FORMAL OPERATIONAL REASONING AND ITS RELATIONSHIP TO COMPLEX SPEECH PATTERNS AND TENTATIVE STATEMENT USE

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ABSTRACT

The primary purpose of the present investigation was to assess the relationship between a child's level of formal operational reasoning and characteristics of his spontaneous speech. The variables of specific concern were the mean length of T-units, a measure of linguistic complexity, and the frequency of use of tentative statements. Three different tasks of formal reasoning were employed to assess this relationship: a relatively language-free problem-solving task developed by Neimark and Lewis, the equilibrium in the balance task developed by Inhelder and Piaget, and a verbal task of formal reasoning developed by Weitz, Bynum and Thomas. A speech sample was collected from each subject on an individual basis by showing him three different photographs and asking him to explain what he saw in each. A total of 144 middle-class boys, 48 in each of grades 4, 6 and 8 served as subjects. All the boys' scores on the Raven's Progressive Matrices Test were above the minimum of the normal IQ range. The data for each grade separately were analysed in terms of both simple correlations and stepwise regression analyses. Both speech characteristics and formal operational reasoning were found to increase significantly across grade level. Very minimal support was evident for the contention that speech characteristics are related to formal reasoning ability. The results indicated that the mean length of T-units was not significantly related to any of the three reasoning tasks

at any of the three grade levels. In addition, a significant relationship between the frequent use of tentative statements and formal reasoning was evident only at the grade 6 level on two of the reasoning tasks. Results also indicated that the amount of language produced by the grade 4 children was significantly related to their performance on two of the reasoning tasks. Those language variables which were significantly related to formal reasoning ability tended to remain so when examined in the presence of the Peabody Picture Vocabulary IQ. The results generally support Piaget's contention that reasoning processes are independent of language.

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INTRODUCTION

The linguistic abilities of both children and adults have recently been the object of intensive investigation by numerous researchers of varying disciplines. While much of this research has been primarily concerned with developmental patterns and sociological variables, relatively little attention has been paid to the possible relationship between the use an individual makes of the grammatical elements of his language and his performance on either verbal or non-verbal problem-solving tasks. It is the purpose of the research outlined below to investigate the possible relationship between the linguistic patterns a child typically employs during spontaneous speech and his performance on complex cognitive tasks requiring logical formal operations.

A review of theory and previous research relevant to the present investigation will be presented under various headings. First, evidence concerning sociological and developmental differences in the grammatical complexity of individual speech patterns will be presented. Next, consideration will be given to evidence concerning individual and sociological differences in the use of expressions denoting uncertainty on the part of the speaker. Finally, the theoretical positions regarding the relationship between language and thought will be presented followed by a brief review of empirical investigations related to that relationship.

Individual Differences in Linguistic Patterns

That the frequency of usage of different linguistic structures varies from individual to individual has been reported by Bernstein (1962). In his analysis of the orally produced language of sixteen year-old boys during a discussion of capital punishment, he found clear differences between the linguistic structures used by the middle-class boys and those used by the working-class boys. The former group used a higher proportion of the egocentric sequence 'I think', of subordinate clauses, of complex verbal stems, of the passive voice and of uncommon adjectives and adverbs while the latter group used a higher proportion of the sociocentric sequence 'You know/see' and of personal and selected pronouns. From this evidence, Bernstein has proposed the existence of two distinct linguistic codes: one employed by the middle-class and characterized as 'elaborated' since it makes greater use of complex grammatical elements, and the other employed by the lower-class and characterized as 'restricted' since it makes less use of these complex elements. Subsequent research by other investigators has largely supported his findings. Rackstraw and Robinson (1967), Hawkins (1969) and Jones and McMillan (1973) have found that these differences exist in the oral productions of five year-old children while Lawton (1963, 1964) and Robinson (1965) report similar differences in both the oral and written language of groups of twelve and fifteen year-old boys. Williams and Naremore (1969), in their study of the oral productions of fifth and sixth graders during home interviews, found that the use of certain elaborated linguistic structures was more closely related to social class than to race. The existence of these two codes and their relation to social class then, appears to have been well established.

In addition to the evidence which relates the use of complex linguistic structures to social class is the evidence which relates the use of similar complex linguistic structures to age level. Loban (1963), in his study of the developmental changes in written and oral language during the elementary school years, noted that subordinate clauses were increasingly employed by a child as he passed from the early to the later grades. Similar findings have been reported by Hunt (1965) and O'Donnell, Griffin and Norris (1967). Hunt (1965) further refined Loban's (1963) measure of subordination into a measure he termed the T-unit. This unit he defines as "one main clause expanded at any of many different points by structures that are modifiers or complements or substitutes for words in the main clause." He concluded from his results that the length of a T-unit is closely tied to a child's age. While T-unit length may be a reliable indicator of age level alone, it should be noted that both Hunt (1965) and Loban (1963) also found that considerable differences existed on their measures within any one grade level. This finding demonstrates that while children's language becomes more complex as they mature, some children in any one age group are linguistically more mature than their peers.

The question concerning the availability of complex linguistic structures to the lower-class groups or the linguistically less mature groups is at present unclear. Bernstein (1970) stresses that the codes refer to performance and not competence in the Chomskian sense of these terms. "It is...important to point out that the codes refer to cultural not genetic controls upon the options speakers take up." (p. 7). Indeed, Robinson (1965b) has found that if lower-class members are placed in a situation which requires the use of a more elaborated code than they typically employ, in this case the composition of a formal letter, no significant differences in language use is found between them and their middle-class counterparts in the same task. Similarly, Heider, Cazden and Brown (1968) reported that no differences existed between middle and lower-class children in their respective abilities to decode the middle-class children's encodings of faces and abstract figures. Houston (1970) emphatically states that in the course of her research with children of varying social origins, she has been unable to detect any differences between the children in their ability to comprehend the language of middle-class adults in any situation. She equally stresses that the grammatical elements a child chooses in which to express himself depend in part on the situation at hand and in part on the habitual style of the child involved. In fact, most researchers agree that by the time a child reaches the age of five or six he has largely mastered the syntactic complexity of his language

(Menyuk, 1971). A pilot study recently conducted by the present writer to determine whether grade four children comprehend the syntactical structures not typically found in their written language, revealed that in fact these children have no difficulty in understanding them. Differences in the frequency of usage of various structures subsequent to their acquisition therefore becomes largely a matter of individual choice. One of the more interesting questions which follows from this evidence is the question concerning the consequences of the differences in frequencies of usage of various linguistic structures on the performance of other linguistic or nonlinguistic cognitive tasks.

Of particular interest for the present research is the finding by a number of researchers that considerable individual differences exist in the use of expressions denoting uncertainty. This type of statement may be formulated in a variety of ways. Bernstein's analysis has pointed to the egocentric sequence 'I think' as an expression denoting uncertainty on the part of the speaker. Loban (1963) includes the 'I think' sequence in his 'tentative statements' category and in addition includes such expressions as 'perhaps, unless, maybe' and conditional statements. He cites the following examples from his data:

It might be a gopher, but I'm not sure.
That, I think, is in Africa.
But maybe they don't have any dogs in Alaska.
I'm not exactly sure where that is. It looks

like it might be at school.

That's white grass - unless there's snow or the sun is reflecting.

Turner and Pickvance (1971), not entirely satisfied with Loban's category since its limits were not clearly defined, further subdivided expressions of uncertainty into the following classes: 1) egocentric sequences, 2) sociocentric sequences, 3) questions, 4) refusals, 5) assessments of possibility and probability, and 6) suppositions based on perception. These categories, they point out, were established on the basis that the children they studied actually made use of these types of expressions. They note that while other categories such as 'disjunctive' statements (e.g. There's a house or a church), 'conditional' statements (e.g. If it's got a hole in it, it's a guitar) and 'suppositions' (e.g. I suppose/bet/expect/guess) are also ways of making tentative statements, these types of statements rarely occurred in the speech of the five year-old subjects examined in their study. The possibility remains, however, that these categories may be more frequently employed in the language of older children and adults.

The major purpose of Turner and Pickvance's (1971) study was to determine the extent to which social class and verbal ability were related to the frequency and type of expressions of uncertainty used. They report that for the five year-old children studied, social class was most closely related to the use of egocentric sequences, certain types of questions, refusals, the assessment of possibility and suppositions based on perception and that the middle-class child used more of these expressions than the lower-class child. They also report that verbal ability was most closely related to the use of one kind of sociocentric sequence and certain types of questions. These results are not entirely in agreement with those of Loban (1963). In his examination of the written and oral language of elementary school children, he found that the use of the tentative statements he describes was most frequent in the high-language-ability group in all grades studied from grade three through grade six. Unfortunately, this finding is somewhat confounded by the fact that his high-language-ability group also tended to have a higher socioeconomic status than the low-language-ability group. The question concerning the extent to which the use of tentative statements is a function of either of these two variables is therefore not entirely clear. However, since both studies in question cited a relatively low frequency of these expressions, and with not all members of a group using them, it seems reasonable to assume that differences in the use of these expressions are to be found both within a social class as well as between social classes. This assumption should also hold in terms of the frequency of use within and between language ability groups.

In addition to the evidence concerning the frequency of use of these expressions, a note must be added concerning possible differences in the comprehension of these structures.

While it was stated earlier that children appear to have mastered the syntax of their language by the age of five or six, some direct evidence concerning that status of the expressions in question is available. Olds (1968) investigated the comprehension of a number of syntactical structures in children, among them conditionals, conditionals + not, conditional questions and expressions using 'should' and 'unless'. His results indicate that children as young as seven years of age have a well-developed comprehension of these structures with the exception of constructions employing 'unless'. He observed that the younger children especially tended to interpret this structure as an 'if' construction. In the light of this evidence, therefore, it seems safe to conclude that comprehension of these structures is not an important variable to consider in differences in their use and that usage merely reflects the options chosen by the individual speaker.

The antecedents of the use of expressions of uncertainty have received considerable attention in Bernstein's (1970) sociolinguistic theory. His theory explains these differences in terms of the socialization practices of the middle and lower-class members. He suggests that the forms of socialization typically employed by middle-class parents is an open, person-oriented system where the child is not assigned a constrained role but rather is given opportunities to develop his own role within the family structure. The middle-class child is encouraged to take part in the decisionmaking process within the family and consequently learns to clarify his reasoning and to justify his intentions and judgments. It is further suggested that these experiences create an awareness of uncertainty on the part of the child in certain areas of experience and consequently induce the child to be more flexible in his social orientation. To quote from Bernstein (1962) himself, "the orientation of the individual is based upon the expectation of psychological difference, his own and others." The lower-class child, on the other hand, is not given these opportunities to determine his own role and consequently makes considerably less use of these expressions since opportunities for their use are infrequently granted by the lower-class child's parents. Turner and Pickvance (1971) support Bernstein's theory and offer the following conclusion:

> "...the socialization procedures typically employed in middle-class families are likely to encourage the middle-class child to perceive reality in terms of more than one alternative, in terms of a range of possible interpretations. Further, these procedures may tend to create anxiety in the child, for not only is he made aware of a range of interpretations, he is also expected, to a certain extent, to make an individual choice from the range, and, further to choose correctly. These socialization procedures are, in our opinion, the main sociological antecedents of an orientation toward the use of expressions of uncertainty. They are thought to underlie the middle-class children's use of the egocentric sequence and also their use of other expressions of uncertainty." (p. 319).

In addition to his suggestions concerning the antecedents of the use of expressions denoting uncertainty, Bernstein (1961) also speculates on the consequences of the use of an 'elaborated' code of which these expressions form a part. He writes:

> "A formal (elaborate) language facilitates the verbal elaboration of subjective intent, sensitivity to the implications of separateness and difference, and points to the possibilities inherent in a complex conceptual hierarchy for the organization of experience." (p. 292).

