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ABSTRACT

Two basic requirements for the successful initiation of a program for test assembly are the development of detailed item content classification systems and the delineation of the professional judgements made in building a test from a pool of items to detailed content, ability, and statistical specifications in terms precise enough to be translated into computer programs. A guiding principle has been that the computer is to serve the professional staff, not supersede them. Every test assembled is subject to professional review; revisions can be requested; and the items selected are held "in limbo" until the test has been accepted. The systems development turned out to be much more sophisticated than originally expected. It is undoubtedly more complex than would be required for most testing situations since it is designed to handle a wide variety of tests in each subject area and the numerous constraints that are imposed on item selection by the rigorous test specifications and need for parallelism of forms that is basic to some of Educational Testing Service's (ETS) national programs like the College Board tests. In addition to a unique identification number and the classification for each item, the computerized file contains a complete history of the item's uses, up to five sets of statistics, codes for the security level and present activity status of the item, and up to 15 12-letter key words--which in the case of some verbal items constitute the complete items. (Author/BJG)

COMPUTER ASSISTED ASSEMBLY OF TESTS

at Educational Testing Service

A paper presented at

The Computer Assisted Test Construction Conference

San Diego, California

October 1974

Educational Testing Service
Princeton, New Jersey

Computer Assisted Assembly of Tests at Educational Testing Service

Toward the end of 1966, the Test Development and Data Processing Divisions at ETS began working together on the development of an operational system for assembly of tests by computer. This work was preceded by almost two years of experimentation and planning, including a simplified pilot assembly of a mathematics achievement test and the development of a mathematical model for the simulation of the logical processes involved in the selection of reading comprehension passages, to demonstrate feasibility.

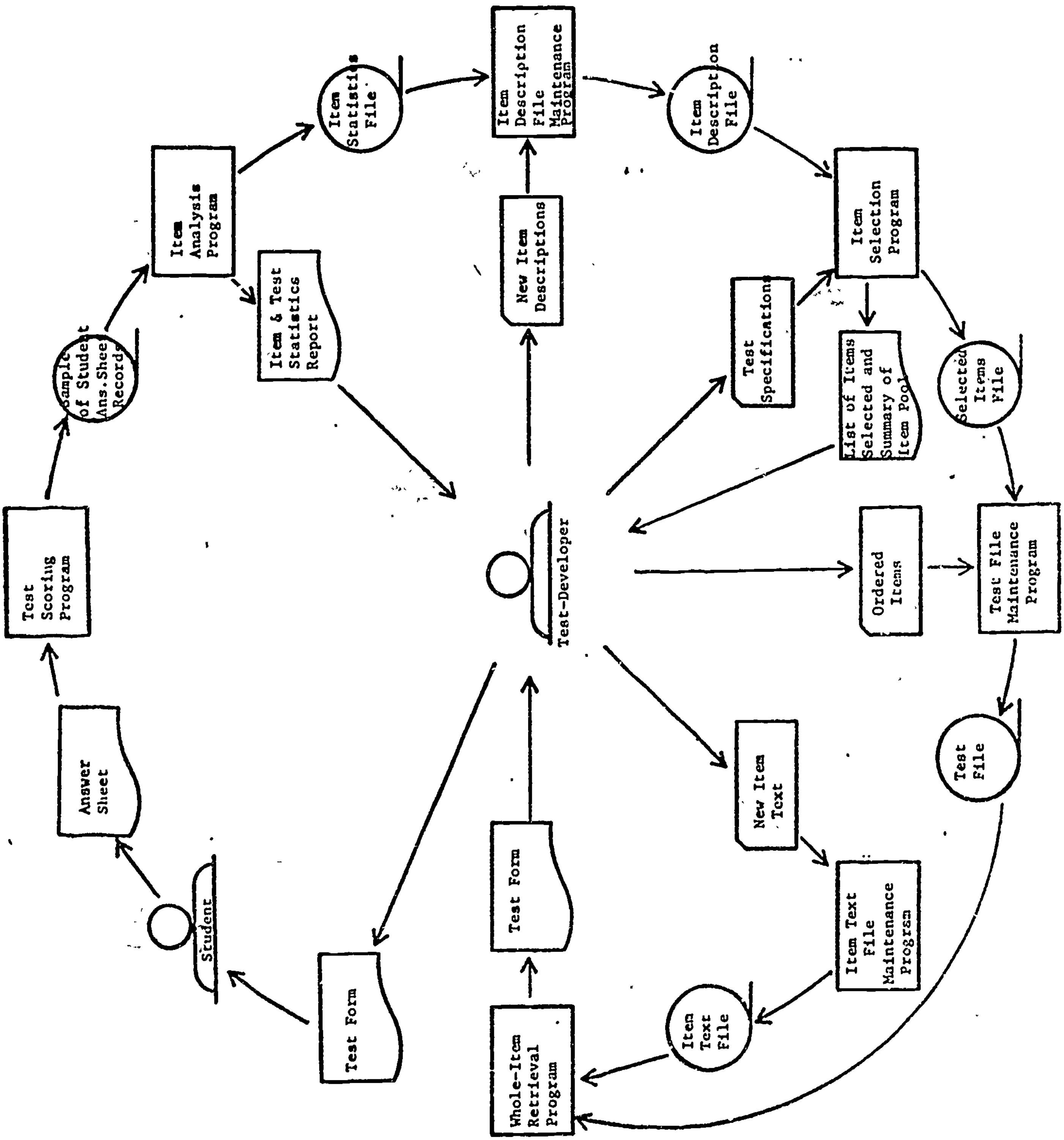
The Verbal Aptitude and Mathematics areas were selected for the first phase because the item pools were largest, the number of tests to be assembled each year were greatest, and the SAT test-specifications most detailed and rigorous. Any system capable of assembling these tests could be easily adapted for other subject areas. Aptitude Tests have been routinely assembled by computer since 1968. We have also experimentally assembled mathematics achievement tests and have pilot tested the adaptation of the system to social studies by assembly of American History Tests. However, we have not pressed the expansion of the system to other areas because of some problems in developing classification systems and the realization that the present procedure is not cost effective in areas with relatively small item pools and infrequent test assemblies. Our present computerized item files include about 15,000 Verbal items, 12,000 Mathematics items and several hundred American History items. The flexibility of the system has been demonstrated by the adaptation and simplification of the program packages for a Russian Language pool for the Defense Language Institute.

