs had similar mean IQ's, 108 for group A and 107 for group B, but the two groups differed in that group A had very high scores on the M1, M4 and M6 measures while group B had rather low scores on those measures (total scores, adjusted for CA, for group A = 1.124 and group B = .767).

A more detailed examination of the speech of mothers in both groups was made in order to see if there were any marked similarities within groups, or differences between groups. While a sample of only two mothers in each group is very small, nonetheless some patterns may be elucidated.

Comparing the speech styles of A and B mothers in their telling of a story about a circus, three significant points of difference appear: One, while both A and B mothers respond to what their children are saying to them in the course of their story-telling, A mothers show much more indulgence of the child's responses which are not totally appropriate to the pictures, or to what they had been previously saying. Typical of the A mothers' interaction is the following:

Mother: Can you name all the faces in the picture?

Child: Bubble-gum, bubble-gum.

Mother: Bubble-gum, that's . . . right. It certainly does look like bubble-gum. Where do we get bubble-gum at?

Child: When we want some.

Mother: When we want some. And where do we put the pennies at?

The B mothers, however, follow a course often like this:

Mother: All the people are coming to the circus, see that?

Child: I don't want to get on horsies.

Mother: You don't want to get on the horsies? And then this tent, see this tent, it's a tent.

Child: I want a tent.

Mother: People go in the circus and see a show.

While both A and B mothers do equal amounts of repeating what their children have said, that fact of allowing each twin to change the topic gives A mothers less need to use directions such as see that, look at that, as they are not pulling the child along some path charted by themselves. This greater indulgence for topic changes on the part of A mothers also carries the hidden valuation of the child's speech and comments as something worthy of being explored, considered, and examined, while the insistence of B mothers on maintaining the topic they have chosen may suggest to the child that his information is not quite so important.

Another obvious point of difference is that B mothers simply do a great deal more talking than A mothers:

B Mother: Here's a castle and here's, it looks like a fairyland.

Child: It is a fairyland.

Mother: Yeah, because there's a baby in a basket and there's a castle, and I don't know what to make of them but see what, somebody was riding horses and threw him off. I think he's going to get up and what's her gonna find?

Child: Baby.

Mother: I think he'll take the baby and take it over to that castle and see if it belongs to anyone there. And he's going to find that baby and take it to the castle and find out whose it is.

Child: Yeah, he's looking in there.

At a similar point in the story, the A mother's interaction pattern looks more like this:

A Mother: What does this look like to you?

Child: A doll's house.

Mother: I don't know. I like that. Do you like dolls?

Child: Yes.

Mother: That's a pretty doll--who has hair like that?

Child: My Mom deserves it.

Mother: Yeah, your mother deserves to have yellow hair.

Notice here that in addition to a free change of topic--the story in the book is not really followed--the mother is not overwhelming her child with a long flow of information, nor is she asking the child merely to support her interpretation of the picture book.

A third factor, one which is not separate, but, in fact, may be determining of the other two is the differences in the A and B mothers' understandings of what telling a story means. For the B mothers clearly the situation is one where a package of information must be serially presented to the child in some continuous and coherent form. For the A mothers, the process is more open. There seems to be much less emphasis on the shape of the story, and much more emphasis on using the vehicle of a storybook to relate to their children. (This where both sets of mothers were given identical instructions by the experimenters.)

An examination of all the story-telling transcripts indicates that only one-third of all mothers (N = 15) fall into the category formed by type A, suggesting that perhaps the B mode is the more usual and accepted way of dealing with a story-telling situation. Furthermore, there were no broad differentiations of style made by mothers of DZ pairs. Apparently, if a mother consciously or unconsciously elected to use mode A or B, she did so with both twins regardless of zygosity.

Mothers' expressed attitudes toward language development seems to have little to do with whether or not a mother uses mode A or mode B. A mode mothers said things such as "Children should not constantly interrupt adults," "Children should not interrupt others' conversations unless they are part of the discussion," "There are always times for silence--not terribly often at 2 1/2," and B mode mothers also said, "When adults are talking, it doesn't concern them," "There are times when everyone must be quiet, however children should be encouraged to express themselves."

What would be of value now is a further quantification of these modes, and an examination of a larger group of mothers, including mothers of singletons as well as mothers of twins. If a quantifiable distinction of such modes can be made on a larger sample, then it may be said that such modes indeed exist.