Robinson and Rackstraw (1967) arrive at a similar conclusion when they write: "Egocentric sequences show an awareness of points of view other than one's own and, hence, imply an objective frame of reference." Loban (1963) while making no speculations concerning the antecedents of the use of tentative statements, makes a strong statement concerning the consequences. He postulates that:

> "The child with less power over language appears to be less flexible in his thinking, is often not capable of seeing more than one alternative, and apparently summons up all his linguistic resources merely to make a flat dogmatic statement." (p. 54).

The opinion of these researchers appears to be that children who make relatively infrequent use of tentative statements also are subject to a cognitive deficit in so far as their orientation to the nonlinguistic world is concerned. Specifically, the expressed opinion implies that such children would have difficulty in dealing with cognitive problems which require the ability to think in terms of alternatives to successfully arrive at the correct solution.

<u>Language and Thought</u>

The proposition that linguistic performance may be related to thought processes is strongly supported by some researchers and equally strongly denied by others. Piaget in particular emphatically denies the hypothesis that language is related to cognition in any relevant way and maintains the position that language is primarily a matter of social communication and is unnecessary for any stage in the development of logical thought. This position is clearly outlined by the following quotations:

> "...the role of language seems to consist... in stimulating general intellectual activity and in facilitating social mobility rather than in bringing about the structures of operations." (Piaget, as quoted in Furth, 1971, p. 63).

and

> "Logical relations are, first and above all, operational structures. Although their most advanced forms are certainly expressed by language, their origins are found in the coordination of the subject's own actions." (Piaget, 1968).

Empirical support for Piager's theory comes not only from his own research and that of his colleagues in Geneva (e.g. Sinclair-de-Zwart, 1969), but also from the work of researchers elsewhere. Of particular relevance to his position are the results of studies investigating the cognitive capacities of deaf children and adolescents. Furth (1971a), in an article reviewing both his own research with the deaf and that of others, observed that little difference existed between deaf and hearing children in their performance on a wide variety of tasks. He noted that the results of the thirty-nine investigations conducted between 1964 and 1969 suggest that performance of deaf children on tasks requiring rule-learning, requiring the use of logical symbols, on Piaget-type tasks, on memory tasks and on perceptual tasks is comparable to the performance of hearing children. In the few cases where the younger deaf children demonstrated some retardation in their performance, he notes that their performance had caught up to that of the hearing children by the age of 15-16. In summary, he points out that the performance of deaf children does not substantially differ from that of hearing rural children. In view of this evidence, Furth suggests that the deficit in the deaf children's performance which exists when they are compared to urban hearing children is likely a result of differences in experience and test attitudes. In a subsequent study of formal operational reasoning ability in deaf adolescents, Furth (1971b) noted that 28% of the deaf sample demonstrated formal operatory success compared with 58% of the rural hearing sample and 75% of an urban hearing sample. He concluded that since some of the deaf children were successful at the tasks, language cannot be considered a necessary condition for the achievement of formal operational reasoning.

Further evidence concerning the independence between language and thought is supplied by the research of Sinclair-de-Zwart (1969). In a series of experiments, she attempted to teach young children who were unable to conserve volume the grammatical expressions used by the children who were able to do so. She found that these children had great difficulty learning the use of the comparatives 'more' and 'less' and even greater difficulty learning to use the co-ordinated expressions 'long and narrow' and 'short and fat'. Of the children who did learn the appropriate use of these expressions, only 10% were subsequently successful at conservation tasks. She concludes from these results that "Verbal training does not ipso facto bring about the acquisition of operations" and that "...language is not the source of logic, but on the contrary is structured by logic".

A contrasting opinion concerning the relationship between language and thought is offered by Vygotsky (1962). He views language as a dominating influence on thought once language has developed. Vygotsky suggests that while language and thought develop independently during the first few years of life, once the rudiments of language have been acquired, language "increasingly serves problem-solving and planning as the child's activities grow more complex." He has found that when a child reaches the stage of intellectual development at which he experiments with the physical properties of the world around him, his speech is characterized by "...the correct use of grammatical forms and structures before the child has understood the logical operations for which they stand...He masters the syntax of speech before the syntax of thought." Vygotsky concludes that it is the speech structures mastered by the child as he matures that become the basic structures of his thinking. Luria (1959) supports this position and claims that as a child acquires a language system, he must reorganize his thought processes as the language system develops.

Another approach to the relation between language and cognitive processes comes from the disciplines of philosophy and anthropology. The question that has been posed asks whether the lexicon and syntax of the particular language a speaker uses affects his perceptions and interactions with his world in a different manner than if he spoke another language. This is essentially the linguistic-relativity hypothesis expounded by Whorf (as cited in Carroll, 1964 and Cazden, 1972). While his theory deals specifically with the use of discreetly different languages, his theory could reasonably be extended to incorporate subcultural differences within a particular language. Little empirical evidence has been obtained to date to substantiate Whorf's hypothesis. However, should cognitive differences exist in individuals employing different linguistic codes as described above, some support for his theory might be established subculturally.

Linguistic Patterns and Cognitive Development

If the differential use of tentative statements does indeed lend itself to greater cognitive flexibility as suggested by several of the authors cited, then one stage in cognitive development where such an effect might be most clearly demonstrated would be in the stage of formal operations outlined by Piaget. Piaget describes the development of the intellect as a succession of qualitatively different stages through which a child passes from infancy through adolescence.

These stages are discreetly different from one another in terms of the behaviour manifested at any one stage and a child passes through these stages in an invariant order. While this sequence always remains fixed, Piaget points out that these stages of development are not to be confused with age level since considerable individual differences exist in terms of the age at which any particular stage has been attained. At birth, the infant commences with the sensori-motor stage and as he matures passes into the concrete operational stage, then the pre-operational stage, and finally, at some point during his adolescence, into the formal operational stage.

This final stage, the formal operational stage, as formulated by Piaget and Inhelder (1958), is chiefly characterized by the ability on the part of the adolescent to determine not only what is real, but also, and this is the crucial aspect of formal operations, to determine what is possible. A quote from Flavell (1963) best explains this major difference between pre-operational and formal operational thought.

> "Unlike the concrete operational child, the adolescent begins his consideration of the problem at hand by trying to envisage all the possible relations which could hold true in the data and then attempts, through a combination of experimentation and logical analysis, to find out which of these possible relations do in fact hold true. Reality is thus conceived as a special subset within the totality of things which the data would admit as hypotheses; it is seen as the 'is' portion of a 'might be' totality, the portion it is the subject's job to discover." (p. 204).

The adolescent, then, approaches a problem in a qualitatively different way than a concrete or pre-operational child. He uses the results of these previous periods, i.e. the classifications, seriations and correspondences previously acquired, but now he is able to form these elements into propositions and to combine these propositions such that all the possible outcomes may be considered. This approach to problem-solving would appear to require a considerable amount of cognitive flexibility to determine all the possible relevant variables and the relations among them to arrive at a successful solution. If the ability to detect alternatives is the major component of formal operations, it would be of interest to determine whether children who habitually use language to express the possible existance of more than one point of view are also more successful at tasks requiring detection and consideration of alternatives for their solution.

Few studies have been reported concerning the relationship between an individual's characteristic speech pattern and his performance on either verbal or nonverbal cognitive tasks. One such study of six year-old girls is reported by Robinson and Creed (1968). Using a group of high IQ and low IQ subjects who had been participating in a language training programme for one year, they found that while IQ was a significant predictor of perceptual discrimination abilities, the 'elaborate' code users within the low IQ group also showed superior perceptual discrimination abilities when compared to the 'restricted' code users in that group. In addition, when they investigated these same children with respect to their abilities to verbalize perceptual differences, they again found that while IQ was a significant predictor, the 'elaborate' code users within the low IQ group performed significantly more effectively than the 'restricted' code users in this group.

The effects of differing language structures on cognitive growth have also been investigated by Greenfield (1973) in a cross-cultural context. She found that unschooled children who spoke Wolof but who had not learned to write Wolof or any other language were less able to classify objects according to more than one attribute when more than one classification was possible than the schooled children who had learned to write a language. The unschooled children were also unable to answer the question "Why do you think these objects are alike?" but had no difficulty responding to the question "Why are these things alike?" The schooled children did not have any difficulty responding to the former question. Greenfield (1973) attributes this difference to an inability on the part of the unschooled child to adopt differing 'points of view'.

Greenfield also found that the unschooled children expressed their reasons for superordinate groupings by single words (e.g. "red"), while the schooled children used predications (e.g. "This is red; those are red"). The former response is a situation dependent one while the latter is more abstract. She speculates that these differences in the responses between the two groups of children are due in part to the children's ability to write a language.

> "Writing is practice in the use of linguistic contexts as independent of immediate reference. Thus, the embedding of a label in a total sentence structure (complete linguistic predication) indicates that it is less tied to its situational context and more related to its linguistic context. The implications of this fact for manipulability are great: linguistic contexts can be turned upside down more easily than real ones. Once thought is freed from the concrete situation, the way is clear for symbolic manipulation and for Piaget's stage of formal operations, in which the real becomes a subset of the possible (Inhelder and Piaget, 1958)."

Greenfield suggests that a similar context dependency in speech may exist subculturally and may be associated with similar effects on cognitive growth. A study by Jones (1972) is more directly relevant to the question of the effects on problem-solving of differential use of tentative statements. She employed two groups of twelve year-old boys matched on IQ but discrepent in verbal ability. The high-verbal boys used significantly more tentative statements than did the low-verbal ones. Nevertheless, she found no differences between the two groups in their performance on nonverbal tasks of formal operations. Both groups reached the same stage of formal operations regardless of linguistic patterns employed. However, since the stage these groups had attained was not the highest level of formal operations as described by Piaget, the possibility remains that a difference in performance between two such groups may be detected at a later age. In addition, it may be that the use of a linguistic code associated with more frequent use of expressions of uncertainty exerts an influence only on these tasks if they are linguistically presented. These two hypotheses, one concerning the possible facilitory effect of a particular linguistic pattern on nonverbal tasks of formal operations and the other concerning the possible facilitory effect of a particular linguistic pattern on verbal tasks of formal operations, will be the major hypotheses to be investigated in the present research.

PROCEDURE AND EXPERIMENTAL DESIGN

Aims of Study

The primary purpose of the present investigation was to assess the relationship between a child's level of formal operational reasoning and characteristics of his spontaneous speech. The variables of specific concern were the mean length of T-units, a measure of linguistic complexity, and frequency of use of tentative statements. Both verbal and nonverbal forms of operational reasoning tasks were employed to investigate this relationship across grades 4, 6 and 8.

Subjects

A total of 144 subjects were selected from two schools under the Roman Catholic School Board of St. John's, Newfoundland. Forty-eight subjects were selected from each of grades 4, 6 and 8. This age range, from approximately 10 years to approximately 14 years, was considered appropriate to determine whether, as a child progresses from the concrete to formal reasoning stage, any facilitory effects of linguistic patterns are operating.

The children in the sample were selected with the following constraints:

1. No child in the sample obtained a scaled IQ score lower than 80 on the Raven's Progressive Matrices Test. This precaution was taken to ensure that all the children in the sample were at least within a normal IQ range.
2. No child in the sample came from a socioeconomic level lower than 30.00 as measured by the Blishen Socio-Economic Index for Occupations in Canada (Blishen, 1967). This scale has a mean of 35.58 and standard deviation of 10.74 for the Newfoundland sample. The cut-off point of 30.00 resulted in only the highest 53% of the occupations being included in the sample. This constraint was imposed to minimize the effect of social class on the tasks to be presented.
3. All the children in the sample were boys. It was decided to investigate only one sex in view of the large number of subjects to be tested, and, since Loban's (1963) research had indicated that boys' speech patterns tended to be more variable than that of girls', boys were chosen for the present investigation. It should be pointed out that while no sex effects have been found with respect to formal reasoning skills (O'Brien and Shapiro, 1968), it may be possible that

the language skills of girls interact differently with formal reasoning than they do for boys so that the results of the present study must be interpreted cautiously with respect to girls.