It was agreed from the outset that there were two basic requirements for the successful initiation of any such program - the development of detailed item content classification systems and the delineation of the professional judgments made in building a test from a pool of items to detailed content, ability, and statistical specifications in terms precise enough to be translated into computer programs. Our guiding principle has been that the computer is to serve the professional staff, not supersede them. Every test assembled is subject to professional review; revisions can be requested; and the items selected are held "in limbo" until the test has been accepted. The accompanying figure shows the interaction between the test developer and the computer.

The systems development turned out to be much more sophisticated than we had originally expected. It is undoubtedly more complex than would be required for most testing situations since it is designed to handle a wide variety of tests in each subject area and the numerous constraints that are imposed on item selection by the rigorous test specifications and need for parallelism of forms that is basic to some of ETS's national programs like the College Board tests. In addition to a unique identification number and the classification for each item, the computerized file contains a complete history of the item's uses, up to five sets of statistics, codes for the security level and present activity status of the item, and up to fifteen twelve-letter key words - which in the case of some verbal items, constitute the complete items.

The basic computer programs in the system are a file maintenance package and an item selection package. The comprehensive inventories produced almost as a by-product of the selection package have turned out to be one of the most valuable features of the system. By providing a summary of items available for any category by difficulty level and discrimination index, they are an invaluable guide to where attention should be focused in item writing to keep a balanced pool. It is also possible to determine whether our item pools are adequate to meet requests for special tests and to assemble them quickly. An example of an inventory print-out for one type of verbal items is attached.

The selection program is not a simple item retrieval system; rather it is designed to fit multidimensional test specifications. Control of the test assembly process remains in the hands of the test developer because it is he who determines the specifications and reviews the product. When tests are requested from the computer, the statistical specifications provided must include acceptable ranges of means and standard deviations of difficulty and discrimination indices, and item selection is guided by designating the number of items need from each major category and for each minor category digit,


Item Statistics File
Item Description File Maintenance Program
Item Description File
Item Analysis Program
New Item Descriptions
Item Selection Program
Item & Test Statistics Report
Test Specifications
List of Items Selected and Summary of Item Pool
Selected Items File
Sample of Student Ans. Sheet Records
Test Scoring Program
Test-Developer
Ordered Items
Test File Maintenance Program
Test File
Answer Sheet
New Item Text
Student
Test Form
Item Text File Maintenance Program
Test Form
Item Text File
Whole-Item Retrieval Program

ANTONYMS - SAMPLE INVENTORY Free Use Items (SAT)

1168 ITEMS ARE IN THE REDUCED POOL

MEAN DELTA = 12.31
DELTA STD DEV = 2.7357

MEAN R-BIS = 0.426

DELTA	FREQUENCY
0.0 - 4.9	7
5.0 - 5.9	26
6.0 - 6.9	15
7.0 - 7.9	30
8.0 - 8.9	73
9.0 - 9.9	75
10.0 - 10.9	119
11.0 - 11.9	121
12.0 - 12.9	181
13.0 - 13.9	199
14.0 - 14.9	114
15.0 - 15.9	126
16.0 - 16.9	61
17.0 - 17.9	10
18.0 - 18.9	9
19.0 - 19.9	2
20.0 - 26.0	

R-BIS	FREQUENCY
0.0 - 0.09	
0.10 - 0.19	
0.20 - 0.29	176
0.30 - 0.39	306
0.40 - 0.49	310
0.50 - 0.59	284
0.60 - 0.69	92
0.70 - 0.79	
0.80 - 0.89	
0.90 - 0.99	

DELTA	R-BIS 0.0 - 0.09	0.10 - 0.19	0.20 - 0.29	0.30 - 0.39	0.40 - 0.49	0.50 - 0.59	0.60 - 0.69	0.70 - 0.79	0.80 - 0.89	0.90 - 0.99	MEAN R-BIS
0.0 - 4.9				2	1	4					.467
5.0 - 5.9				9	9	8					.445
6.0 - 6.9				3	4	5	3				.481
7.0 - 7.9				7	6	10	7				.501
8.0 - 8.9			1	15	15	25	17				.496
9.0 - 9.9			2	13	15	32	13				.492
10.0 - 10.9			2	18	37	43	19				.493
11.0 - 11.9			1	19	34	52	15				.488
12.0 - 12.9			6	39	70	54	12				.459
13.0 - 13.9			20	56	81	39	3				.420
14.0 - 14.9			16	60	31	5	2				.370
15.0 - 15.9			78	39	3	5	1				.292
16.0 - 16.9			35	21	3	2					.299
17.0 - 17.9			9		1						.266
18.0 - 18.9			5	4							.279
19.0 - 19.9			1	1							.295
20.0 - 26.0											
MEAN DELTA			15.2	12.9	11.9	11.0	10.3				

ANTONYM INVENTORY (Continued)

SUMMARY OF CONTENT

LEVEL	DIGIT 1	2	3	4	5	6	7	8	9
0				1	1	1168	1168	1168	1168
1	282	604	839	337					
2	302	564	326	308	1				
3	214		3	510					
4	352			12					
5	18								
6					1163				
7									
8					3				
9									

MINOR CONTENT MEAN DELTA

LEVEL	DIGIT 1	2	3	4	5	6	7	8	9
0				9.10	13.30	12.31	12.31	12.31	12.31
1	12.80	12.54	12.38	11.80					
2	11.77	12.06	12.13	12.39	6.90				
3	11.55		10.56	12.58					
4	12.84			12.90					
5	12.07								
6					12.30				
7									
8					15.73				
9									

MINOR CONTENT MEAN R-BIS

LEVEL	DIGIT 1	2	3	4	5	6	7	8	9
0				.429	.349	.426	.426	.426	.426
1	.418	.418	.423	.439					
2	.435	.433	.433	.420	.309				
3	.424		.463	.420					
4	.424			.414					
5	.428								
6					.426				
7									
8					.256				
9									

indicating acceptable limits by requesting exactly so many items, at least so many items, or at most so many items. The computer surveys the entire pool, produces a reduced item pool of all those items that could be eligible for the particular test, and then begins a selection process by assigning a priority number to each item according to a complex procedure.