Summary

Mothers clearly have a great deal to do with the process of acquisition, but just how this influence is effected cannot be determined within the present sample and measures. Mothers adjust their mean length of utterance--from 9.1 for adult conversation as a mean to 4.5 for interaction with their children--in communication with their twins, and factors in their speech style, as well as their attitudes have shown to be correlated with various aspects of the child's language behavior (see Chapter V, section four).

Only a more detailed and codified exploration of patterns within speech styles might show whether or not such patterns have specific effects on the process of acquisition, but the hypothesis might easily be proposed that they do have some effect.

Mothers' perceptions appear to have a significant effect on their own speech style factors only when such perceptions are in question. Still an unresolved question is the fact that mothers of MZ twins whom they have believed to be DZ pairs show extreme shifts in style in interaction with their children.

A factor analysis of the child's abilities in language followed by subsequent analysis of the mother's contribution to such behaviors might shed more light on the interconnections of the process of acquisition, but the present sample was too small for such an analysis.

CHAPTER VII

CONCLUSION

Given that there may be at least two sets of language behavior skills, those which show high contribution to phenotypic variance and those which show low contribution, and given that among both groups of skills there are measures of language behavior which show evidence of rule-bound behavior, it cannot be firmly argued that the language acquisition mechanism proposed by Chomsky et al. has been supported. What is supported by these data, however, is the idea that the language acquisition process is a complex interconnection of many skills, each subject either predominately to environmental or genetic influence, where mother's speech behavior, as an aspect of the environment has been shown to be correlated with the child's performance on measures of these skills.

Of all those hypotheses presented as an appendix to Chapter I, the Lorenz model comes closest to describing the findings of the present study. Lorenz proposed (1965) that complex behaviors might, in fact, be broken down into a series of interconnected behaviors each of which would be either wholly innately determined <u>or</u> wholly determined by the environment. This model would fit the findings of heritability for the measures studied here taken by themselves.

Lorenz claims that the outcome of such a series of behaviors would be a well-integrated complex behavior constructed of that series of individual behaviors. This argument applies to the child's use of all the aspects of language as a coordinated whole.

The evidence for environmental influence of the mother on behaviors showing both high and low heritabilities as measured in this population, however, suggests that any model of acquisition must be more complex than that proposed by Lorenz.

Beyond this, it is also important that language behavior skills found to have a high heritability in this sample were not shown to have any consistent pattern of significant positive correlation with IQ. If that had been the case, then it might be argued that the genetic factor which determines the genetic contribution to phenotypic variance in language behavior is, in fact, IQ. However, despite the fact that IQ measures many aspects of verbal behavior such as analogies, vocabulary, and the like, only measures of vocabulary and morphology showed a consistent pattern of positive correlation with

IQ. Of these, only vocabulary showed heritability in this population.

This, of course, leads to the question as to whether IQ is not an estimate of a number of different types of innate abilities, among which vocabulary development appeared a good test item precisely because it showed consistent high genetic contribution to phenotypic variance in test samples.

Beyond the Lorenz Model

The Lorenz model is not the only one which can be applied here. These data can also be somewhat more clearly elucidated by the introduction of two other models: Geschwind's neurophysiological model of language operations in the brain (1972); and Chomsky's (1965) model of the operations of transformational grammar (this being seen here as entirely separate from the earlier discussion of Chomsky's claims for innate language universals).

Geschwind's model, based on information about the possible neural correlates of language operations, argues that there are separate sites and special pathways which control different aspects of language performance. If these areas exist, and are seen as heritable (but plastic) areas largely under genetic control, then a one-to-one correspondence should be able to be drawn between language performance areas and the performance on language tests here found heritable (see Table 22).

The Chomsky concept of transformational grammar suggests that there are different levels of grammatical operation, and that different steps take place along the way. Here, too, levels and types of operations may be linked with tests of language ability, and heritability (see Table 23).

Neither the Geschwind nor the Chomsky model is completely supported by these data, though there is a fairly good fit: all measures showing high heritability in this population but one, personal pronoun use, are covered by Geschwind's neural areas, and the distinction between deep and surface structure operations in the Chomsky model does tend to preserve a one-to-one relationship between deep structure and measures showing high heritability, and surface structure and measures showing low heritability.

Geschwind's model offers a better explanation for these data than does the Chomsky model. In fact, while Geschwind's model indicates specific areas which would lead to specific heritable language behaviors, the Chomsky model sheds little light on exactly why some language behaviors should show such high genetic contribution to phenotypic variance, and others show little or none.