4. None of the children in the sample had failed any grade. This precaution was taken to ensure that all the children at each grade level had had similar educational backgrounds and were progressing through school at the normal rate.

A description of the sample with respect to the means and standard deviations of the Raven's IQ, age and SES variables is presented for each grade in Appendix B.

Order of Task Administration

The data collection proceeded for a period of four months from February 1973 to June 1973. The collection of data on each task was completed for all subjects before subsequent tasks were presented and proceeded in the following order:

1. The Raven's Progressive Matrices Test was administered to several class groups at each grade level. In one of the schools employed, the Vice-Principal had administered this test two weeks previous to the time that the present experimenter gained access to this school so that it was decided to use the scores obtained from his administration. In the second school, this task was supervised by the present researcher. In both cases, the test was administered to groups of approximately 30 subjects with no time limit imposed. The raw score of each subject was then transformed to a

scaled IQ score based on norms established several years previously for 3,000 school children in the St. John's area. On the basis of these scores, subjects inappropriate for selection were eliminated.

2. The Peabody Picture Vocabulary Test was then administered individually to each subject selected for the final sample. The purpose of this test was to provide a 'traditional' estimate of each child's verbal intelligence in order to compare its effectiveness in predicting formal reasoning ability with the effectiveness of the present measures employed: the mean T-unit length and the frequency of use of tentative statements.

3. During the same session, after the Peabody Picture Vocabulary Test had been administered, a speech sample was obtained from each subject following a procedure to be detailed below. The entire session lasted approximately 20-30 minutes.

4. A problem-solving task developed by Neimark and Lewis (1967) was then administered, again on an individual basis, with each session lasting from 30-60 minutes.

5. The Equilibrium in the Balance task developed by Inhelder and Piaget (1958) was then administered, individually, with sessions lasting from 10-20 minutes.

6. A task developed by Weitz, Bynum and Thomas (1971) was the final task presented. This task was administered on a group basis with 20-30 subjects per group and was untimed. Subjects required from 20-50 minutes to complete the task.

Instrumentation

Procedure and materials used to obtain speech samples. To assess a child's linguistic code, Turner and Pickvance (1971) employed two different tasks to obtain the speech sample required for analysis. In the first task, the child was given three sets of four pictures each, each set comprising a short story. The child was then requested to verbalize the story in his own words to the experimenter. In the second task, the child was given three picture postcards, one at a time, of paintings by Trotin, and asked to describe what was taking place in each picture. Loban (1963) used a similar task to this latter one, employing six pictures rather than three, and encouraged the child to report what he saw in each one.

For the present research, a similar technique was employed. Three large colour photographs were presented one at a time to each child. These photographs were selected from a series of educational photographs intended for group discussions in elementary schools compiled by Owen (1972, photographs 1B/15, 1B/16, 1B/17). The first photograph showed two young boys sitting at a table covered with books and papers. A man who is likely their father is standing behind one of the boys, speaking to him and pointing to something in one of the books. The second photograph was of a young Indian boy and a very old Indian man with long white hair and a long white beard, sitting in front of what appears to be a handicraft shop. The old man is talking to the young boy and the young boy is taking notes on a small pad with a pen. The last photograph showed a young boy and a middle-aged man, both holding wrenches, attempting to repair the boy's broken bicycle. It was hoped that, since these photographs all pictured young boys engaged in familiar activities, the boys in the sample would have no difficulty in discussing what was taking place in each one.

Before taping was begun, the experimenter greeted the subject, asked him to come and sit beside her at a table and told him that he was to be shown three pictures and that he was to describe what he saw in each one. During the showing of the photographs, the experimenter interfered with the child's speech production as little as possible by only encouraging the child when speech had stopped. The experimenter never asked specific questions about the photographs and limited questioning to phrases such as "What else do you see in the picture? What else is happening in the picture? Can you tell me anything more about the picture?" Each interview was recorded on tapes which were subsequently transcribed for analysis.

It should be noted here that a possible limitation of the present study lies in the limited conditions employed for the collection of the speech samples. However, the procedure is nevertheless comparable to other studies in the literature to date.

<u>Description of speech measurements</u>. The individual speech samples were analysed for the mean length of T-units

by the procedure developed by Hunt (1965, pp. 20-22). As stated previously, the mean length of T-units is a reliable measure of linguistic maturity and is an indication of the amount of subordination typically used by the speaker. This measure is comparable to the measure of subordination suggested by Bernstein (1962) and that suggested by Loban (1963).

The individual speech samples were also analysed for the frequency of occurrence of tentative statements. The types of tentative statements selected were those reported by Turner and Pickvance (1971) as being related to the 'elaborate' code. These statements were of the following types:

1. Egocentric sequences - 'I think'
2. Indirect questions - questions prefaced by 'I wonder, I can't think, I don't know'
3. Assessments of possibility and probability - modal adjuncts such as 'perhaps' and 'maybe' and verbal auxilliaries such as 'might be' and 'could be'.
4. Suppositions based on perception - statements with 'looks as if, looks like, looks as though'.
5. Also included in the analysis were the disjunctives, conditionals and suppositions which were not evident in the five-year-old sample studied by Turner and Pickvance (1971) but which were observed in the older children studied in the present investigation.

<u>Description of the Neimark and Lewis problem-solving task</u>. This task is a relatively language-free task which tests for the development of logical problem-solving strategies. Neimark and Lewis (1967) found that these strategies emerge in children at about 11-12 years of age and that performance on this task improves steadily through adolescence. In a further study, Neimark (1970) found that this task correlated significantly with Inhelder and Piaget's (1958) concept of correlation task. It appears, therefore, that this task reliably assesses a child's level of formal operational reasoning. Consequently, it was employed to provide a nonverbal measure of each child's level of reasoning ability.

For this task, the subject is given an answer sheet with n patterns with each pattern composed of k binary elements (black and white circles). A simplified version of the task and an example of the answer sheets appears in Appendix A. He is also given a 9-inch square board with k moveable shutters equally spaced around a circle 8 inches in diameter. Underneath the board is concealed one of the n patterns on the answer sheet. The subject must determine which one of the n patterns is hidden behind the board by uncovering as few of the shutters as possible.

The patterns on the answer sheet have been so constructed that the maximal strategy for solution of the problem is to open the shutters in such an order that on each 'move' half the possible patterns can be eliminated. Any other strategy will result in having to make more than the minimal number of 'moves'.

Preceding the testing session, each subject was given a demonstration of the task. For this purpose, the subject was given a board with three shutters and an answer sheet containing four possible patterns. The experimenter opened one shutter and asked the subject which of the four patterns could then be eliminated. The subject was then asked which of the shutters should be opened next in order to solve the problem. Regardless of the subject's choice, it was always pointed out to him which move solved the problem and which did not. The subject then performed four practice problems to familiarize him with the mechanics of the procedure. Two of these problems consisted of four shutters and six possible patterns and the other two consisted of four shutters and eight possible patterns.

For each problem, the subject was required, upon opening a shutter, to write down the letter of the shutter opened on the appropriate line (e.g. whether it was the first, second, third, etc.), and to write the letter of the shutter across each pattern which had been eliminated as a result of the information gained from opening that particular shutter.

Following these practice problems, the subject was presented with eight experimental problems which consisted of a board with eight shutters and an answer sheet which contained eight possible patterns for each problem. From this point, the experimenter no longer interfered with the subject except to make sure that the subject eliminated the correct patterns on each move.

The scoring procedure is based on a reduction of uncertainty measure, H; where $H=\log_2 n$. If the problem consists of four shutters and four patterns, the amount of information required to solve the problem is two bits. If the problem consists of eight shutters and eight patterns, three bits of information are required. Since the answer sheet is constructed so that the maximum amount of information which can be gained on any one move is one bit, a minimum of two moves is required to solve a problem with four shutters and four patterns and a minimum of three moves is required when the problem consists of eight shutters and eight patterns. On each move, the expected informational outcome, $\bar{E}$, is calculated by weighting each informational outcome by the probability of its occurrence, assuming each pattern on the answer sheet has an equal chance of being concealed behind the board. Therefore, in the case where only one alternative from four has been eliminated, thereby providing only .415 bits of information, $\bar{E}$=.25 (2 bits) + .75 (.415 bits)=.811 bits. The scores for each move are summed across all the moves and divided by the total number of moves to obtain a score for each problem. These scores are then summed across all the problems and divided by the total number of problems to obtain a single score for each subject. The maximum performance is indicated by a score of 1.00.

<u>Description of Inhelder and Piaget's equilibrium in the balance task.</u> The purpose of this task is to test for the understanding of a physical principle and to assess a child's development of proportional schemata. This task has been widely employed in the past to assess a child's level of formal operational reasoning (e.g. Lovell, 1961; Bart, 1971; Jones, 1972), and both Ward (personal communication, 1973) and Jones (personal communication, 1973) have found this task to be one with considerable potential in terms of discriminating a wide range of levels of development. For these reasons, this task was selected for the present investigation.

A modified procedure of that developed by Inhelder and Piaget (1958) and of that developed by Lovell (1961) was employed in the present research. Each child was given six problems to solve. On the first problem, the subject was presented with the balance in equilibrium with two weights of equal size, one on each arm at equal distances from the fulcrum. The experimenter then added a weight of a different size to one side of the balance and the subject was asked if he could make the arms straight across once more by adding a weight to the other side. The second problem required solution to a 2:1 ratio of balancing the weights and the third problem required the subject to reverse the situation of problem two when equilibrium has been achieved. If the subject was unable to achieve equilibrium in the second problem, a balanced arm was presented to him and he was asked if he could now reverse the weights. The fourth problem required solution to a double use of the 2:1 ratio of balancing weights. The fifth problem required the subject to predict where on the arms two weights of 5:2 ratio should be placed to achieve equilibrium and the final problem required the subject to predict the outcome of placing an additional weight on one side of the balance when it was in equilibrium. Following solution or attempted solution to each problem, the subject was asked why he had moved the weights in the manner that he had. In addition, following the presentation of the final problem, each subject was asked if he could formulate a rule about how to balance weights, taking into account both the weights and the distance from the centre. An example of the apparatus and the specifics of the problems and the questions are shown in Appendix A.

The task was scored on the basis of protocols from both Inhelder and Piaget (1958) and Lovell (1961). A total of seven stages were categorized from the data with the least developed fromal reasoning ability assigned to level 1 and the most developed formal reasoning ability assigned to level 7. Briefly, subjects were assigned to level 1 if they attempted to balance the arm by holding it up with their hands. Subjects were assigned to level 2 if they were unable to add equal weights at equal distances in the first problem. Level 3 was assigned to the subject if he was unable to reverse a balance in equilibrium. Assignment to level 4 resulted if the subject approached solution to the ratio problems in a trial and error fashion. Subjects were assigned to level 5 if they approached the ratio problems systematically but without appreciation of metric proportionality. Level 6 was assigned if the subject approached the ratio problems metrically and level 7 if the subject explained his actions and the rule in terms of a system of compensations between the weights and their distance from the fulcrum.

Since performance on this task is assessed by the use of both the verbal and nonverbal responses of the subjects, it was selected to provide a measure of formal reasoning ability for each child which might lie between those of the Neimark and Weitz tasks.

