COGNITIVE MAPPING OF THE HOME ENVIRONMENT

by

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ABSTRACT

The dissertation describes an experiment in cognitive mapping. Cognitive mapping is the process by which spatial information is acquired, coded, stored, decoded and applied to the comprehension of the everyday physical environment. A cognitive map can also be a physical drawing, produced by hand to communicate the original map in the head. The dissertation uses the term, manual map, to distinguish the graphic hand drawn representation from the actual cognitive map. The experiment required adult household members to sketch a floor plan of their home, complete a spatial aptitude and graphic ability test and supply biographical, socio-economic, and attitudinal information. Children over the age of three also sketched a floor plan and completed an I.Q. test. All seventy sample households (222 respondents) lived in houses with identical floor plans.

A major finding of the experiment was that manual maps can be reliable and valid research instrument in the study of cognitive maps. Psychometric techniques were used in the data analysis to test for reliability and validity. Both spatial aptitude and graphic ability were found to be significantly related to the ability of individuals to communicate their cognitive maps. Persons with superior mental faculties have cognitive maps which more closely reflect reality. When psychophysical functions were examined, there appeared to be a linear relationship between

subjective distance and area and real distance and area. Socio-economic variables, biographical data, and the subject's cognitive structure of the home as revealed through the semantic differential, did not produce significant correlations with the ability to communicate cognitive maps. Children's ability to produce a manual map which resembles reality is significantly related to age, spatial aptitude, and graphic ability. A child's manual map is a reflection of his general stage of mental development.

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PREFACE

Early in 1972 the International Geographic Union issued a list of "priority research areas in human geograpy". Heading the list was perception studies:

> Geographers have for a long time been aware of the difference between the 'objective' (or 'real') environment and the environment as perceived. But it is only in the last decade or two that a systematic attempt has been made to measure space perception and space preferences, and to evaluate them and to examine the search procedures that people employ to explore the environment in which they find themselves. The field is a very difficult one in which to operate. Furthermore, it clearly overlaps with psychology in terms of basic techniques and with both sociology and planning in terms of the implications and findings ... Despite the difficulties, perception studies are of central importance for the study of geography. (p. 13)

At the time the above statement was being issued by the IGU, many geographers and psychologists were in the midst of research projects dealing with that very topic. That year (1972) and subsequent years have seen a dramatic growth in the amount of published research on cognitive mapping and related aspects of environmental perception.

Recent advancements in cognitive mapping have originated primarily from a coalition of geographers and psychologists with important contributions from a number of architects and planners.

Kenneth Boulding who himself established a milestone in environmental perception with the publication in 1956 of a book called The Image, has referred to those researchers in cognitive mapping as "... an "invisible college" which represents almost a new discipline, cutting across the old discipline of geography and psychology" (Downs & Stea, 1973 p. 11).

One of the implicit goals of this dissertation is to provide an example to future students who may wish to pursue research in the "invisible college". As such, this dissertation has adopted a psychological approach to a geographic topic. It has been written in the style of psychological thesis; it has used tests and measurements developed and employed in psychology, and it has been designed on a style of scientific research typical in psychology. Although the research design and research instruments may derive from psychology, the research topic, cognitive mapping, is of fundamental concern to geographers.

1.0 INTRODUCTION

Cognitive mapping has gained widespread acceptance as a viable area of research in geography and in some senses has come into "vogue". The relative infancy of this field, however, is still reflected in its lack of a strong theoretical foundation. A great deal of work must be done before congitive mapping can be said to contain any sort of unified and comprehensive theory. As it presently stands, there is a growing body of individual research projects and experiments, many with conflicting results, waiting to be tied together in some sort of theoretical framework. The usual pattern of events in other disciplines is that theory evolves slowly from a long trial of many individual research efforts. As Downs and Stea (1973) point out, "It is important to recognize the degree of compatibility between answers - for once, geographers are beginning to cumulate knowledge by consciously replicative and overlapping studies (p. 320)".

Subscribing to the above statement, this dissertation is an attempt to further our degree of certainty about "facts" in cognitive mapping. The dissertation is replicative in that it employs many of the techniques and methodologies used in other cognitive studies. In this way some degree of reliability can be attached to presently used research techniques. It is also replicative in that researchers will find it relatively easy to duplicate the experimental situation. The dissertation is overlapping in that its content deals with the classic cognitive maps (hand drawn graphic representation) and psychophyisical analytic techniques currently employed by other geographers in cognitive distance experiments.

Although Downs and Stea claim that ... "the current *ad hoc* posture towards methodological questions is acceptable and even necessary in the exploratory stage of any research effort" (1973 p. 7), it is hoped that the experimental design of the research and the rigor of analysis employed in this dissertation will lend credibility to the results. It is additionally hoped that by example, other research will also employ similar rigor so that the results of the present experiment may be compatible with and comparable to future research.

This dissertation describes an experiment (Campbell & Stanley, 1966) in cognitive mapping.

1.1 Cognitive Mapping - Definition and Terms

Tolman (1948) first coined the phrase "cognitive map" referring to the spatial mapping processes used by rats to navigate and learn routes through a maze. These, of course, are maps in the non-literal sense. Tolman's mental maps were not a graphic representation, but a spatial structuring of reality as composed of visual, tactile and olfactory input. Since that time, the phrase has been reworked and redefined so as to become a useable construct in environmental cognition research. Hart and Moore (1971) in their outstanding paper on the development of spatial cognition claim that the "terms *cognitive maps* and *cognitive mapping* imply map-like representations of geographic or other large-scale environments ... it begs the question, however, to suggest that spatial relations are necessarily represented in cartographic form. Therefore, we prefer to use the more inclusive terms of developmental psychology - spatial cognition and cognitive representation. (p. 7-3)."