In any event, what is apparent from these data is that the problem of language acquisition can no longer

TABLE 22

GESCHWIND'S MODEL WITH PRESENT DATA

Geschwind's description of language operations	Present language tests	Genetic Contribution to Phenotypic Variance	Associated Brain Pattern or Area
Production: saying the name of a seen object	PPVT Vocab.	High	Visual pattern-angular gyrus-Wernicke's area-Broca's area-motor cortex.
	S-B Vocab.	High	
	M1 Vocab.	High	
Production: keeping the order of words, using functor words correctly adding in words, doing morphophonemic transformations	M6 Syntax	High	Broca's area in general: where repetition involves Broca's area-Wernicke's area.
	Osser Syntax	Low	
	Osser MT	High	
	Story MT	High	
	M6 MT	Low	
	M4 MT	Low	
	Osser Inser.	High	
	M6 Inser.	High	
Comprehension: the understanding of words in sentences as having meaning	Harvard	High	Wernicke's area alone.
---	M6 Del.	Low	---
	Osser Del.	Low	
	Osser Verb Cor.	Low	
	M6 Verb Cor.	Low	
	Story Verb Cor.	Low	
	Story Words	Low	
	Story Utts.	Low	
	CMLU	Low	
	Berko	Low	
	M4	Low	
---	Story Per. Pro.	High	---

TABLE 23

CHOMSKY MODEL WITH PRESENT DATA

Abstract Level	Language Operation	Relevant Present Tests	Genetic Contribution to Phenotypic Variance (Heritability)
Deep structure	semantic insertions	Vocab. tests (3)	High
Deep structure	morphophonemic transformation which is the results of syntax operations	MT measures (4)	High (2) Low (2)
Deep structure	syntax operations	Osser, M6 Harvard	High, low High
Surface structure	pure morph change	Berko M4	Low Low
Surface structure	discourse operations	Story elements	Low (3)

be formulated as a question of simply a mechanistic model with varying specifications, nor can the process be interpreted as some form of reinforcement-contingency system. What is happening is clearly subject to both genetic and environmental control. What remains to be determined is the exact nature of both the genetic and environmental influences, as they operate to control the outcome of the child's language development.

APPENDIX A

HYPOTHESES

HYPOTHESES RE MECHANISMS OF ACQUISITION

<u>One</u>

This hypothesis suggests that cultural input, once entered, becomes an invariant element of the genetically developed system.

Assume, at this point, that human biological adaptation is such that all men are equipped with (1) built-in vocomotor adaptation in the physiology and morphology of speech production and perception (which, in terms of Russian research, would also include speech control of affective and motor functions), and (2) a semiotic function --for which Lenneberg argues stating that "the cognitive function underlying language consists of an adaptation of a process of categorization and extraction of similarities." Then it may be theorized that language is the culturally adaptive link between the two biological systems, a link which once made becomes invariant.

Thus language acquisition would be an interactive process by which a cultural adaptation serves to "knit together" two separate genetically built-in systems. This link may occur very early in the child's development. Deaf children continue to babble exactly the same as hearing children until the age of six to eight months. At this point deaf children's sound production diminishes and children who can hear begin to produce sounds in relation to phonemes. It may be at this point that the linkage begins to be triggered, and sounds begin to be stored in comparative units. For the deaf child this situation becomes one of a developmental option not taken. (However, it may be assumed that the 'semiotic function' continues to develop.) The option may be taken later, but, according to Lenneberg, not later than prepuberty, which he suggests as the last possible time at which language acquisition can take place.

Overall, this hypothesis supports the concept of differential speech functions. For if language is not totally built-in, not in terms of a LAD or language acquisition device genetically evolved only for language (McNeill, 1966), or in terms of specific language universals, but is a learned system, whose only universal function is to link two built-in systems, then different cultures, adapting to different environments (as well as different groups within a culture adapting to different social needs) will in course establish language systems which operate through differing functions.

Such functions in fact constitute a code associated outcome of the linkage. Furthermore, these functions would not be 'external': if language does link unit processing systems with an affective-motor system, the active integration of these two through language acquisition might lead to

(1) Slightly different systems of memory storage, as well as (2) some modification of patterns of secondary processing. Then too, different languages employing different speech functions might actually affect different balance between the two biological systems.