Description of the Weitz, Bynum and Thomas task. This task is a completely verbal form of items requiring formal logical operations for their solution. Weitz (1971) has found this task to be a reliable measure of formal reasoning in children from 9 to 15 years of age. He found that as a child grows older, he is able to correctly answer an increasing number of the items on this task which is composed of 12 binary propositions of formal logic. Consequently, this task was chosen to assess each child's level of formal reasoning ability on a verbal form of such a task and was intended also to serve as a comparison to the two other tasks: the non-verbal task of Neimark and the verbal and nonverbal task of Inhelder and Piaget.

This task, which is reproduced in Appendix A, was scored by summing the number of items answered correctly.

DESCRIPTION OF STATISTICAL ANALYSIS

The simple relationship between each of the language variables and each of the operational reasoning measures was assessed through use of the Pearson product-moment correlation coefficient. Such correlation coefficients were calculated for each grade level separately. In order to examine the multiple relationship between reasoning ability and the group of language variables, a computerized stepwise regression analysis was performed. Only certain language variables were grouped together for inclusion in the regression analysis following a rationale to be outlined below. The stepwise regression procedure was thus used in a somewhat limited sense to determine the unique contribution of a particular variable amongst a subset composed of variables individually significant in their relationship with the criterion measure. Regression analyses were performed separately for each grade level and for each of the problem-solving tasks.

Stepwise Regression

The nature of stepwise regression is such that the predictor variables are entered into the regression equation one at a time with the order of entry dependent upon the amount of additional variance accounted for from greatest to least. In this manner it is possible to determine the order of best prediction amongst the variables and to determine the amount of criterion-score variance they account for. The following information is output by the analysis:

1. multiple R, a measure of relationship between the criterion measure and the set of predictor variables in regression at a given stage.
2. R Square, representing the proportion of criterion-score variance accounted for by the equation predicting the criterion variable at a given stage.
3. simple R, a measure of the simple relationship between a criterion variable and the variable entered into regression at a given stage.
4. an F value, result of the F test to determine the significance of the contribution of the predictor variable which was entered into regression at a given stage. This F test is made to determine the relative effect of the entering predictor variable in excess of the effect of other variables already entered into regression.

The Criterion Variables

The criterion variables were:

1. The score obtained by each subject on the Neimark and Lewis task.
2. The score obtained by each subject on the Inhelder and Piaget task.
3. The score obtained by each subject on the Weitz, Bynum and Thomas task.

The Predictor Variables

The predictor variables employed were as follows, with the abbreviation used throughout indicated at the end of each.

1. The number of words produced by each subject (No. Words)
2. The number of T-units produced by each subject (No. T-U's)
3. The mean length of the T-units produced by each subject (ML T-U's)

These first three variables will be considered jointly as the measures of verbal fluency. It should be pointed out that the mean length of T-units, while being considered a measure of verbal fluency, is also the main index of linguistic complexity and maturity.

4. The number of tentative statements produced by each subject (No. TS)
5. The number of tentative statements produced by each subject expressed as a proportion of the total number of words (TS/W)

The number of tentative statements category was divided into three subcategories in order of frequency of use as follows:

6. The number of suppositions based on perception produced by each subject (Supp. Per.)
7. The number of disjunctives used by each subject (Disjun.)
8. The combined total of remaining types of tentative statements produced by each subject (OTS)

9. The proportion of suppositions based on perception to the total number of words produced by each subject (Supp. Per./W)

10. The proportion of disjunctives to the total number of words produced by each subject (Disjun./W)

11. The proportion of the other types of tentative statements to the total number of words produced by each subject (OTS/W)

12. The scaled IQ score obtained by each subject on the Peabody Picture Vocabulary Test (PIQ)

Stages of Analysis

The predictor variables were entered into the regression analysis in three distinct stages as follows:

Stage 1. If any of the verbal fluency measures showed a significant simple correlation with the task under consideration, all three variables were entered into the analysis. This step was performed to determine the effects of these variables when considered jointly and independently of all the other variables.

Stage 2. If the tentative statements variable showed a significant simple correlation with the task, this variable was then entered into the analysis to determine its effectiveness in conjunction with the verbal fluency measures. In addition, if any of the other tentative statements variables showed a more significant correlation with the task than the number of tentative statements that variable was subsequently entered into the analysis, again to determine its effectivensss in conjunction with the fluency measures.

Stage 3. This stage considered the effect on the significance of the language variables when they were in the presence of the 'traditional' measure of verbal intelligence, PIQ. This variable was entered into the analysis first, followed by those language variables which were entered into the regression equations during Stages 1 and 2.

Supplementary Analysis

For the analysis of results, the age, socioeconomic status (SES) and Raven's IQ (RIQ) variables were not directly included in the regression analysis. The major purpose of this research was to determine the relationship between language variables during speech and formal operational reasoning, and to observe the effect on this relationship when the language variables are considered in the presence of a 'traditional' measure of verbal intelligence. Since all three variables, age, SES and RIQ were expected to be related to the tasks and to the language variables and were employed primarily for the purposes of selection of the subjects, it was decided to leave these variables out of the regression analysis in order not to obscure the effect on the reasoning tasks of the language variables alone. Tables 4, 5 and 6 present the simple correlations of age, SES and RIQ with the language and task variables for each grade and they will be discussed separately after the language and verbal IQ measures have been considered.

RESULTS OF THE DATA ANALYSIS

The means and standard deviations of all the variables for each grade level are shown in Appendix B along with the complete correlation matrices of each variable with each other variable for each grade level. The results of the correlational and the regression analyses for each grade follow.

Results for Grade 4

The correlations to be considered between the language, verbal IQ and task variables are shown in Table 1.

Regression analysis for the Neimark task. Stage 1 of the analysis produced the following order of prediction:

Variable	Multiple R	R Square	Simple R	F Value	df
No. Words	.28	.08	.28	4.00	1/46
No. T-U's	.33	.11	.24	1.59	1/45
ML T-U's	.34	.12	.24	.40	1/44

Stage 2 was not performed for this task since, as is evident from Table 1, the required simple correlations did not reach significance. Stage 3 of the analysis provided the following results:

Variable	Multiple R	R Square	Simple R	F Value	df
PIQ	~~.01~~	~~.00~~	~~.01~~	~~.01~~	~~1/46~~
No. T-U's	.24	.06	.24	2.68	1/45
ML T-U's	.30	.09	.24	.37	1/44
No. Words	.30	.12	.28	1.32	1/43

TABLE 1

Correlations Between Task Variables and Language and PIQ Variables for Grade 4

Language and PIQ Variables	Reasoning Tasks: Neimark	Piaget	Weitz
No. Words	.28*	.28*	-.13
No. T-U's	.24	.28*	-.10
ML T-U's	.24	.12	-.18
No. TS	.18	.19	-.19
TS/W	-.02	.09	-.03
Supp. Per.	.08	.10	.03
Disjun.	.12	.11	-.11
OTS	.13	.13	-.25
Supp. Per./W	-.03	-.01	.10
Disjun./W	.08	.11	-.02
OTS/W	-.06	.07	-.14
PIQ	.01	-.02	.12

*p=.05

Regression analysis for the Piaget task. Stage 1 produced the following order of prediction for the fluency measures:

Variable	Multiple R	R Square	Simple R	F Value	df
No. T-U's	.28	.08	.28	4.00	1/46
ML T-U's	.29	.08	.12	.12	1/45
No. Words	.31	.10	.28	.75	1/44

As in the previous task, stage 2 was not performed for this task since the relevant simple correlations did not reach significance as is evident in Table 1. Stage 3 provided the following result:

Variable	Multiple R	R Square	Simple R	F Value	df
PIQ	.02	.00	-.02	.03	1/46
No. T-U's	.28	.08	.28	3.89	1/45
ML T-U's	.28	.08	.12	.14	1/44
No. Words	.31	.10	.28	.74	1/43

Regression analysis for the Weitz task. In view of the fact that none of the relevant variables correlated significantly with this task as is evident in Table 1, none of the three stages of the analysis were performed for this task.

Summary of results for Grade 4. It appears that the hypotheses concerning the use of tentative statements and the use of complex linguistic patterns have not been supported at this grade level. None of the tasks presented were significantly related to either the number of tentative statements nor to the mean length of T-units. Of the language variables, however, the number of words was significantly related to the Neimark task and both the number of words and the number of T-units were significantly related to the Piaget task. Since both these variables are highly correlated measures of volume ($r=.97$, $p=.001$), it appears that the amount of language a child produces at this grade level is related in some way to performance on these tasks of formal reasoning. The fluency measures in question tended to remain of borderline significance in the presence of the Peabody IQ.

<u>Results for Grade 6</u>

The correlations to be considered between the language, verbal IQ and task variables are shown in Table 2.

<u>Regression analysis for the Neimark task</u>. Stage 1 of the analysis was not performed since, as is evident in Table 2, none of the three fluency variables showed a significant correlation with the task. Of the variables under consideration in Stage 2, the suppositions based on perception expressed as a proportion of the total number of words was significantly related to the task and when placed in the regression analysis with the fluency variables produced the following result:

Variable	Multiple R	R Square	Simple R	F Value	df
Supp.Per./W	.29	.08	.29	4.18*	1/46
No. Words	.35	.12	.18	1.93	1/45

*p=.05

TABLE 2

Correlations Between Task Variables and Language and PIQ Variables for Grade 6

Language and PIQ Variables	Reasoning Tasks: Neimark	Piaget	Weitz
No. Words	.18	.18	.00
No. T-U's	.14	.14	-.01
ML T-U's	.12	.10	-.04
No. TS	.22	.19	.30*
TS/W	.23	.13	.30*
Supp. Per.	.27	.13	.30*
Disjun.	.14	.15	.20
OTS	.03	.16	.14
Supp. Per./W	.29*	.10	.27
Disjun./W	.18	.04	.14
OTS/W	-.04	.08	.13
PIQ	.16	-.04	.34*

*$p < .05$

Those variables in regression at Stage 2 were subsequently entered into regression in the presence of the PIQ variable to produce the following results[1]:

Variable	Multiple R	R Square	Simple R	F Value	df
PIQ	.16	.03	.16	1.26	1/46
Supp.Per./W	.30	.09	.29	3.30	1/45
No. Words	.36	.13	.18	1.89	1/44

Regression analysis for the Piaget task. No regression analyses were performed for this task since, as is evident from Table 2, none of the variables in question bore a significant relation to this task.

Regression analysis for the Weitz task. Again, as for the other two tasks, Stage 1 of the analysis was not carried out since as Table 2 indicates, none of the fluency measures were related to this task. As the number of tentative statements variable did show a significant relation to the task, this variable was included in Stage 2 and yielded the following result:

Variable	Multiple R	R Square	Simple R	F Value	df
No. TS	.30	.09	.30	4.73*	1/46
ML T-U's	.33	.11	-.04	.88	1/45
No. T-U's	.34	.11	-.01	.16	1/44
No. Words	.38	.14	.00	.15	1/43

*$p<.05$

[1]The two remaining fluency variables which were entered into this and the previous analysis at this stage presumably made only a negligible change in the Multiple R and were therefore not listed in the output.

While other tentative statements variables were significantly related to the task, they did not show a greater correlation than the number of tentative statements variable itself and was therefore not included in any further analysis.

Stage 3 of the analysis produced the following result:

Variable	Multiple R	R Square	Simple R	F Value	df
PIQ	.34	.12	.34	5.98*	1/46
No. TS	.41	.17	.3[illegible]	2.93	1/45
ML T-U's	.43	.18	-.04	.86	1/44
No. T-U's	.43	.19	-.01	.07	1/43
No. Words	.45	.20	.00	1.04	1/42

*$p < .05$

Summary of results for Grade 6. It appears that, as in Grade 4, the hypothesis concerning the use of complex structures of language has not been supported. The mean length of T-units did not significantly relate to the formal reasoning required in any of the tasks presented. The tentative statements variable at this grade level, however, did relate to the Weitz task and a subcategory of these statements, the suppositions based on perception, related to both the Neimark and the Weitz tasks. Some support at this grade level then is evident for the hypothesis that children who make greater use of these statements are better able to perform the operations required in formal reasoning. When the tentative statements variables in question were considered in the presence of the Peabody IQ they did account for approximately an additional 6 percent of the variance in reasoning scores, even though this change was not statistically significant.