The highest priority item is then selected. This means that the entire pool of items is searched every time an item is selected. Therefore, it can be stated that every item is picked specifically because it best meets the specifications. After each item is selected, new priority numbers are assigned to a further reduced pool. In the verbal assembly package, an array of key words used is added to and checked after each item is selected since specifications require that no substantive word be used more than once in a test. Controls are built-in through the priority number computation to insure leaving the pool as balanced as possible after a test is selected to maximize the number of parallel tests that can be assembled.

Items are classified (and it follows that tests can be assembled) on the following parameters:

- Delta - difficulty of the item as determined by item analysis. A distribution across 15 delta levels may be specified for the test assembly as well as test mean and standard deviation. Furthermore, the item selection program allows for delta scaling "on the fly" for compensation across testing programs (or grade levels).
- R-bis - discriminating power of item as determined by item analysis. Required test mean and standard deviation are specified for assembly.
- Content - a nine-digit classification scheme to describe item content can be accommodated by the system. Furthermore, items can be classified into broad major categories within an overall subject. The semantics of this classification scheme are independent of the program.
- Item Security/Item Activity - two codes to indicate the current use or status of the item.
- Key Words - up to a dozen 15-character words appearing in or

descriptive of the item.

There are three primary files associated with the CAAT System.

- The Item Description File contains: 1) item classification data, 2) up to 10 previous uses of the item (tests in which it has appeared), 3) up to five complete sets of item analysis statistics, and 4) key words.
- The Test Description File is a history of which tests have used which items. For each test, items are listed in the order they appeared within each test section. This provides the means of matching new Item Analysis data to the items in the Item Description File, since the CAAT item identification numbers (accession numbers) are not known by the Item Analysis program.
- The Selected Items File is a transient storage area for tests which have been selected by CAAT but not yet approved by the test developer. When final approval has been given, the test is removed from the Selected Items File, added to the test file and the corresponding Item Description records are updated to reflect the new use.

The basic content classification format allows for any number of four-letter major categories, and within each of these categories up to nine digits, each with ten levels - a staggering number of possible unique classifications. In Verbal Aptitude, the major categories are acronyms for item types such as ANAL for analogies, ANTM for antonyms or RC for reading comprehension; in Mathematics they are broad content areas such as ALGB for algebra. The digits are used for finer classifications of content or item type and for such things as grade level, and type of thinking or ability tested. A basic requirement is that a group developing and using such a system agree on the meaning of a classification and use it consistently, since the computer couldn't care less what the letters and numbers stand for.

In developing subject-matter classifications, we have tried to make them detailed enough to be useful for the assembly of unit and end-of-course tests as well as broad survey-type tests such as the College Board Achievement Examinations. In developing ability classifications in each subject area, we have tried to reflect the objectives of education in the field in terms of cognitive levels or thought processes. Our present classifications may not be detailed enough for diagnostic testing within topics but there is room enough in the classification system to add this type of detail if it should become desirable. Although we have not yet tried it, we think we can use a combination of the content and ability dimensions to match individual school's behavioral objectives should we move to assembling tests on request for this purpose.

In planning the system, we developed a content classification format that can, hopefully, be generalized to all subject areas without limiting flexibility. The approach to content classification is completely different for mathematics and verbal items, with social studies more similar to mathematics, but the format looks the same to the computer and the same programs can be used for file development and maintenance and for making inventories of the pool. The item selection logic is fundamentally similar with some adaptation for special problems in each area. Attached to this paper are sample classifications of a mathematics, a verbal aptitude, and a social studies item. As mentioned before, for verbal items, the major classifications are item types with the digits used for finer distinctions and grade level. For mathematics and social studies, the major classifications are broad, horizontal subject-matter categories such as ARIT for Arithmetic or AMHY for American History. In mathematics the first digit, which we call a major-minor category, is used for up to ten large subdivisions of each major area such as algebraic operations or linear functions in Algebra. The second and third digits refer to the first digit and theoretically, if not practically, provide the possibility of 100 sub-classifications for each major-minor category and 1000 unique classifications within each major area. The fourth and fifth digits are not being used at this time in mathematics but are available for finer classifications. To our classifiers, "happiness is the fourth and fifth digit."

Digits 6-9 have been assigned the same meaning overall mathematic questions as follows:

Digit 6 controls with respect to curriculum and has three levels of traditional versus modern subject matter and symbolism.

Digit 7 indicates grade level from 1 for primary to 9 for advanced college level.

Digit 8 describes the nature of the setting to insure variety in appearance and tasks. The ten levels distinguish between abstract and concrete settings, with and without figures or graphs, etc.

Digit 9 we call the ability process dimension. It is a hierarchial classification into six levels which is our pragmatic adaptation of the Bloom taxonomy to mathematical problems and abilities to be tested.

In social studies, the use and pairing of digits varies with the major category except that digits 7-9 are used across all areas for grade level, type of stimulus, and ability tested. All nine digits are used for History.

The task of classifying all the old items in our files and transcribing the data has been and continues to be a mammoth and incomplete one. However, new items are classified when written and put on tape immediately and a system has been developed for linking item analyses directly with the computerized item files.

The computer output from the test selection process is a listing by major category of item accession numbers with classification, delta (difficulty index) and r-biserial and any key words available. Summary statistics are provided for each category and the test as a whole along with an inventory of all items in the reduced pool from which the test was chosen.

As described above, the primary output of the present system is a list of item numbers. The actual items are retrieved manually, put into an appropriate order within the test, typed, and printed. The desirability of automating this

SAMPLE CLASSIFICATIONS

Mathematics

A	R	I	T	1	2	5	Ø	Ø	2	4	5	3

The above classification describes an arithmetic item testing powers/roots of odd/even integers. The content is modern; grade level, junior high school setting, abstract, numbers only; ability level, comprehension of a concept.

Verbal

A	N	T	M	3	2	1	3	6	Ø	Ø	Ø	Ø

The above classification describes an antonym item in which the stem has a science connotation. It tests a fine distinction; it is a single word (as opposed to a phrase); which is an adjective. The "grade level" is appropriate for SAT (11th-12th grade).