However interesting this hypothesis may appear, there is insufficient information on the existence and nature of speech functions, and the semiotic or cognitive-comparative, and vocal-motor systems remain hypothetical. Furthermore, important neurophysiological and biochemical information, as well as necessary conditions for empirical testing are presently unobtainable.

Two

A second hypothesis is the idea that biological and cultural adaptation affect different and distinct aspects of a perceived invariant process. As according to Lorenz, if behavior could only be broken up into appropriately defined units, it would then be possible to unequivocally determine which units in a given piece of behavior were wholly innate and which units were developed through learning (Lorenz, 1965). The result of such an analysis of behavior would be a chain of innate and learned elements.

Thus if Hypothesis One--that every piece of language behavior is seen as a function of a matched pair of genetic

(G) and cultural (C) factors--is represented as f (GC), then Hypothesis Two would read f (G), f (C), and so on.

There are two problems with this hypothesis. The first problem is the idea of obtaining some absolute delimitation of elements in language behavior. The second is the idea of testing for complete heritability or complete environmental effects on these bits or units of behavior. Of course, the specific type of language code might be considered as a learned unit. Since different cultural languages differ, and children of one culture brought up in another can learn the other culture's language, it appears 'referential sounds' are learned. And furthermore, the physiology of mechanisms for the production of speech appear to be innate. Despite this learned-code innate-morphology distinction, it seems that very little can be determined to be concretely innate or specifically learned. The fact of first word onset may be a more-than-less innate process, and the nature of early syntax may be a more-than-less learned process but this is as definitive as can be discerned within the framework of the hypothesis, given present behavioral and genetic information.

<u>Three</u>

Another possibility is that a limited number of physiologically built-in mechanisms such as the morphology of speech production, audition, and neural storage provide constraints for cultural adaptations which are free to vary within the general genetic distribution of such constraints. Here language behavior would be seen as having a culturally and individually varied range of expression within the limits of memory, sound production, sound perception processing and the like.

As opposed to Hypothesis Two, this hypothesis does not suggest that two general mechanisms are built-in, nor does it suggest that any built-in mechanisms are invariantly or developmentally linked by means of an external or cultural adaptation such as language.

Four

This hypothesis may be broadly called the "Russian Hypothesis." In this theory neural connections and neurophysiological processes in the CNS are over-determined by means of a particular type of cognition called inner speech (which constitutes the second signaling system in Russian theory, and itself is created by means of naturally occurring developmental conditioning of the child by adults). Says Luria in Cole and Maltzman (1969):

> "Soviet psychology holds that higher forms of reflection, which are expressed in active, voluntary and conscious forms of activity, are the result of the work of the brain as manifested in social conditions, and are not inherent properties of the mind. Soviet psychology conceives of mind as the product of social life and treats it as a form of activity which was earlier shared by two people (that is, originated in communication), and which only later, as a result of

> mental development, became a form of behavior within one person. In the first stage of development some action may be carried out by the child on command by an adult. Later, having mastered this social stimulation and transformed it into a mode of behavior, the child begins to carry out this action according to his own command. In the first stages of development the attention of the child is organized by the adult with the aid of a gesture or by naming an object. As a consequence, the child develops the ability independently to organize this attention by a similar method, which then becomes voluntary. Complex forms of conscious activity ("higher psychological functions") are least of all initial "properties" of mental life or inherent qualities of the brain. They are functional systems formed by the social experience of the child. An essential role in this formation is played by speech, which is the basic means of communication and which serves as the basis for the second signal system. The second signal system represents "the new principle of nervous activity" and serves as the "higher regulator of behavior." (Soviet Psychology, pp. 143-144.)

Clearly, in Soviet psychology socio-cultural communication conditioning determines not only language development, but through language, determines the process of cognition.

Albeit these hypotheses provide exciting considerations, the present research has been preliminary to the testing of any complex hypotheses.