Results for Grade 8

The correlations to be considered between the language, verbal IQ and task variables are shown in Table 3.

Regression analysis for the Neimark task. As is evident from Table 3, none of the variables showed a significant relation to this task. Therefore, no regression analyses were carried out.

Regression analysis for the Piaget task. Only the PIQ measure showed a significant correlation with the Piaget task. Since none of the language variables were significantly related to this task it was not necessary to perform Stage 3 of the analysis.

Regression analysis for the Weitz task. Stage 1 of the analysis yielded the following results:

Variable	Multiple R	R Square	Simple R	F Value	df
No. Words	.37	.14	.37	7.36**	1/46
No. T-U's	.37	.14	.35	.13	1/45
ML T-U's	.44	.20	.14	3.09	1/44

$^{**}p<.01$

From the simple correlations shown in Table 3, it may be noted that the suppositions based on perception variable was of borderline significance in its relationship with the Weitz task. However, the correlation between these two variables dropped to .10 when the former was expressed as a proportion

TABLE 3

Correlations Between Task Variables and Language and PIQ Variables for Grade 8

Language and PIQ Variables	Reasoning Tasks Neimark	Piaget	Weitz
No. Words	.19	.14	.37**
No. T-U's	.25	.06	.35**
ML T-U's	-.09	.16	.14
No. TS	.15	.18	.20
TS/W	.04	.15	.01
Supp. Per.	.15	.13	.26
Disjun.	.06	.07	.11
OTS	.09	.17	-.01
Supp. Per./W	.05	.13	.10
Disjun./W	-.01	.05	.01
OTS/W	.01	.09	-.12
PIQ	-.10	.35**	.28*

**p<.01

*p=.05

of the number of words. The suppositions based on perception variable was therefore not entered into a regression equation at Stage 2 since it would not be expected to significantly change the proportion of variance accounted for by the number of words variable.

Stage 3 of the analysis yielded the following order of prediction.

Variable	Multiple R	R Square	Simple R	F Value	df
PIQ	.28	.08	.28	4.00	1/46
No. Words	.43	.18	.37	5.71*	1/45
No. T-U's	.43	.18	.35	.09	1/44
ML T-U's	.48	.24	.14	2.89	1/43

*$p<.05$

Summary of results for Grade 8. As in both the previous grades, the hypothesis concerning the use of complex structures of language has not been supported. Again, the mean length of T-units variable was not significantly related to any of the three formal reasoning tasks presented. The hypothesis concerning the use of tentative statements was only very minimally supported by the near significant relationship of one of those variables to the Weitz task. Of the language variables, the two measures of volume, the number of words and the number of T-units, showed a significant relation to the Weitz task. That the above measures relate significantly only to the task which was presented in a purely verbal form is of some interest. This result seems to imply that while language at this grade level is of little importance during solution to a nonverbal task, it does play a role when the child is faced with a reasoning task requiring the use of language for its solution. It is also evident that the 'traditional' PIQ measure is a relatively good predictor of formal reasoning ability at this age level since it correlated significantly with both the Piaget and Weitz tasks. Of specific relevance, however, is the finding that the relationship between the Weitz task and the number of words remained significant in the presence of the Peabody IQ, with the fluency measure accounting for an additional ten percent of the variance.

Supplementary Analysis

Tables 4, 5 and 6 present the correlations of the age, SES and RIQ variables with the language, PIQ and task variables.

It appears that age within the groups is not closely related to the majority of the language variables. Only at the grade 4 level is it evident that the older children in this group make greater use of tentative statements and its subcategory of suppositions based on perception. These variables no longer distinguish the older from the younger children within the higher grades.

The age variable is also not significantly related to the PIQ variable at the grade 4 and 6 levels but does show a rather unusual significant negative correlation with PIQ at the grade 8 level. This result may be a function of the fact that the age range under consideration is a very narrow one thus producing this bizarre relationship or it may be that some of the older children at this grade level had failed a grade,

TABLE 4

Correlations of the Age, SES and RIQ Variables with the Language, PIQ and Task Variables for Grade 4

Language, PIQ and Task Variables	Age, SES and RIQ Variables		
	Age	SES	RIQ
No. Words	.21	.12	.36**
No. T-U's	.19	.13	.36**
ML T-U's	.13	.02	.12
No. TS	.32*	.21	.35**
TS/W	.26	.18	.13
Supp. Per.	.41**	.10	.04
Disjun.	.08	.11	.24
OTS	.08	.16	.36**
Supp. Per./W	.28*	.10	-.10
Disjun./W	.09	.08	.20
OTS/W	.04	.12	.19
PIQ	.10	.10	.37**
Neimark	.12	-.06	.13
Piaget	.36**	.06	.32*
Weitz	-.02	.07	-.02

$^{**}p < .01$

$^{*}p \leq .05$

TABLE 5

Correlations of the Age, SES and RIQ Variables
with the Language, PIQ and Task Variables
for Grade 6

Language, PIQ and Task Variables	Age, SES and RIQ Variables: Age	SES	RIQ
No. Words	-.12	.03	.05
No. T-U's	-.15	-.05	.04
ML T-U's	.05	.17	.06
No. TS	.07	.47***	.10
TS/W	.13	.47***	.14
Supp. Per.	.14	.42**	.05
Disjun.	-.06	.34*	.22
OTS	-.02	.28*	.06
Supp. Per./W	.22	.41**	.07
Disjun./W	-.09	.31*	.26
OTS/W	-.02	.18	.06
PIQ	-.12	.32*	.28*
Neimark	-.26	.27	.18
Piaget	-.19	.20	.15
Weitz	-.14	.23	.26

***p<.001
**p<.01
*p≤.05

TABLE 6

Correlations of the Age, SES and RIQ Variables

with the Language, PIQ and Task Variables

for Grade 8

Language, PIQ and Task Variables	Age, SES and RIQ Variables		
	Age	SES	RIQ
No. Words	-.13	.18	.23
No. T-U's	-.24	.15	.36**
ML T-U's	.18	.05	-.14
No. TS	.09	.11	.24
TS/W	.17	.04	.14
Supp. Per.	.06	-.06	.10
Disjun.	.04	.13	.20
OTS	.08	.26	.28*
Supp. Per./W	.12	-.13	.01
Disjun./W	.08	.16	.17
OTS/W	.13	.18	.17
PIQ	-.50***	.06	.26
Neimark	.13	.37**	.20
Piaget	.01	.43**	.20
Weitz	-.19	.33*	.40***

***p<.001

**p<.01

*p≤.05

unknown to the researcher, or that the older children had missed a considerable amount of school during their previous education.

With respect to the relationship between the age variable and the formal reasoning tasks, only the Piaget task at the grade 4 level discriminated the older children from the younger ones, demonstrating that this task is a sensitive measure of development within this age range but not within the older age ranges.

The effects of a child's socio-economic status on the variables under consideration changes across the three grade levels. At the grade 4 level the SES variable was not related significantly to any of the other variables. At the grade 6 level, the SES variable was significantly related to the tentative statements and the PIQ but this result was not maintained at the grade 8 level. The relation between SES and the three reasoning tasks appears to increase considerably with grade. While SES had no effect on the tasks at the grade 4 level, it approached significance with the Neimark task at the grade 6 level and was significantly related to all three tasks at the grade 8 level. This result may well indicate that as a child grows older he increasingly suffers from a detrimental effect of his home background on school-oriented tasks.

The relation of the RIQ variable to the other variables was also not consistent across the three grades. It was related to number of words and tentative statements at grade 4 and to number of T-units at grades 4 and 8 but was not related to these variables at the grade 6 level. It was also not consistently related to the formal reasoning tasks showing a significant relation only to the Piaget task at grade 4 and to the Weitz task at grade 8.

DISCUSSION

As is clearly evident from the results of both the regression analyses and the simple correlations, the complexity of the linguistic structures a child typically employs during spontaneous speech is not significantly related to the child's performance on the three formal reasoning tasks presented. The mean T-unit length variable, the main index employed to assess linguistic complexity, did not bear a significant simple correlation to any of the reasoning tasks at the grades 6 and 8 levels and was only of borderline significance in its relation to the Neimark task at the grade 4 level. In addition, when mean T-unit length was placed into the regression analyses, in no instance did it provide a significant change in the amount of the variance accounted for by the other language variables in prediction. Clearly then, knowledge of the degree of linguistic complexity children demonstrate at grades 4, 6 and 8 does not allow for prediction of the children's level of formal operational reasoning. Whether such a predictive relationship exists between linguistic complexity and formal reasoning on tasks other than those employed in the present research remains to be established. Furthermore, whether such a predictive relationship between linguistic complexity and problem-solving ability is evident at age levels lower than that employed here also remains for future investigation.

With respect to the question concerning the possible relationship between a child's frequency of use of tentative statements and his formal reasoning ability, the results of both the regression analyses and the simple correlations are not consistent across the three grades. At the grade 4 level, none of the tentative statements variables were significantly related to any of the three formal reasoning tasks. At the grade 6 level, the number of tentative statements and the subcategory of suppositions based on perception were both significantly related to the Weitz task. The latter variable when it was expressed as a proportion of the total number of words was also significantly related to the Neimark task. When these variables were placed into the regression analyses together with the fluency variables, they were first in order of prediction and the fluency variables in neither case added a significant amount of variance to that already accounted for by the tentative statements variables. For the grade 8 subjects, suppositions based on perception demonstrated a near significant relation to the Weitz task. However, this variable had little predictive value when expressed as a proportion of the total number of words.

From these results, it appears on the surface that some support is evident for the facilitory effect of the use of tentative statements on reasoning during the transition stage from concrete to formal operational thought, the stage to which most of the children in grade 6 belong. However, when the tentative statements variables are considered in terms of their consistently significant correlations with the SES variable at the grade 6 level, and since SES approaches a significant relation to both the Neimark and Weitz tasks at this grade level, it seems possible that SES may be vitiating the effect between the tentative statements variables and specific reasoning tasks. This interpretation of the results for the grade 6 children seems particularly reasonable in view of the lack of significant relationships between the tentative statements and the reasoning tasks at grades 4 and 8 and in view of the increasingly significant relations observed between all three reasoning tasks and SES from the grade 6 to grade 8 level.

It is of some interest to note the relationship between performance on the reasoning tasks and the volume of speech produced by the youngest children in the sample. There was a significant relationship between performance on the Neimark and Piaget tasks and the number of words produced by the grade 4 children. These relationships were no longer evident at the higher grade levels.

Some recent evidence from researchers investigating the use children make of language during problem-solving situations allows for some speculation as to why the amount of speech the younger children produced may be related to the tasks presented. Jones (1974), investigating the relationships between silent and aloud rehearsals and age during performance on a paired-associate task, found that the younger children in her sample produced more overt vocalizations during the task than did the older children. Furthermore, Beaudichon (1973) has reported that younger children produce more speech during problem-solving tasks as the tasks increase in difficulty than do older children.