Social Studies

W	E	H	Y	4	2	3	3	2	5	4	4

The above classification describes an item in the history of Western Europe. Chronologically, it is 16th century; geographically, France; its subject matter is Governmental Institutions and the emphasis is Political-internal. The "grade level" is College specialized. The item is based on a quotation and the ability level being measured is application.

process has been recognized from the start of the development of CAAT, and studies of Whole Item Storage and Retrieval (W.I.S.A.R.) have been undertaken. The main difficulty has been in the handling of graphic items (pictures, charts, etc.). To achieve the quality of reproduction that has become standard at ETS would require very expensive hardware. Similarly, although not as severe a limitation, the type fonts available on a high-speed printer are not of the accustomed quality. ETS currently uses IBM Executive Selectric typewriters for final copy of examination booklets.

For demonstration purposes, a Whole Item Storage and Retrieval System has been implemented as an adjunct to the CAAT system. The programs were developed external to ETS and have been adapted with the help and kind cooperation of their author Dr. Willard Brown, Western Washington State College, Bellingham, Washington. Dr. Brown's program has been modified to type test copy using the CAAT Test File as its source of item numbers. IBM Selectric typewriter terminals may be used, however there is no graphic capability other than creative combination of type characters.

All of us involved in computerized assembly of tests at ETS are aware that what we have accomplished is a major step but only a first one. One continuing problem is the time and money for development of sufficiently large and diverse pools of pretested items in other subjects to have available questions at different levels of difficulty within each content and ability classification so that the computer can assemble tests to specifications with minimal compromises. Although the system contains the capacity to apply a linear adjustment to the difficulty indices if an item is to be used at a different level, we have not yet been able to do the studies necessary to ascertain appropriate adjustment factors. We continue to search for a satisfactory method of whole item storage and retrieval, looking toward both computerized test production and printing and interactive testing using computer terminals. Although hardware and technology for these already exist, we have not yet found it economically possible or the output of high enough quality for our present special requirements - particularly since so many of our test questions use nonverbal stimuli such as figures, graphs, cartoons, etc.

What lies ahead for the future? If the use of the system is to be expanded, we must move to whole item storage with tests being produced as computer print-out or transmitted to remote terminals for individualized interactive testing at consoles. If, as seems likely, the need for large national administrations of tests for selection diminishes, there will be little impetus for expanding the present system of computer assisted test assembly. Instead, its greatest potential would seem to be its adaptation for the assembly of customized tests from item pools for guidance, placement, and evaluation, for individualized interactive testing, and for test administrations at computer terminals with immediate scoring and feedback. The technology for all of these already exists; what is still needed is time and money for development and the ability to make the procedures cost effective.

Discussion

Insofar as the objective, the developing of a reliable, inexpensive methodology for observing father behavior under natural conditions is concerned, it appears to have been attained. The technique of observing fathers interacting with preschool children at home with no other family member present was found to be relatively inexpensive, acceptable to 3 social classes, and reliable in terms of collection of data and in coding of data. The procedure should be useful to those interested in father behavior as a dependent or independent variable, e.g., as a consequence of unemployment or a cause of child aggression. It should be noted that paternal interactions with preschool children would quite likely be different under different circumstances in the home. An analysis of observational data obtained at the end of the interview when the father was observing his child trying to complete a task indicated that there were low, although significant correlations with paternal behaviors during the interview when the child was not engaged in a mastery effort and the father was focused on the youngster (Radin & Epstein, 1975). Even more important, the correlational pattern between child cognitive measures and observed paternal behaviors when the child was completing a task was completely different than the pattern reported in this paper. Thus, although it can be said that a methodology has been developed for observing fathers at home interacting with preschoolers when other members of the family are not present, one cannot assume that this observational technique represents a sampling of all father behaviors under those circumstances. The problem of sampling is endemic to ethological techniques, as Lytton (1971) has pointed out. Thus in addition to the differential behavior observed in laboratory and home setting described by Lytton (1973), one must be aware that there is differential behavior within

~~the home~~ given different conditions, even when the individuals present are held constant. However, to obtain information about paternal behavior when the father is distracted by other activities, a condition not atypical in the average home, it can be said that a reliable, easily implemented procedure has been developed in this investigation.

The hypotheses concerning significant relations between nurturant paternal behavior and child cognitive measures was supported, but only for boys, and for middle- and working-class boys. These findings are in keeping with those obtained in the pilot study for the project (Radin, 1972), and with results found by Pederson, Rubenstein, and Yarrow (1973). For boys as a group, and for each class subgroup of boys, there was at least one observed father behavior factor which correlated significantly with a cognitive measure. For middle-class boys, two significant factors were obtained which together accounted for almost one-third of the variance in the child's IQ. The usual social class indicators were essentially irrelevant in predicting boys' cognitive scores; it was paternal behavior that was more critical. It must be acknowledged that the causal direction may be reversed, as Bell (1968) and Osofsky & O'Connell (1972) have stressed; the children's cognitive ability may be eliciting specific types of paternal behaviors. It is also possible that a third variable is causing both father and child behavior and/or that the effect is circular with both father and son affecting one another's behavior. The question cannot be settled in a correlational study such as this. It does seem legitimate to hypothesize, however, that the father's behavior was having some influence on the child's cognitive competence.

Although father behavior can be said to be significantly associated with cognitive competence in four-year-old boys of all social classes, there were sharp differences in the type of paternal behavior which was found to be important in the lower class as contrasted with the middle and working class. For the lower class, only the absence of verbal restrictiveness, fostered cognitive functioning. No set of behaviors enhanced cognitive performance. The fact that there was no significant difference in the amount of verbal restrictiveness present in the three classes highlights the unique pattern present in the lower class.

Perhaps the role played by paternal verbal restrictiveness can be better understood if examined in the light of the set of behaviors labelled Positive Response to Child and Cognitive Stimulation. For this factor, there were significant class differences in number of behaviors observed. As was found by Sears, Maccoby and Levin (1957), Kamii (1965), and in the pilot study (Radin, 1972), the lower class had significantly fewer behaviors of this type than either the middle or working class. This finding, combined with the positive association between these nurturant behaviors and cognitive measures in the middle-class and working class suggests that there may be a floor below which paternal nurturance has no effect. A certain minimum amount may be needed to influence cognitive functioning in the child or to influence the mediators between paternal behavior and cognitive competence of the preschooler. An alternate explanation is that other class-linked variables such as hunger, crowding, poor health and norms valuing physical prowess over intellectual pursuits may dilute the positive relationship between paternal warmth and the cognitive functioning of the young boy in lower-class families. Thus sufficient nurturance may be present but its effect may be counteracted in certain contexts. The data also suggest that the impact of restrictiveness may be affected by its context in which it is embedded. In the lower class where there is less positive responsiveness or nurturance for the four-year-old boy, restrictiveness may have a detrimental effect on the youngsters' intellectual functioning. In the middle and working class where there is more paternal warmth and stimulation, an equal amount of restrictiveness may be innocuous.