APPENDIX B

BLOOD-GROUPING RESULTS

TABLE A

RESULTS OF ANTISERA BLOOD GROUP ANALYSIS

		M	N	S	s	D	C	E	c	e	Le^a	Le^b	K	k	Fy^a	Fy^b	Jk^a	Jk^b	Yt^a	Gy^e	Mf		Du
1.a	B	+	+	+	-	+	+	-	-	/	+	/	-	+	+	+	+	+	+	+	-		
1.b	B	+	+	+	-	+	+	-	-	/	+	/	-	+	+	+	+	+	+	+	-		
2.a	O	-	+	-	+	+	+	-	+	/	+	/	+	+	-	+	+	-	+	+	-		
2.b	O	-	+	-	+	+	+	-	+	/	-	+	+	+	-	+	+	-	+	+	-		
3.a	A_2	+	+	-	+	+	+	-	-	/	+	-	-	+	-	+	+	+	+	+	-		
3.b	O	+	-	+	+	+	-	+	+	+	-	+	-	+	-	+	-	+	+	+	-		
4.a	B	+	-	+	+	-	+	-	+	/	-	-	-	+	+	+	+	-	+	+	-		-
4.b	B	+	-	+	+	-	+	-	+	/	-	-	-	+	+	+	+	-	+	+	-		-
5.a	O	+	-	+	-	+	+	-	+	/	+	/	-	+	-	+	+	+	+	+	-		
5.b	O	+	-	+	+	+	+	-	+	/	+	/	-	+	-	+	+	+	+	+	-		
6.a	A_2	+	+	-	+	+	+	-	+	/	-	+	-	+	-	+	-	+	+	+	-		
6.b	A_2	+	+	-	+	+	+	-	+	/	-	+	-	+	-	+	-	+	+	+	-		
7.a	A_1B	+	-	+	+	+	+	-	+	/	*	*	-	+	+	+	*	*	+	+	*		
7.b	A_1B	+	-	+	+	+	+	-	+	/	*	*	-	+	+	+	*	*	+	+	*		

TABLE A (continued)

RESULTS OF ANTISERA BLOOD GROUP ANALYSIS

		M	N	S	s	D	C	E	c	e	Le^a	Le^b	K	k	Fy^a	Fy^b	Jk^a	Jk^b	Yt^a	Gy^a	Mt
8.a	O	-	+	-	+	+	-	-	+	+	-	+	-	+	-	+	+	+	+	+	-
8.b	O	-	+	-	+	+	-	-	+	+	-	+	-	+	-	+	+	+	+	+	-
9.a	A_1	+	-	+	+	-	-	-	+	+	-	+	-	+	+	+	+	+	+	+	-
9.b	A_1	+	-	+	+	-	-	-	+	+	-	+	-	+	-	+	+	+	+	+	-
10.a	O	-	+	+	+	+	+	-	+	/	+	/	-	+	-	-	+	-	+	+	-
10.b	O	-	+	+	+	+	+	-	+	/	+	/	-	+	-	-	+	-	+	+	-
11.a	O	+	+	-	+	+	+	-	-	/	-	+	-	+	-	-	-	+	+	+	-
11.b	O	-	+	-	+	+	+	-	+	/	+	/	-	+	+	+	+	+	+	+	-
12.a	O	-	+	+	+	+	+	-	+	/	-	+	-	+	+	+	+	-	+	+	-
12.b	O	+	+	*	-	+	+	-	+	/	-	+	-	+	-	-	+	-	+	+	-
13.a	O	+	+	+	+	+	-	+	+	+	-	+	-	+	+	+	+	+	+	+	-
13.b	O	+	+	+	+	+	-	+	+	+	-	+	-	+	+	+	+	+	+	+	-
14.a	A_2	+	-	-	+	+	+	-	+	/	-	+	-	+	+	+	+	-	+	+	-
14.b	B	+	-	-	+	+	+	-	+	/	-	+	-	+	-	+	+	-	+	+	-
15.a	AB	+	+	-	+	+	+	-	+	/	-	+	-	+	+	+	/	+	+	+	-
15.b	AB	+	+	-	+	+	+	-	+	/	-	+	-	+	+	+	/	+	+	+	-
16.a	A_1	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	-
16.b	A_1	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	-
17.a	O	+	+	-	+	+	+	-	+	/	+	/	-	+	+	+	+	+	+	+	-
17.b	O	+	+	-	+	+	+	-	+	/	+	/	-	+	+	+	+	+	+	+	-

TABLE B

RESULTS OF PRIVATELY CONDUCTED
BLOOD GROUP ANALYSIS

Twin Pairs	Blood Group Tests Run
20.A	AB Rh positive
20.B	O Rh positive
21.A	O Rh negative
22.B	A Rh positive