In view of the results of these two studies, one could speculate that the younger children in the present sample were still at the stage where overt production of speech during complex problem-solving situations is evident. Perhaps the children in the grade 4 group who produced the greatest amount of language during the presentation of the photographs were also the children who produced the greatest amount of speech during the formal reasoning tasks. It was evident to the present experimenter that, while no measure of the language produced during their performance on the Neimark and Piaget tasks were established, the grade 4 children spoke aloud to themselves considerably more during these tasks than did the older children. It is possible that the grade 4 children approached the task designed to collect the language sample in much the same manner as they approached the tasks designed to assess their level of formal operational reasoning. If the above speculations are correct, perhaps both the age of the children and the task difficulty may account for the relationship between the amount of speech produced and performance on these two reasoning tasks. This relationship implies that for the young children, the amount of language they produce during problem-solving situations in some way facilitates their performance on tasks of reasoning ability.

A further explanation of the relationship which was evident between the amount of language the younger children produced and their performance on the reasoning tasks seems worthy of consideration. Perhaps the children who produced the most speech during the initial testing session of the presentation of the photographs and who subsequently demonstrated superior performance on the formal reasoning tasks were less intimidated by the formality of these testing situations and therefore less constrained in their abilities to deal with the situations at hand. Perhaps for the older children this element of intimidation may not have been present during any of the testing situations.

The relationships of the language variables to the Weitz task, the purely verbal form of a task requiring formal reasoning, were different across the three grades than for the Neimark and Piaget tasks. At the grade 4 level, while none of the language variables achieved a significant relation to this task, the majority of these correlations were in the negative direction. This result is rather mystifying. Unlike the other reasoning tasks, the Weitz task was administered to groups. For the younger children in particular, the group administration may have introduced a degree of unreliability. It may also be that the children in this group who tended to produce more language and to make greater use of tentative statements were more restless during their performance on this task and subsequently demonstrated a slightly inferior performance. At the grade 6 level, however, the Weitz task was significantly related to the number of tentative statements and to suppositions based on perception as well as to the PIQ measure. At the grade 8 level, this task was again significantly related to the PIQ measure as well as to the two measures of fluency, the number of words and the number of T-units. The results for these higher grades support Furth's (1971) contention that, while language is not related to formal reasoning per se, language skills do become of greater importance with respect to formal reasoning when the problems are presented in verbal form.

The relationship between the reasoning tasks and the 'traditional' measure of verbal intelligence, the PIQ, also varied across the three grades. This measure was not a significant predictor of performance on any of the three reasoning tasks for the grade 4 children. For the grade 6 children it was a significant predictor of performance on the Weitz task and for the grade 8 children this measure significantly predicted performance on both the Weitz and Piaget tasks. It appears from this result that the level of verbal ability as assessed by the PIQ measure is related to tasks of formal reasoning when the latter specifically require verbalization. The finding of a significant relationship with the Piaget score at the grade 8 level may be taken to support this conclusion when it is considered that high scorers on the Piaget task were ones who could verbalize their solution.

When the PIQ measure was placed in the regression analyses along with other significant language variables, the language variables in all cases accounted for an additional 6 to 10 percent of the variance. Whereas the PIQ and the language variables may be inter-related, each nevertheless contributes some unique component to formal reasoning ability.

The developmental growth aspect of the language and task variables under consideration were substantiated by the present investigation. That children make greater use of the complex structures of their language with increasing age, as previously demonstrated by Loban (1963), Hunt (1965) and O'Donnell, Griffin and Norris (1968), has also been observed in the present research. The mean length of T-units, the measure employed to assess the children's linguistic complexity, increased consistently across the three grades ($F=10.76$, $df=2/141$, $p<.01$). In addition, from the variance observed on the mean T-unit length variable within each grade (see Appendix B), it was evident that some of the children at each grade level use a more complex or 'elaborate' language pattern than their peers. Since mean T-unit length was not related to SES for any of the grades, some variable other than SES within the relatively restricted SES range employed appears to be operating on the children's use of the grammatical elements of their language. Perhaps Bernstein and his colleagues, with their sociological approach to the study of language, may throw some light on the nature of these possible variables.

The developmental increase in the frequency of use of tentative statements has also been established by the present research ($F=14.40$, $df=2/141$, $p<.01$). Children at the grade 8 level made considerably greater use of these statements than did children in the earlier grades. The use of these statements appears not to reflect a superior cognitive ability within this age group but rather appears to be a language variable characteristic of this group as a whole.

Developmental growth with respect to the reasoning tasks presented in this research has also been established for each task (Neimark, $F=16.37$, $df=2/141$, $p<.01$); Piaget, $F=27.84$, $df=2/141$, $p<.01$; Weitz, $F=21.78$, $df=2/141$, $p<.01$). The children's performance on the three tasks increased consistently across the three grade levels. There were not, however, consistent relationships between the tasks for all the three groups (see Appendix B). At the grade 4 level, none of the inter-correlations between the three tasks were significant. At the grade 6 level the Weitz task correlated significantly with both the Neimark and the Piaget tasks and all three tasks were significantly related to each other at the grade 8 level. These tasks, therefore, do not measure similar abilities in the younger children. While for the older children the three tasks do have a common core, each, to the extent of its reliability, seems to assess a unique component of reasoning ability.

A child's socioeconomic status appears, from the present research, to have increasing effects on his performance on tasks of formal reasoning with age. While the SES variable was not related to either of the three tasks at the grade 4 level, it approached significance in its relationship to these tasks at the grade 6 level and was significantly related to all three tasks at the grade 8 level.

It may be that the child-rearing practices suggested by Bernstein (1970) as distinguishing middle-class from working class families, and which he postulates foster the development of differentiation in speech patterns, have the more general effect of fostering the development of greater reasoning ability. The child-rearing practices which he describes do in fact appear quite similar to those which other investigators (e.g. Dyk & Witkin, 1965) have suggested as antecedents of a more differentiated cognitive style, which may or may not be related to the tasks of reasoning ability as investigated in the present research.

In summary, with respect to the major aims of the present research, several conclusions are evident concerning the relationships between the language variables considered and the three formal reasoning tasks presented. First, the results indicate that the linguistic complexity of individual speech patterns is not significantly related to performance on the three reasoning tasks at either the grade 4, 6 or 8 level. Second, the relationship between the frequent use of tentative statements and performance on these tasks is evident only at the grade 6 level on two of the tasks. Finally, although the present research did not specifically set out to investigate this relationship, the results indicated that the amount of language produced by the grade 4 children is significantly related to their performance on two of the reasoning tasks. However, in view of the somewhat limited circumstances employed for the collection of the speech samples, the results of the present study remain somewhat tenuous. In addition, since only boys were employed in the present investigation to determine that relationship, it remains to be demonstrated whether the language variables under investigation interact with the sex of the subjects in their effectiveness on formal reasoning.

Since the present research demonstrated that the amount of speech produced by the youngest members of the sample was significantly related to their performance on both the Neimark and Piaget tasks, the relationship between language production and reasoning at this and younger age levels seems worthy of future investigation. Specifically, an investigation of speech production during the actual problem-solving situation itself, rather than a correlational study such as the present one, may prove more fruitful in determining how speech facilitates reasoning at these early ages.

Furthermore, it remains possible that a child's writing ability is more closely related to his reasoning ability than is his speech fluency. If writing indeed involves an ability on the part of the writer to separate linguistic contexts from immediate references (Greenfield, 1973) a process which must surely require a considerable amount of cognitive planning, then perhaps as a child grows older his writing ability may facilitate the reasoning processes required during formal operations. If writing ability were investigated in terms of both linguistic complexity and quantified with respect to its concrete or abstract relation to the referent situation, perhaps a clearer relationship between the cognitive processes operating during language production and reasoning may be established.

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APPENDIX A

1. A simplified version of the Neimark and Lewis problem-solving task (from Neimark and Lewis, 1967).

2. An answer sheet for the Neimark and Lewis problem-solving task for the experimental problems.

3. A version of Piaget and Inhelder's equilibrium in the balance task (from Inhelder and Piaget, 1958).

4. A description of the six problems presented for the balance task.

5. The Weitz, Bynum and Thomas task (from Weitz, 1971).

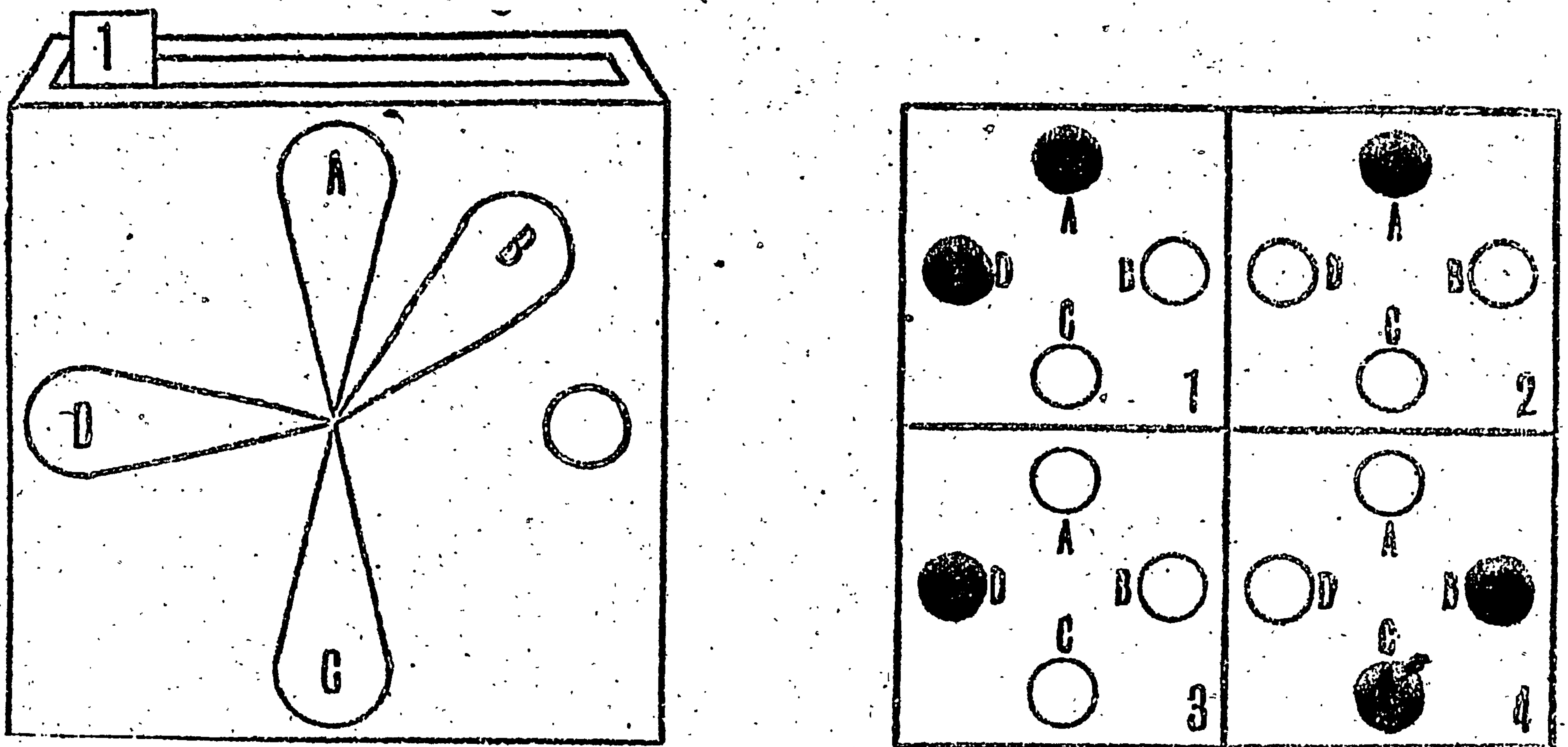
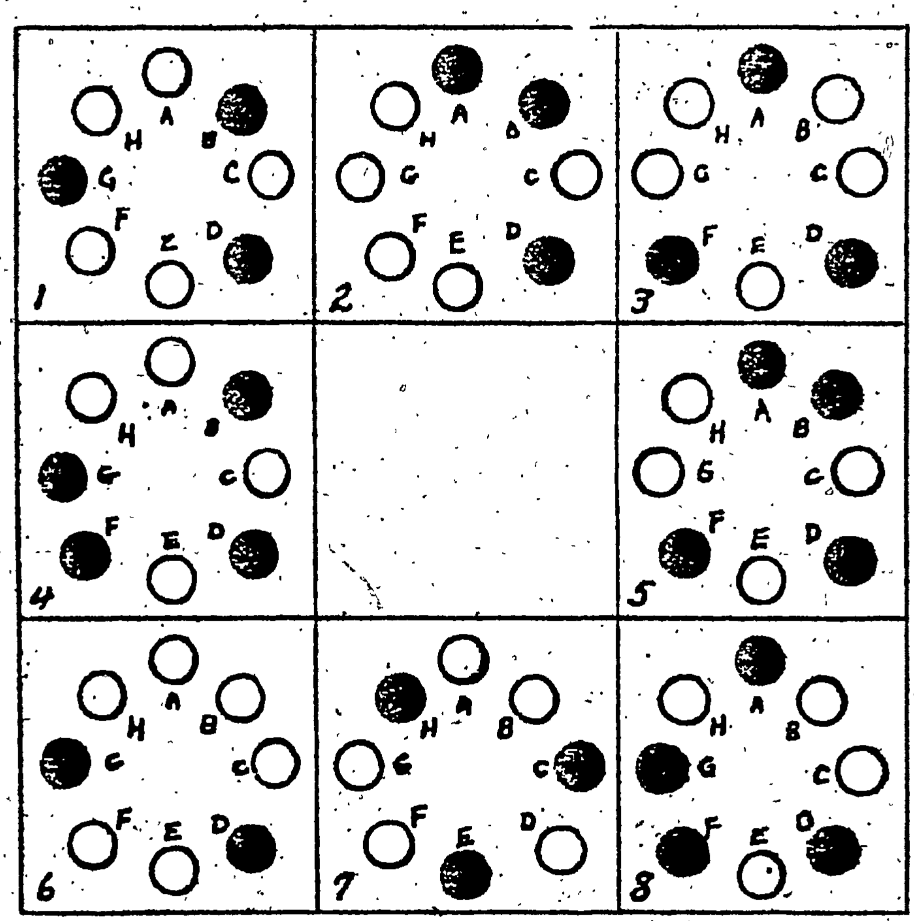