The factor Positive Responsiveness and Cognitive Stimulation, which proved to be the most important set of paternal behaviors for boys' cognitive competence resembles the growth-producing factor obtained by Clarke-Stewart (1973), who observed lower and working-class mothers interacting with infants up to 18 months of age. The one factor Clarke-Stewart found to be most highly associated with competence in the child included expression of affection, contingent responsiveness, verbal stimulation, stimulation with objects, and acceptance of the child's behavior. Clarke-Stewart labelled this factor "Optimal Care". That label would have been appropriate in this study as well. Yarrow (1963) also found both maternal stimulation and affection were related to IQ in adopted infants. Another way of conceptualizing the factor Positive Response and Cognitive Stimulation is to perceive it as a combination of what Hoffman (1970) has referred to as induction, plus affection. The data from this investigation suggest it would be difficult to separate these paternal behaviors with four-year-old boys; warmth and intellectual stimulation seem to be inherently linked.

The hypothesis that motivation to achieve would mediate the relationship between paternal behavior and boys' cognitive measure in all social class was partially confirmed. Motivation, as assessed by behavior while taking the Stanford Binet, mediated the relationship between intellective scores and paternal responsiveness for all boys, and for working-class and middle-class boys. In all of the above instances, paternal nurturance enhanced the boys' motivation to achieve or master the task before him, and this enhanced motivation in turn enhanced his score. When the motivation factor was controlled, there was no longer any link between father and son behaviors. Motivation also mediated the negative relationship between IQ and paternal controlling behavior in the middle class, and between Piaget MTP and paternal restrictiveness in the lower class. Here the linkage functioned somewhat differently. These paternal behaviors reduced the child's motivation, and this diminished motivation reduced the cognitive score. It appears that there is a type of mastery motivation which is responsive to father behavior and which affects the child's cognitive performance. There were, however, associations between paternal behavior and cognitive scores of sons not mediated by the mastery motivation factor. Thus is appears that motivation is only one mediator of the relationship between paternal behavior and intellectual functioning of the preschool boy. Possibly another relates to the degree of identification with the father, a variable not explored in this study.

The fact that the motivation measure employed in this study yielded meaningful data with all three cognitive scores, including two which were administered in a different week and by another examiner suggests that the items on the face sheet of the Binet may be a fruitful technique of tapping the child's adaptive responsiveness to tasks put before him. Motivation While Taking the Binet warrants further exploration with other age groups and other populations.

The hypothesis regarding the relationship between paternal behavior and the cognitive competence of four-year-old girls was essentially disconfirmed. There was only one significant association between an observed father factor and an intellective score for girls, and this may have well been due to chance factors. The regression equations did suggest that some paternal behaviors might affect the cognitive functioning but the presence of suppressor variables makes the relationship tenuous. For example, it was only when one father factor was held constant in the middle class and working class, that any father factor became a significant predictor. The more outstanding finding emerging from the regression equation involving girls was that there was one significant predictor for all girls with all three cognitive measures and that was father's occupation. The higher the status of the occupation, the higher the girl's score. This finding tends to support Bayley and Schaefer's (1964) view that this may be a genetic factor influencing girls' intellective abilities which is not operative with boys. In this day of automatic promotions and pressures to stay in school, educational level may be less reflective of inherent ability than occupational level.

Whether or not a genetic factor is affecting girls more than boys, an examination of the factor structure undergirding observed father behavior with daughters sheds some light on the seeming disconnection between a father's behavior and his daughter's intellective functioning. Over half of the explained variance and 1/3 of the total variance in father behavior with girls was accounted for by mixed messages. For boys, all four factors reflected either clearly nurturant or clearly restrictive messages with the two restrictive factors being detrimental to the child's cognitive functioning and one of the nurturant factors appearing to be enhancing. For girls, the one restrictive factor did no harm; the two nurturant factors did not help cognitive development. Perhaps the ambivalent messages tended to alienate the girl from her father so that his other unambivalent behaviors neither helped nor hurt her. These findings are all the more provocative in view of the fact that only two of the individual 26 father behaviors coded showed significant sex differences. It was clearly the clustering that differed in father behavior with sons and daughters, not specific frequencies.

The finding that there were virtually no predictors of girls' cognitive functioning except father occupation, a structural, non-explanatory variable, leads to speculation about other factors that might be having a positive influence on the young girls' functioning. There is ample evidence from the literature to suggest that four-year-old girls are using their mothers as the prime model. Radin's (1974) previous study of mothers, using a methodology similar to that employed in this investigation, indicated that maternal nurturance is associated with cognitive competence in preschool daughters but not in preschool sons. These findings dovetail with those obtained in the current study. Hetherington and Frankie (1967) found that nursery and kindergarten-aged girls imitated their mothers more than their fathers. Further, an investigation by Lynn and Cross (1974) indicated that 4-year-old girls preferred to play with their mothers, in contrast with 2 and 3-year-old girls who preferred their fathers. Lynn & Cross attributed this finding to pressure on 4-year-old girls to be concerned with their sex role but felt more research was needed to determine the underlying cause of this pressure. Perhaps the mixed message coming from fathers of these youngsters is a relevant factor.