APPENDIX C

MEANS, STANDARD DEVIATIONS
AND RANGES FOR RAW SCORES
ON TWENTY-THREE MEASURES

TABLE C

MEANS, STANDARD DEVIATIONS AND RANGES FOR
TOTAL RAW SCORES ON 23 MEASURES

Measures	All Subjects		
	Mean	Standard Deviation	Range
PPVT	25.17	9.64	9-42 (33)
S-B Vocab.	12.12	2.85	5-17 (12)
M1 Vocab.	25.29	3.78	16-33 (17)
M4 Morphology	3.93	1.67	0.0-7 (7)
Berko	9.45	6.35	0.0-25 (25)
Harvard	50.26	12.86	1-72 (71)
Osser	3.14	3.73	0.0-12 (12)
M6	8.02	4.13	0.0-17 (17)
Osser MT	3.52	2.66	0.0-10 (10)
Story MT	1.42	1.96	0.0-6 (6)
M6 MT	5.07	2.85	0.0-12 (12)
M4 MT	4.88	1.60	0.0-8 (8)
Osser Insertions	8.02	7.03	0.0-27 (27)
M6 Insertions	6.88	6.08	0.0-30 (30)
Osser Deletions	21.26	15.68	1-64 (63)
M6 Deletions	19.98	17.71	0.0-65 (65)
Osser Verbs Correct	9.33	4.95	1-16 (15)
Story Verbs Correct	5.37	3.80	0.0-14 (14)
M6 Verbs Correct	13.24	5.58	0.0-22 (22)
Story Words	37.2	21.92	0.0-100 (100)
Story Utterances	6.55	3.69	0.0-15 (15)
Story Personal Pr.	3.23	3.01	0.0-11 (11)
Child's MLU	5.90	2.49	0.0-13.3 (13.3)

TABLE D

MEANS, STANDARD DEVIATIONS AND RANGES FOR
MZ RAW SCORES ON 23 MEASURES

Measures	MZ Twin Pairs		
	Mean	Standard Deviation	Range
PPVT	24.77	10.31	9-42 (33)
S-B Vocab.	11.73	3.25	6-17 (11)
M1 Vocab.	25.14	3.93	17-33 (16)
M4 Morphology	4.18	1.33	1-6 (5)
Berko	10.76	6.07	3-25 (22)
Harvard	53.5	10.00	30-72 (42)
Osser	3.36	4.37	0.0-12 (12)
M6	8.64	4.34	2-17 (15)
Osser MT	3.18	2.84	0.0-9 (9)
Story MT	1.75	2.07	0.0-6 (6)
M6 MT	4.82	2.87	0.0-12 (12)
M4 MT	4.91	1.38	2-8 (6)
Osser Insertions	6.96	6.16	0.0-21 (21)
M6 Insertions	5.14	5.13	0.0-20 (20)
Osser Deletions	22.55	17.55	1-64 (63)
M6 Deletions	17.86	18.13	0.0-62 (62)
Osser Verbs Correct	9.45	4.93	2-16 (14)
Story Verbs Correct	4.90	3.77	0.0-11 (11)
M6 Verbs Correct	14.73	5.29	6-22 (16)
Story Words	36.7	22.37	10-83 (73)
Story Utterances	5.85	3.05	3-15 (12)
Story Personal Pr.	3.65	3.35	0-11 (11)
Child's MLU	6.4	1.92	3.3-10.1 (6.8)

TABLE E

MEANS, STANDARD DEVIATIONS AND RANGES FOR
DZ RAW SCORES ON 23 MEASURES

Measures	DZ Twin Pairs		
	Mean	Standard Deviation	Range
PPVT	25.60	9.10	9-42 (33)
S-B Vocab.	12.55	2.33	5-15 (10)
M1 Vocab.	25.45	3.69	16-33 (17)
M4 Morphology	3.65	1.98	0.0-7 (7)
Berko	8.55	6.38	0.0-20 (20)
Harvard	46.7	14.87	1-64 (63)
Osser	2.90	2.95	0.0-8 (8)
M6	7.35	3.88	0.0-14 (14)
Osser MT	3.90	2.47	1-10 (9)
Story MT	1.10	1.83	0.0-6 (6)
M6 MT	5.35	2.87	2-12 (10)
M4 MT	4.85	1.84	0.0-8 (8)
Osser Insertions	9.0	7.86	0.0-27 (27)
M6 Insertions	8.8	6.58	0.0-30 (30)
Osser Deletions	19.85	13.66	3-50 (47)
M6 Deletions	22.3	17.39	1-65 (64)
Osser Verbs Correct	9.20	5.10	1-16 (15)
Story Verbs Correct	5.85	3.87	0.0-14 (14)
M6 Verbs Correct	11.6	5.55	0.0-19 (19)
Story Words	37.7	22.04	0.0-100 (100)
Story Utterances	7.25	4.20	0.0-15 (15)
Story Personal Pr.	2.80	2.65	0.0-8 (8)
Child's MLU	5.44	2.94	0.0-13.3 (13.3)