Figure 1. Schematic of a problem board with four shutters and an answer array containing four patterns. Shutter B has been opened revealing a white circle beneath; thus, patterns 1, 2, or 3 might be the answer, but pattern 4 is ruled out. In this instance, gambling is not rewarded. (From Neimark and Lewis, 1967).

Name ______________________ Answer Sheet H ______________________

Date ______________________ Group ______________________

Problem ______________________



Shutter moved 1.______ 5.______ Answer______

2.______ 6.______

3.______ 7.______

4.______ 8.______

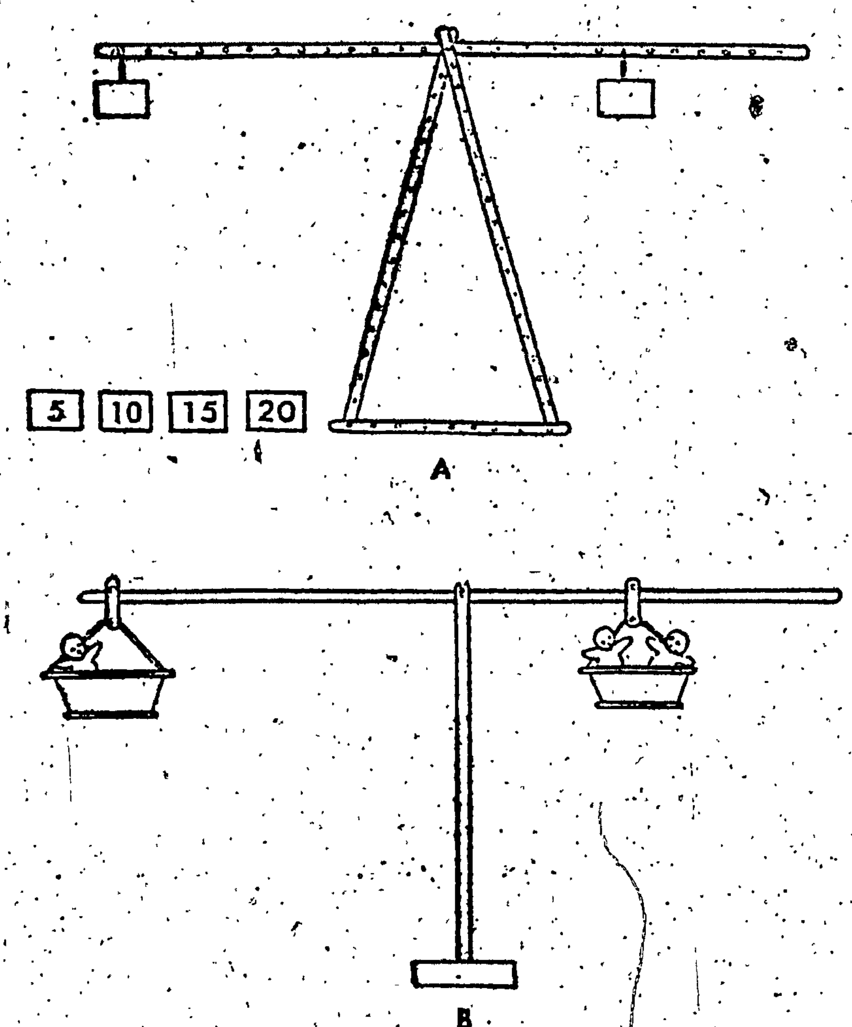


FIG. 9. The balance scale is here shown in two forms: (A) a conventional balance with varying weights which can be hung at different points along the crossbar; (B) a balance equipped with baskets which can be moved along the crossbar to different points and in which dolls are used as weights.

Problem 1

A 2w is placed on each side of the balance 4 holes from centre. The experimenter adds 3w to one side, asks the subject to produce equilibrium by adding weights to opposite side. The experimenter records the subject's actions and explanation.

Problem 2

A 2w is placed at a 5-hole distance from the centre on one arm and a 1w is placed at a 15-hole distance from the centre on the other arm. The subject is asked to achieve equilibrium. The experimenter records the subject's actions and explanation.

Problem 3

The subject is asked to reverse the weights in Problem 2 if he has achieved equilibrium. If he has been unable to do so, the experimenter presents the balance in equilibrium using weights from Problem 2 and asks the subject to reverse them. The experimenter records the subject's actions and explanation.

Problem 4

A 6w is placed at 5 holes from the centre and a 1w is placed at 10 holes from the centre on one side of the balance. The subject is asked to achieve equilibrium by placing a 3w and a 2w on the other arm. The experimenter records the subject's actions and explanations and asks the further question "Would it make any difference if you switched the 3w and the 2w?"

Problem 5

The subject is shown a 5w and a 2w and asked to predict where they should be placed on each of the arms to achieve equilibrium. The experimenter records the subject's explanation.

Problem 6

The subject is presented with the balance in equilibrium, with a 4w at 5 holes from the centre on each side, and asked to predict what would happen to the arms if a 1w were added to one side. The experimenter records the subject's prediction.

At the end of the presentation of the problems, the experimenter asked the following question and recorded the subject's explanation: "Can you make any rule about balancing the weights that takes into account the weights and the distance from the centre?"

The Weitz, Bynum and Thomas

Task of Formal Operations

You are going to be given some sentences from which you will be asked to draw some conclusions.

Here is a sample:

Suppose you know that:

If Ted comes, Jack goes.
Ted is coming.

From these two sentences could we say -

Jack goes Yes___ No___

***

There are two answers, Yes, or No, of which only one is correct. You are asked to find which one of the two answers is correct. Mark an X on the Yes or No lines found to the right of each question.

For the sample questions above, mark X in either the Yes or No space. Please answer all 48 questions. You may start by turning the page and answering question number 1.

1. Suppose you know that:
   You are a good athlete and a bad dancer.

   From this sentence could we say -
   You are a good athlete. 1. Yes___ No___

2. Suppose you know that:
   Fred cannot be in the classroom and playing ball outside at the same time.
   Fred is not in the classroom.

   From these two sentences could we say -
   Fred is playing ball outside. 2. Yes___ No___

3. Suppose you know that:
   George is neither mean nor angry.

   From this sentence could we say -
   George is not angry. 3. Yes___ No___

4. Suppose we know that:
   If Jack makes the team his father will be glad.
   Jack does make the team.

   From these two sentences could we say -
   His father will be glad. 4. Yes___ No___

5. Suppose you know that:
   Frank will get clothes and toys or he will get neither.
   Frank gets clothes.

   From these two sentences could we say -
   Frank gets toys. 5. Yes___ No___

6. Suppose you know that:
   Either we go to the movies or eat a hamburger but not both.
   We go to the movies.

   From these two sentences could we say -
   We do not eat a hamburger. 6. Yes___ No___

7. Suppose you know that:
   Nixon's being President has no connection with whether or not you go to school.
   Nixon is President.

   From these two sentences could we say -
   You do not go to school. 7. Yes___ No___

8. Suppose you know that:
Some boys' not doing their homework has no connection with whether or not Apollo 11 will land on the moon.

From these two sentences could we say -
Apollo 11 did not land on the moon. 8. Yes___ No___

9. Suppose you know that:
Either we watch TV or we hear the radio but not both.
We do not hear the radio.

From these two sentences could we say -
We watch the TV 9. Yes___ No___

10. Suppose you know that:
It is cold outside and raining cats and dogs.

From this sentence could we say -
It is raining cats and dogs. 10. Yes___ No___

11. Suppose you know that:
He will not give her both a ring and a car.
He will give her a ring.

From these two sentences could we say -
He will not give her a car. 11. Yes___ No___

12. Suppose you know that:
If Jim plays good music, Sue sings.
Sue does not sing.

From these two sentences could we say -
Jim does not play good music. 12. Yes___ No___

13. Suppose you know that:
Milton cannot be playing basketball and singing at the same time.
Milton is singing.

From these two sentences could we say -
Milton is not playing basketball. 13. Yes___ No___

14. Suppose you know that:
If Morris plays ball, he gets exercise.
Morris does not play ball.

From these two sentences could we say -
Morris does not get exercise. 14. Yes___ No___

15. Suppose you know that:
    Lou will get both a car and a boat
      or he'll get neither.
    Lou gets a car.

From these two sentences could we say -
    Lou does not get a boat. 15. Yes___ No___

16. Suppose you know that:
    Henry cannot be rich and handsome
      at the same time.
    Henry is not handsome.

From these two sentences could we say -
    Henry is rich. 16. Yes___ No___

17. Suppose you know that:
    If Paul is lazy his mother is angry.
    His mother is angry.

From these two sentences could we say -
    Paul is lazy. 17. Yes___ No___

18. Suppose you know that:
    Ken will get both wine and cheese
      or he'll get neither.
    Ken will not get wine.

From these two sentences could we say -
    Ken will get cheese. 18. Yes___ No___

19. Suppose you know that:
    Miriam is neither skinny nor fat.

From this sentence could we say -
    Miriam is not skinny. 19. Yes___ No___

20. Suppose you know that:
    Connie will learn both Math and English
      or she will learn neither.
    Connie does not learn Math.

From these two sentences could we say -
    Connie does not learn English. 20. Yes___ No___

21. Suppose you know that:
    Either we will go to sleep or eat a
      peach but not both.
    We are <u>not</u> going to eat a peach.