Although mothers were not included in this investigation, there was indirect evidence from the data suggesting that the girls were indeed modeling their mothers and highly influenced by them. One of the factors on the Cognitive Home Environment Scale, the instrument administered during the interview, provided some clues. The factor was labelled Mother Stimulates (the other four factors obtained all pertained to fathers. They were Future Expectations for Child, Grades Expected, Father Stimulation, and Use of External Resources.) The three items with the highest loadings on the Mother Stimulates factor were Educational Gifts purchased, Craft Items in the Home, and Mother Assists the Child to Learn. When the Mother

Stimulates factor was correlated with Binet IQ of the child, one significant correlation was obtained; for middle-class girls there was a positive correlation of .47($p < .001$). For all other groups the correlation was below .19. Similarly there was only one significant correlation between Mother Stimulates and Piaget Verbalization: for lower-class girls there was a positive correlation of .46($p < .05$). For all other groups the correlation was below .21. Thus it appears that mothers are differentially enhancing the intellective growth of their daughters. Since there were no significant sex differences in the factor, it is unlikely that mothers are trying to stimulate daughters more than sons. Rather, the impact is different. Further, in only one subgroup was the factor Mother Stimulates significantly correlated with the variable Child Initiates. For middle-class girls the correlation was .46($p < .01$), suggesting that middle-class assertive girls may be modeling their initiating mothers. This interpretation would be in keeping with the Robinson and Robinson (1968) interpretation of the Fels study data where an inference was made that achieving girls identify with their accelerating, somewhat aggressive mothers.

Finally, when regression equations were computed using the cognitive measures as dependent variables and the father factors, demographic data, and Cognitive Home Environment factors as independent variables, the factor Mother Stimulates was a significant predictor for girls' groups, not for boys' groups. With Binet IQ as the dependent variable, Mother Stimulates was the first and only significant predictor for middle-class girls. With Piaget Verbalizations as the dependent variable, Mother Stimulates was the first significant predictor to emerge for lower-class girls and the only factor with a positive beta weight.

From the above discussion it appears that fathers have little influence on their daughters except possibly through their ambivalent behavior to encourage the child to find another model with which to identify. However, a second CHES factor, Future Expectations, suggested that the father may influence his daughter indirectly, through his impact on his wife. Although virtually no father behavior was significantly associated with girls' intellective scores, fathers' expectations for the child correlated significantly with Binet IQ for all girls and with Binet IQ and Piaget Verbalizations for working-class girls. In addition, in the regression equations which included CHES factors, father behaviors and demographic data, Future Expectations was the only significant predictor of IQ for working-class girls, and the first significant predictor to emerge when Piaget Verbalization was the dependent variable. Thus it appears that paternal expectations, but not behaviors, affect their daughters' cognitive competence. Possibly, the father with high expectations for his daughter communicates this fact to his wife and she in turn modifies her behavior and becomes a more stimulating parent and model. Mothers may therefore serve as the mediator of paternal influence on four-year-old girls. Hetherington (1972) refers to the mother as the mediator of the effect of father absence on daughters' behavior with men. Hoffman (1970) describes the mother as the mediator of paternal power-assertiveness techniques. In this instance the maternal mediating effect is seen in a more positive light.

One issue which was not answered in this study was why fathers behave in an ambivalent way with their daughters and not their sons. Several hypotheses were tested and found unsupported. The possibility that fathers do not understand girls and do not know how to interact with them was tested by comparing the behavior factor scores of fathers of girls who had old daughters with the scores of fathers of girls without older daughters. There were no significant differences. The variable Child Initiates did show sex differences with boys having higher scores, but it is not clear why less assertive behavior by girls should foster paternal ambivalence.

The only tentative explanation that did emerge from the data was that middle- and working-class fathers appeared to have ambivalent attitudes toward assertive initiating girls. For example, in the middle class, the CHES factor, Future Expectations, was negatively correlated with the father behavior factor Attention to the Child's Verbalization, whereas his future expectations for his daughter were not related to any cognitive measure. Thus, the girl who talks a good deal, regardless of her ability, was expected to have a limited future in the middle class. A similar picture emerged in the working class. Girls who made more explicit demands, or were more assertive, were also seen as having poor future prospects. This inference was made from the negative significant correlation obtained between the father behavior factor Meeting and Ignoring Explicit Needs and the CHES factor Future Expectations. In contrast, Meeting and Ignoring Explicit Needs was positively correlated with future expectations for girls in the lower class at the .001 probability level. Possibly in this socio-economic stratum where women often serve as the major breadwinner, assertiveness is not seen as damaging but rather enhancing of future prospects. In the other social classes, fathers may be conflicted about aggressive daughters, and view their future as dim. This interpretation of fathers' reactions to assertive girls is highly speculative, of course, but the issue warrants further investigation.

In sum, paternal nurturant behaviors were associated with, and perhaps facilitate 4-year-old boys' intellective functioning while restrictiveness behavior appears to hinder it. The child's motivation to master tasks is one of the intervening variables in both cases. Paternal behavior appears to have little impact on his daughters' cognitive functioning, possibly because much of his behavior with her contains a mixed message, and this strengthens her tendency to use her mother as her major model. Thus it appears that both the child's sex role and motivation mediate the relationship between paternal behavior and the cognitive functioning in 4-year-old children. The applicability of this conclusion to non-white and non-Anglo populations remains to be tested.

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TABLE 1

Varimax Factor Matrix: Father Behavior with Boys

Variable	Positive Response to Child & Cognitive Stimulation	Empathy & Psychological Manipulation of Child	Prevention & Physical Control of Child (Physical Restrictiveness)	Verbal Restrictiveness	h^2
Verbal Reinforcement	.77	-.09	-.04	-.14	.62
Consulting	-.03	.85	-.01	-.15	.74
Order with Explanation	.60	.07	.09	.25	.44
Preventive Warning	-.00	.02	.76	-.03	.58
Bribing	-.06	.78	.04	.41	.78
Psychological Manipulation	.27	.50	.02	.31	.42
Preventive Manipulation	-.16	-.01	.63	-.07	.42
Correcting	.56	-.12	.11	-.01	.34
Fully Meeting Explicit Needs	.73	-.10	.10	.22	.60
Partially Meeting Explicit Needs	.50	-.04	.33	.17	.39
Not Meeting Explicit Needs	-.02	-.22	.45	.54	.54
Initiates Conversation	.54	.08	-.18	.02	.33
Stops Talking	.67	.01	.10	-.24	.61
Continues Talking	.43	-.01	.22	-.13	.25
Meeting Other Implicit Needs	-.06	.88	.00	.09	.78
Affection	.47	.15	-.04	.08	.26
Sharing	.02	.11	-.04	.30	.11
Requesting	.00	.06	-.12	.24	.07
Asks Information	.47	.05	-.21	-.09	.28
Aversive Order without Explanation	-.04	-.14	.02	.56	.34
Non-Aversive Order without Explanation	-.03	.15	.17	.79	.67
Threatening	.01	.24	-.04	.64	.47
Other Aversive Verbal	.03	-.01	-.05	.52	.28
Aversive Non-Verbal	-.06	-.02	.85	.02	.73
Physically Stops	.27	.04	.48	-.07	.31
(Factor loadings)^2 by column	3.60	2.59	2.46	2.51	11.20
% Total Variance Explained	.14	.10	.10	.10	.45