APPENDIX D

MEHRABIAN MEASURES

ALBERT MEHRABIAN'S

MEASURES OF CHILDREN'S VOCABULARY AND GRAMMATICAL SKILLS

VOCABULARY AND GRAMMAR TESTS

Test 1: Picture Vocabulary

	Materials: The following pictures, each in a set of four, were shown one set at a time.		Procedure: The subject is asked to point out the:
	Set 1.	tree, ball, muscle, mitten	bell
	Set 1.		tree
	Set 2.	horse, tiger, pony, key	horse
	Set 2.		key
(.36)	Set 3.	hat, foot, coat, telephone	hat
(.36)	Set 3.		telephone
(.36)	Set 4.	Airplane, umbrella, flag, boat	airplane
(.36)	Set 4.		flag
(.19)	Set 3.		foot
(.07)	Set 3.		coat
(.29)	Set 4.		boat
(.30)	Set 4.		umbrella
(.35)	Set 5.	leaf, butter knife, brush, crayon	leaf
(.38)	Set 5.		butter knife
(.43)	Set 2.		pony
(.25)	Set 5.		brush
(.28)	Set 5.		crayon
(.56)	Set 1.		muscle
(.34)	Set 6.	magazine, newspaper, notebook, check	newspaper
(.27)	Set 7.	table, chair, desk chair, coffee table	desk chair
(.53)	Set 8.	pocket knife, cane, coin, tack	cane
(.49)	Set 9.	truck, trailer, tractor, jeep	tractor
(.25)	Set 10.	pitcher, petal, shade, shutter	pitcher
(.24)	Set 1.		mitten
(.30)	Set 2.		tiger
(.34)	Set 8.		coin
(.55)	Set 9.		trailer
(.28)	Set 6.		notebook
(.20)	Set 10.		shutter
(.38)	Set 10.		petal
(.39)	Set 8.		tack
(.34)	Set 7.		coffee table
(.35)	Set 10.		shade
(.38)	Set 8.		pocket knife
(.26)	Set 6.		check

Test 2: Comprehension of Simple Commands

Materials: Book, box, pencil, and string
Procedure: The subject is given the following instructions.

(.65) 1. Put the box on the book.
(.35) 2. Put the book on the box.
(.41) 3. Put the pencil on the box.
(.40) 4. Don't put the book on the pencil.
(.57) 5. Put the pencil on the book.
(.67) 6. Put the book on the pencil.
(.70) 7. Put the box on the pencil.
(.57) 8. Put the string and the pencil on the book.
(.41) 9. Put the string on the box and the book.
(.37) 10. Put the string, but not the book or the pencil, in the box.
(.59) 11. Put the string on the box and the pencil, but not on the book.
(.66) 12. Put the box, but not the pencil, on the book.
(.44) 13. Put the box, pencil, and string together.

ALBERT MEHRABIAN'S

MEASURES OF CHILDREN'S VOCABULARY AND GRAMMATICAL SKILLS

Test 3: Comprehension of Meaningless Commands

Materials: Ball, box, string, chair, table
Procedure: These items are to be given as commands to the subject. For each pair, the critical command is the second one. Thus, the first command is used only to induce a set. If the subject fails to carry out the first command in a pair, the tester performs the act, and next requests the subject to do it. If the subject does not respond on repetition of the first command, then he is assigned a score of 0. On the other hand, if the subject obeys the first command in a pair correctly, then the tester gives the second command. If the subject responds to the second command by saying, "It's too hard," "I can't do that," or laughs, he is given a score of 1; otherwise he is given a score of 0.