From these two sentences could we say -
    We will go to sleep. 21. Yes___ No___

22. Suppose you know that:
    You are a baseball player and a basketball player.

    From this sentence could we say -
    You are a basketball player. 22. Yes___ No___

23. Suppose you know that:
    Sue cannot eat a candy bar and snap her fingers at the same time.
    Sue is not eating a candy bar.

    From these sentences could we say -
    Sue is snapping her fingers. 23. Yes___ No___

24. Suppose you know that:
    Either we will run or whistle, but not both.
    We will run.

    From these two sentences could we say -
    We will not whistle. 24. Yes___ No___

25. Suppose you know that:
    Linda is neither weak nor strong.

    From this sentence could we say -
    Linda is not strong. 25. Yes___ No___

26. Suppose you know that:
    If Barbara gets a good report card her mother feels happy.
    Barbara gets a good report card.

    From these two sentences could we say -
    Her mother feels happy. 26. Yes___ No___

27. Suppose you know that:
    Karen will get both dolls and skates or she'll get neither.
    Karen gets dolls.

    From these two sentences could we say -
    Karen gets skates. 27. Yes___ No___

28. Suppose you know that:
    Joan is angry if her mother yells at her.
    Joan is angry.

    From these two sentences could we say -
    Her mother yells at her. 28. Yes___ No___

29. Suppose you know that:
    Helen will play checkers and chess
      or neither.
    Helen does not play checkers.

From these two sentences could we say -
    Helen does not play chess. 29. Yes___ No___

30. Suppose you know that:
    Either we build houses or airplanes
      or both.
    We do not build airplanes.

From these two sentences could we say -
    We build houses. 30. Yes___ No___

31. Suppose you know that:
    John cannot be smiling and playing
      the piano at the same time.
    John is playing the piano.

From these two sentences could we say -
    John is not smiling. 31. Yes___ No___

32. Suppose you know that:
    Either you go fishing or swimming or
      both.
    You go fishing.

From these two sentences could we say -
    You do not go swimming. 32. Yes___ No___

33. Suppose you know that:
    Sarah cannot be working and talking
      at the same time.
    Sarah is not talking.

From these two sentences could we say -
    Sarah is working. 33. Yes___ No___

34. Suppose you know that:
    Either you listen to music or read a
      book or both.
    You listen to music.

From these two sentences could we say -
    You do not read a book. 34. Yes___ No___

35. Suppose you know that:
    Gail has neither brown eyes nor green
      eyes.

From this sentence could we say -
    Gail does not have brown eyes. 35. Yes___ No___

36. Suppose you know that:
    If he is a soldier, he wears a uniform.
    He is not a soldier.

    From these sentences could we say -
    He does not wear a uniform. 36. Yes___ No___

37. Suppose you know that:
    Holly is a good teacher, if she does her homework each night.
    Holly does her homework each night.

    From these two sentences could we say -
    Holly is a good teacher. 37. Yes___ No___

38. Suppose you know that:
    If the moon flight fails, millions of dollars are lost.
    Millions of dollars are not lost.

    From these two sentences could we say -
    The moon flight does not fail. 38. Yes___ No___

39. Suppose you know that:
    Jack is a good lawyer if he wins the case.
    Jack is not a good lawyer.

    From these two sentences could we say -
    Jack does not win the case. 39. Yes___ No___

40. Suppose you know that:
    One is tall and beautiful.

    From this sentence could we say -
    One is beautiful. 40. Yes___ No___

41. Suppose you know that:
    If father laughs, Sue smiles.
    Sue smiles.

    From these two sentences could we say -
    Father laughs. 41. Yes___ No___

42. Suppose you know that:
    Joe smiles if he sees Sue.
    Joe does not see Sue.

    From these two sentences could we say -
    Joe does not smile. 42. Yes___ No___

43. Suppose you know that:
David will learn to dance and sing or he'll learn neither.
David learns to dance.

From these two sentences could we say -
David does not learn to sing. 43. Yes___ No___

44. Suppose you know that:
George will not give his son both a bike and a car.
George will give his son a bike.

From these two sentences could we say -
George will give his son a car. 44. Yes___ No___

45. Suppose you know that:
You will read or write or both.
You will not write.

From these two sentences could you say -
You will read. 45. Yes___ No___

46. Suppose you know that:
John's being a baseball player has no connection at all with whether or not Peter makes the swimming team.
John is a baseball player.

From these two sentences could we say -
Peter makes the swimming team. 46. Yes___ No___

47. Suppose you know that:
Jim will eat fruit or bread or he will eat neither.
Jim does not eat fruit.

From these two sentences could we say -
Jim does not eat bread. 47. Yes___ No___

48. Suppose you know that:
Some girls' not going to school has no connection with whether or not it is raining outside.
Some girls are not going to school.

From these two sentences could we say -
It is raining outside. 48. Yes___ No___

APPENDIX B

1. Means and standard deviations of all variables for each grade.

2. Correlation matrices of all variables for each grade.

MEANS AND STANDARD DEVIATIONS FOR ALL VARIABLES

FOR ALL GRADES

	Grade 4		Grade 6		Grade 8	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age (Mos.)	114.88	3.26	139.67	4.27	163.03	4.88
SES	50.83	11.07	46.62	11.86	48.45	12.46
Raven's IQ	109.90	13.46	109.06	10.75	110.40	13.68
PIQ	109.71	11.21	103.56	10.38	103.14	13.47
No. Words	244.75	125.90	240.18	82.49	259.82	80.05
No. T-U's	32.85	14.76	29.88	9.67	31.27	9.53
ML T-U's	7.35	.93	8.03	1.05	8.35	1.23
No. TS	4.21	3.16	4.75	4.56	9.31	6.92
TS/W	.02	.01	.02	.02	.04	.02
Supp. Per.	1.69	1.79	2.60	3.04	5.25	4.78
Disjun.	.75	1.42	.54	.90	1.35	1.51
OTS	1.77	1.94	1.60	2.05	2.71	3.19
Supp. Per./W	.01	.01	.01	.01	.02	.02
Disjun./W	.00	.01	.00	.00	.01	.01
OTS/W	.01	.01	.01	.01	.01	.01
Neimark	.71	.14	.75	.16	.87	.13
Piaget	3.27	1.30	4.17	.72	4.79	.90
Weitz	24.17	4.40	27.17	3.98	30.67	5.89

INTERCORRELATIONS OF ALL VARIABLES FOR GRADE 4

Variable No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	1.00																	
2. SES	.04	1.00																
3. Raven's IQ	.09	.31	1.00															
4. PIQ	.10	.11	.37	1.00														
5. No. Words	.21	.12	.36	-.01	1.00													
6. No. T-U's	.19	.13	.36	-.06	.97	1.00												
7. ML T-U's	.13	.02	.12	.22	.44	.24	1.00											
8. No. TS	.32	.21	.35	.46	.41	.35	.50	1.00										
9. TS/W	.26	.18	.13	.52	-.10	-.17	.33	.81	1.00									
10. Supp. Per.	.41	.10	.04	.32	.34	.31	.23	.60	.86	1.00								
11. Disjun.	.09	.11	.24	.17	.00	-.08	.46	.43	.40	-.16	1.00							
12. OTS	.08	.16	.36	.32	.36	.34	.27	.76	.53	.17	.12	1.00						
13. Supp.Per./W	.28	.10	-.10	.34	-.11	-.14	.08	.41	.64	.86	-.14	-.02	1.00					
14. Disjun./W	.09	.08	.19	.14	-.06	-.14	.42	.38	.42	-.16	.98	.04	-.10	1.00				
15. QTS/W	.04	.12	.19	.39	-.01	-.02	.14	.60	.62	.04	.08	.88	.02	.05	1.00			
16. Neimark	.12	-.06	.14	.01	.28	.24	.24	.18	-.02	.08	.12	.13	-.03	.08	-.06	1.00		
17. Piaget	.36	.06	.32	-.02	.28	.28	.15	.18	.09	.10	.11	.13	-.01	.11	.08	-.06	1.00	
18. Weitz	-.02	.07	-.02	.12	-.13	-.10	-.18	-.19	-.03	.03	-.11	-.26	.10	-.02	-.14	-.16	-.27	1.00

INTERCORRELATIONS OF ALL VARIABLES FOR GRADE 6

Variable No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	1.00																	
2. SES	-.12	1.00																
3. Raven's IQ	-.54	.26	1.00															
4. PIQ	-.12	.32	.28	1.00														
5. No. Words	-.12	.03	.05	-.00	1.00													
6. No. T-U's	-.15	-.05	.04	-.04	.94	1.00												
7. ML T-U's	.05	.17	.06	.05	.36	.03	1.00											
8. No. TS	.07	.47	.10	.23	.26	.14	.30	1.00										
9. TS/W	.13	.47	.14	.20	-.15	-.23	.13	.86	1.00									
10. Supp. Per.	.14	.42	.05	.28	.23	.11	.30	.84	.72	1.00								
11. Disjun.	-.06	.34	.22	.21	.32	.18	.36	.76	.60	.55	1.00							
12. OTS	-.02	.28	.06	.01	.10	.06	.05	.64	.58	.15	.44	1.00						
13. Supp.Per./W	.22	.41	.07	.23	-.04	-.12	.18	.68	.76	.91	.38	.00	1.00					
14. Disjun./W	-.09	.31	.26	.18	.00	-.12	.28	.57	.63	.39	.87	.32	.35	1.00				
15. OTS/W	-.02	.18	.06	-.01	-.22	-.22	-.10	.42	.55	-.06	.23	.91	-.09	.28	1.00			
16. Neimark	-.26	.27	.18	.16	.18	.14	.12	.22	.23	.27	.15	.03	.29	.18	-.04	1.00		
17. Piaget	-.19	.20	.16	-.04	.19	.15	.10	.19	.13	.13	.15	.16	.10	.04	.08	.14	1.00	
18. Weitz	-.14	.23	.26	.34	.00	-.01	-.04	.30	.30	.30	.20	.14	.27	.14	.13	.40	.38	1.00

INTERCORRELATIONS OF ALL VARIABLES FOR GRADE 8

Variable No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	1.00																	
2. SES	-.15	1.00																
3. Raven's IQ	-.35	.29	1.00															
4. PIQ	-.50	.06	.26	1.00														
5. No. Words	-.13	.18	.23	.20	1.00													
6. No. T-U's	-.24	.15	.36	.19	.89	1.00												
7. ML T-U's	.18	.05	-.14	.05	.34	-.12	1.00											
8. No. TS	.09	.11	.24	.09	.43	.32	.31	1.00										
9. TS/W	.17	.04	.14	.03	.04	-.04	.22	.90	1.00									
10. Supp. Per.	.06	-.06	.10	.02	.46	.34	.32	.81	.67	1.00								
11. Disjun.	.04	.13	.20	.10	.26	.14	.35	.67	.64	.34	1.00							
12. OTS	.08	.26	.28	.12	.12	.12	.02	.63	.65	.10	.46	1.00						
13. Supp.Per./W	.12	-.13	.01	-.03	-.13	.02	.27	.73	.74	.91	.32	.06	1.00					
14. Disjun./W	.08	.16	.15	.06	.08	-.02	.31	.62	.68	.28	.96	.47	.31	1.00				
15. OTS/W	.13	.18	.17	.07	-.12	-.10	-.06	.50	.64	-.02	.38	.93	-.01	.44	1.00			
16. Neimark	.13	.37	.20	-.02	.19	.25	-.08	.15	.04	.15	.06	.09	.05	-.01	.01	1.00		
17. Piaget	.01	.43	.20	.35	.14	.06	.16	.18	.15	.13	.07	.17	.13	.05	.09	.28	1.00	
18. Weitz	-.19	.33	.40	.28	.37	.35	.14	.20	.01	.26	.11	-.01	.10	.01	-.12	.31	.42	1.00