TABLE 2

VARIMAX FACTOR MATRIX: FATHER BEHAVIOR WITH GIRLS

Variable	Meeting & Ignoring Explicit Needs	Aversive & Non-aversive Control	Verbal Restrictiveness & Requesting	Empathy, Psychological Manipulation & Cognitive Stimulation	Attention to Child's Verbalizations	Physical Restrictiveness	h^2
Verbal Reinforcement	.47	.16	-.11	.63	.24	.16	.74
Consulting	-.08	-.13	.22	.50	.03	-.15	.34
Order with Explanation	.06	.78	.14	-.13	.27	.04	.72
Preventive Warning	.17	-.02	.06	-.16	.48	.00	.29
Bribing	-.12	-.06	-.03	.03	-.05	.32	.13
Psychological Manipulation	.24	.48	-.04	.55	.00	.29	.67
Preventive Manipulation	-.13	.89	-.02	.01	-.08	-.19	.85
Correcting	.12	.02	.32	.16	.78	.08	.76
Fully Meeting Explicit Needs	.79	.02	.07	-.11	.28	.04	.72
Partially Meeting Explicit Needs	.56	.03	-.06	.16	.08	-.03	.35
Not Meeting Explicit Needs	.78	.03	.21	.02	-.17	-.05	.68
Initiates Conversation	.35	.08	.12	.67	.32	-.18	.73
Stops Talking	.06	.13	-.12	-.04	.75	-.16	.62
Continues Talking	.55	-.04	.09	.06	.31	.09	.42
Meeting Other Implicit Needs	-.04	-.05	.10	.75	-.08	.18	.61
Affection	-.07	-.12	-.11	.37	.46	-.05	.38
Sharing	.06	.05	-.10	.17	.61	.05	.42
Requesting	.46	-.05	.55	.32	-.11	-.14	.65
Asks Information	.13	.07	.43	.57	.04	-.22	.58
Aversive Order Without Explanation	-.04	.09	.91	.04	.03	-.12	.86
Non-Aversive Order without Explanation	.10	.10	.78	.23	-.09	.03	.69
Threatening	.09	.88	.16	.08	-.05	.24	.88
Other Aversive Verbal	.09	.08	.71	-.04	.10	.36	.66
Aversive Non-Verbal	.46	.26	.03	.35	.15	.67	.85
Physically Stops	.10	.13	.08	-.23	.04	.79	.72
$(\text{Factor Loadings})^2$ by column	2.83	2.62	2.77	2.90	2.50	1.73	15.32
% Total Variance Explained	.11	.10	.11	.12	.10	.07	.61

TABLE 3

SIGNIFICANT CLASS DIFFERENCES IN OBSERVED FATHER BEHAVIOR FACTORS

Father Factor	1st Social Class Subgroup	Mean	SD	2nd Social Class Subgroup	Mean	SD	*t*
Positive Response to Child & Cognitive Stimulation	MC Boys	30.6	23.7	LC Boys	12.8	10.6	3.34**
	WC Boys	26.6	18.9	LC Boys	12.8	10.6	3.15**
Empathy & Psychological Manipulation	WC Boys	3.2	5.3	LC Boys	.9	1.2	2.09*
Attention to Child's Verbalizations	LC Girls	2.8	5.2	WC Girls	.7	1.1	2.16*
Meeting & Ignoring Explicit Needs	MC Girls	6.4	7.0	WC Girls	2.4	3.7	2.75*

Note: MC stands for middle class, WC for working class and LC for lower class.

** $p < .01$
* $p < .05$

TABLE 4

SIGNIFICANT CORRELATIONS BETWEEN OBSERVED FATHER BEHAVIOR FACTORS AND COGNITIVE MEASURES

Cognitive Measure	Sample	N	Father Behavior Factor	Correlation Coefficient
Binet IQ	All Boys	99	Positive Response to Child & Cognitive Stimulation	.25**
	MC Boys	37	" " "	.36*
	MC Boys	37	Preventive & Physical Control	-.41**
Piaget Verbalizations	All Boys	99	Positive Response to Child & Cognitive Stimulation	.38*
	MC Boys	37	" " "	.39*
	WC Boys	39	" " "	.39*
	LC Boys	23	Verbal Restrictiveness	-.45*
Piaget Mean Total Performance	LC Boys	23	Verbal Restrictiveness	-.41*
	LC Girls	21	Meeting & Ignoring Explicit Needs	-.50*

Note: MC stands for middle class, WC for working class, and LC for lower class.

** $p < .01$
* $p < .05$

TABLE 5

SIGNIFICANT PREDICTORS OF COGNITIVE MEASURES
IN STEPWISE MULTIPLE REGRESSION EQUATIONS

Dependent Variable	Subgroup	N	Significant Independent Variable	Sign. of Variable	Sign	Multiple R	Percent of Var. Exp.
Binet IQ	All Boys	99	Positive Response & Cog. Stim	**	+	.255**	.06
	MC Boys	37	Preventive & Phys. Control	**	-	.411**	.17
			Positive Response & Cog. Stim.	*	+	.546**	.30
Piaget Mean Total Performance	MC Boys	37	Father's Occupation	*	+[a]	.329*	.11
	LC Boys	23	Verbal Restrict.	*	-	.410*	.17
Piaget Verb.	All Boys	99	Positive Response & Cog. Stim.	***	+	.381***	.14
	MC Boys	37	" "	*	+	.393*	.15
			Empathy & Psych. Manipulation	*	-	.499**	.25
	WC Boys	39	Positive Response & Cog. Stim.	**	+	.388**	.15
	LC Boys	23	Verbal Restrict.	*	-	.477*	.20
Binet IQ	All Girls	79	Father's Occupation	***	-[a]	.411***	.17
Piaget Mean Total Performance	All Girls	81	Father's Occupation	*	-[a]	.227*	.05
	LC Girls	21	Meeting & Ignoring Explicit Needs	*	-	.496*	.25
			Phys. Restrictiv.	b	+	.573*	.33
			Aversive & Non-Aversive Verbal	*	-	.696**	.49
Piaget Verbal.	All Girls	81	Father's Occupation	***	-[a]	.351***	.12
	MC Girls	28	Phys. Restrictive.	b	-	.330	.11
			Father's Occupation	*	-[a]	.505*	.26
			Aversive & Non-Aversive Verbal	*	-	.625**	.39
	WC Girls	32	Meeting & Ignoring Needs	b	-	.263	.07
			Attention to Verb.	*	+	.463*	.19

a) The higher the status of the occupation the lower the rating. The - sign indicates that the higher the status of the occupation, the higher the cognitive measures. A + sign indicates the lower the status, the higher the cognitive measures.

b) A suppressor variable which was not itself significant.