(.81) 1. Put the ball on the table; put the table on the ball.
(.83) 2. Put the box on the chair; put the chair on the box.
(.89) 3. Drop the box on the floor; drop the floor on the box.
(.86) 4. Put the box on the floor; put the floor on the box.
(.86) 5. Put your hand on the window; put the window on the hand.
(.78) 6. Put your arm around your waist; put your waist around your arm.
(.67) 7. Tie the string around the box; tie the box around the string.
(.61) 8. Put the ball into the box; put the box into the ball.

Test 4: Inflection

This test is a modified version of one of the ITPA tests. Procedure: The experimenter says each item while pointing to the appropriate object or event in the accompanying set of stimuli for this test. In reading the item, the experimenter leaves out the parenthetical phrase which is the correct answer.

Item	Examples of incorrect responses
(.35) 1. This is a block; here are two (blocks) (of them).	block
(.50) 2. The bird can fly; the bird is (flying).	flies, flew, flown
(.54) 3. The girl will tie a ribbon; now the ribbon has been (tied).	tie, ticing
(.58) 4. Here is a toy; here are many (toys) (of them).	four, toy
(.43) 5. This is a leaf; here are some (leaves).	leafs, leaffy, tree
(.63) 6. All these trees are big, but this tree is the (biggest).	bigger, taller, more big
(.44) 7. Here is a man; here are some (men).	mans, daddy, boys
(.37) 8. The ball is big; this ball is even (bigger).	big, more big, little, red
(.31) 9. Mother will write a letter; the letter has been (written).	writted, all done
(.13) 10. These pencils look good, but this one looks the (best).	longer, gooder, red
(.10) 11. The girl is going to fall; now the girl has (fallen).	fell down, fell, falls

ALBERT MEHRABIAN'S

MEASURES OF CHILDREN'S VOCABULARY AND GRAMMATICAL SKILLS

Test 5: Judgment of the Grammaticalness of Sentences and Phases

Procedure: The subject is told "Tell me which one is better," and is then read the two statements of an item. If he repeats the more grammatical one or produces a more elaborate verbalization which includes the more grammatical phrase in the correct order, then he is given a score of 1; otherwise he is given a score of 0 for that item. In case the subject does not respond at all to the instructions, the tester repeats the instructions and the item twice more. Furthermore, if the subject gets a score of 0 on the first or second item, the tester says, "You would say 'how big' wouldn't you? So, 'how big' is better." Again, if the subject fails the second item, the tester says, "You would say 'so little' wouldn't you? 'So little' is better."

	Item	Correct sequence
(.23)	1. I no want the pencil; I don't want the pencil.	I don't want the pencil.
(.30)	2. I hungry; I am hungry.	I am hungry.
(.33)	3. Him tall; he is tall.	He is tall.
(.42)	4. I can't fly; I no can fly.	I can't fly.
(.25)	5. Jump you?; you jump?	You jump?
(.53)	6. He is happy; he happy.	He is happy.
(.35)	7. He walks; walks he.	He walks.
(.41)	8. Eat candy; candy eat.	Eat candy.
(.51)	9. How big; big how.	How big.
(.53)	10. Carry ball; ball carry.	Carry ball.
(.44)	11. Big apple; apple big.	Big apple.
(.58)	12. You sing?; sing you?	You sing?
(.40)	13. Is pretty; pretty is.	Is pretty.

Test 6: Verbal Imitation (Items for this test are taken from Menyuk, 1963.)

Procedure: The tester says, "I'm going to say some sentences for you. I want you to say just what I say. If I say 'The sun is shining,' I want you to say 'The sun is shining.' " If the correct response is obtained, the tester proceeds. If not, he says, "No, you say just what I say. If I say, 'The sun is shining,' you say 'The sun is shining.' " The tester reads the list of sentences with head bent over the list so that no visual cues can be obtained, and waits for the response of the child to each sentence. If a child does not respond at all to a sentence, one repetition of that sentence is given. If the child does not respond again, the next sentence is presented. No second repetition is made and the repetition is given only in the case of no response at all (Menyuk, 1963, p. 431).

	Item read to the child by the tester
	I want to play.
(.43)	Don't use my dough.
(.43)	He got tied up.
(.43)	There isn't any more.
(.57)	He isn't a good boy.
(.46)	I'm writing daddy's name.
(.53)	Where are you going?
(.48)	I see a red book and a blue book.
(.55)	He'll be good.
(.59)	I'll give it to you if you want it.
(.60)	David saw the bicycle and he was happy.
(.60)	He is not going to the party.
(.53)	You have to drink milk to grow strong.