*** $p < .001$
** $p < .01$
* $p < .05$

TABLE 6

PARTIAL CORRELATIONS BETWEEN FATHER BEHAVIOR FACTORS AND CHILD'S COGNITIVE MEASURES WITH SB MOTIVATION CONTROLLED

Subgroup	N	Father Factor	Cognitive Measure	Initial Correlation	Partial Correlation	(a) $z\sqrt{N-Y}$
All Boys	99	Pos. Response & Cog. Stim.	Binet IQ	.25**	.13	1.27
		" " " "	Piaget Verb.	.38***	.30	3.02**
MC Boys	37	" " " "	Binet IQ	.36*	.27	1.61
		" " " "	Piaget Verb.	.39*	.35	2.12*
		Prev. & Phys. Control	Binet IQ	-.41**	-.32	-1.89
WC Boys	39	Pos. Response & Cog. Stim.	Piaget Verb.	.39**	.29	1.78
LC Boys	23	Verbal Restrictiveness	Piaget Verb.	-.45*	-.47	-2.22*
		" "	Piaget MTP	-.41*	-.40	-1.83
LC Girls	20	Meeting & Ignoring Needs	Piaget MTP	-.50*	-.51	-2.24*

Note: MC stands for middle class, WC for working class, LC for lower class, and Piaget MTP for Piaget Mean Total Performance.

(a) Test for significance of a partial correlation (Hays, 1963)

*** $p < .001$
** $p < .01$
* $p < .05$

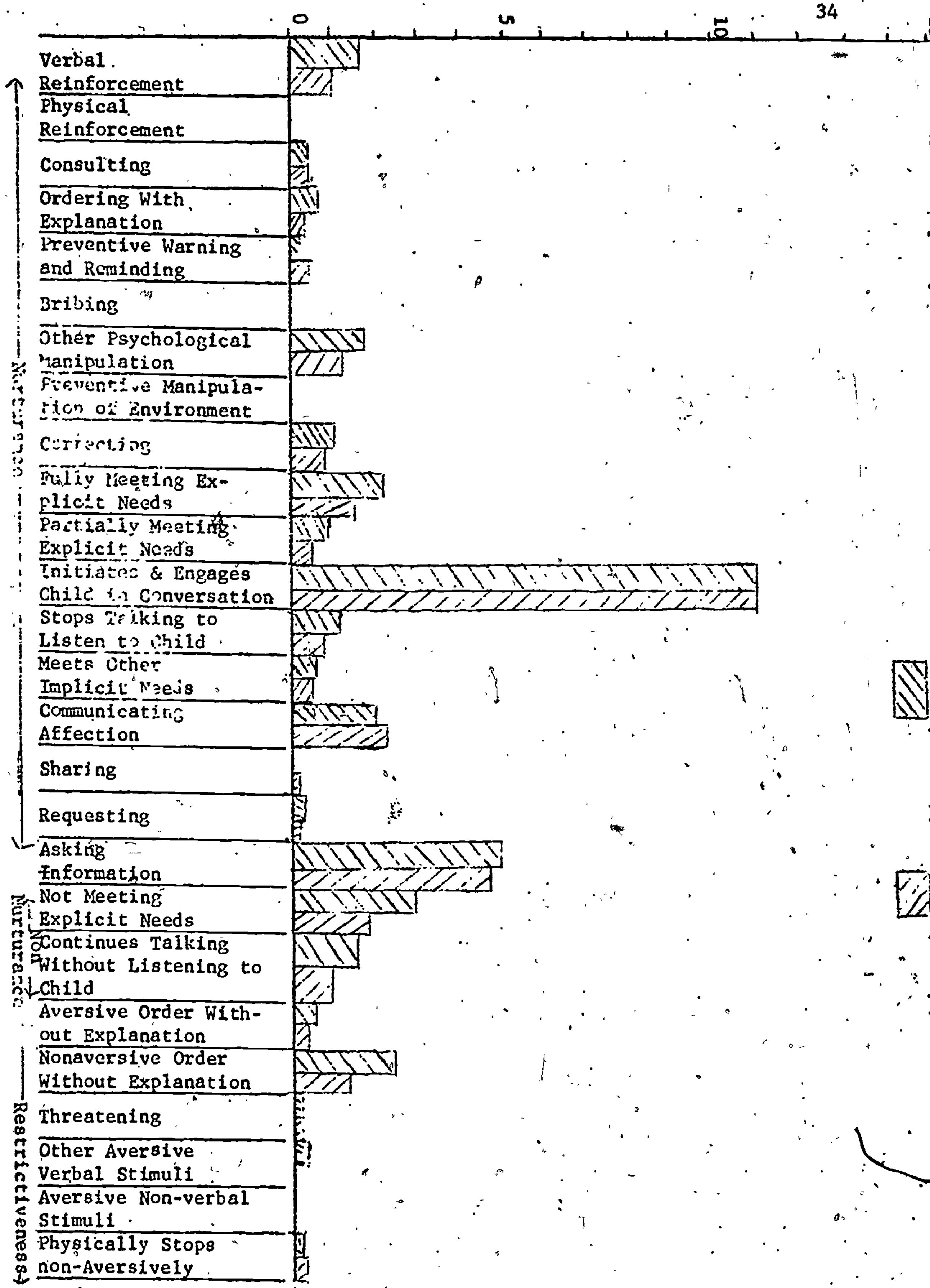

Figure 1

Mean Frequency of Father-Child Behaviors for Males (N = 99); Females (N = 81)