Kaplan (1973) has probably taken the concept of cognitive mapping the furthest by suggesting an individuals' whole structuring of reality may be considered as a cognitive map "... cognitive processes and spatial cognitive maps do not involve essentially different structures ... a spatial cognitive map might be viewed as a special case of cognitive maps in general (p. 75)."

Perhaps the best definition to date and the one adopted in this study has been formulated by Stea (1974):

> Cognitive mapping is the fundamental process by which spatial information is acquired, coded, stored, decoded, and applied to the comprehension of the everyday physical environment (p. 159).

Downs and Stea (1973) in the most complete and comprehensive work on cognitive mapping to date, Image and Environment, present a detailed discussion of the construct of cognitive mapping. It is their contention (as supported by many other researchers) that "human spatial behaviour is dependent upon the individuals' cognitive map of the spatial environment (p. 9)." They further assert that "the cognitive map [is] the basis for deciding upon and implementing any strategy of spatial behaviour (p. 10)." In other words, we cannot describe, predict, or understand human spatial behaviour accurately and completely unless we first understand the cognitive mapping process. In this vein Cadwallader (1973) has shown that cognitive distance is a better predictor of shopping behaviour than real distance. In planning, neighbourhood areas as perceived and defined by area residents (i.e. their cognitive map) have proven to be a valuable aid in the understanding of local resident goals and actions. Although no one has yet proved that cognitive maps do exist, it is usually assumed cognitive maps exist if an individual behaves as if a cognitive map exists (Stea & Downs, 1970).

It must be noted at this point that a cognitive map is not necessarily a "map" per se. "We are using the term map to designate a functional analogue. The focus of attention is on a cartographic representation which has the functions of a familiar cartographic map but not necessarily the physical properties of such a pictorial graphic model ... cognitive maps are derived from analogies of process, not product .... Consequently it is analogy to be used, not believed (Downs & Stea, 1973, p. 11)."

Cognitive maps, however, may be actual physical drawings, produced by hand to illustrate or communicate the original manuscript in the head. Stea (1974) describes cognitive mapping as being concerned "with how stabilized fully formed impressions come to be, how mapping takes place in the brain, and the form and content of the maps as represented in graphic or verbal descriptions (i.e. the input, the throughput, the output) (p. 157)." The output in Stea's case can be (among other things) verbal descriptors, model blocks aerial photo interpretation, symbols, and freely-drawn maps. These graphic maps would be termed cognitive representations by Hart and Moore and differentiated from spatial cognition which is the "input" and "throughput" described by Stea.

There is therefore a paradox in the term cognitive map. It means both a map in the head and a map by the hand. In terms of making spatial decisions the cognitive map in the head is the only map available to an individual; the world for the individual is how he perceives the world to be. The actual communication of a cognitive map (in the head) may take many forms, one of which may be a graphic representation of the spatial arrangements of objects, commonly termed a "map". To separate the two concepts one may adopte the terms cognitive representations, graphic map, schema, diagram, drawing, picture, etc. to represent the hand map. Distinction between the two concepts for purposes of this dissertation will follow the convention of using cognitive map for the mental, in-head processes involved in assimulating, interpreting and storing spatial information, and manual map for the graphic, hand drawn representations commonly used to communicate the original copy in the head.

1.2 Goals

This dissertation has four main goals:

1. Develop a valid and reliable quantitative method of analyzing manual maps. To this end the influence of both graphic ability

and spatial aptitude are investigaged to determine their effect on the individual's manual map.

2. Determine what form of psychophysical relationship exists between cognitive distance (and area) and real distance (and area). These findings will compliment the growing body of similar research presently being conducted by geographers.

3. Analyze the influence of biographical variables (age, income, length of residence, attitude, etc.) on the individual's manual map of the home. The purpose here is to determine whether hypotheses postulated by other researchers can be:
   a. tested by the above quantitative methodology
   b. supported or refuted.

4. Investigate the development of spatial cognition in children. Since all members of the household over three years of age were asked to participate, the experiment offered an excellent opportunity to examine spatial development in children. This area of research has already received considerable attention by geographers.

This dissertation deals with cognitive mapping but more specifically it examines the use of manual maps as a research tool in the study of cognitive mapping.

For a number of years, manual maps have been used as a research technique to examine spatial "images". Lynch (1960) initiated this technique to study "urban images" and was followed by many others. Although most research of this type has concentrated on problems at the scale of the city, researchers have also used the manual map technique on a global scale (Gould & White, 1974), neighbourhood scale (Ladd, 1970), dwelling scale (Altman et al, 1972) and room scale (Argyle, 1967). It may also be possible to extend the use of manual maps to the study of "proxemics" (Hall, 1966; Sommer, 1969) but this has not yet been done. It would also appear that this last example, personal space, is beyond the scale of cognitive maps. Several authors make the point that cognitive maps are a structuring of spatial phenomena which cannot be perceived or apprehended at once. In the case of personal space the apprehension may, in fact, be only a memory rather than a true composite map.

Even though the use of manual maps is widespread, the analysis of such data is almost invariably qualitative. The significance of the results depends upon the researcher's subjective interpretation of the "content" of the graphic representations. Because of this, the research is very difficult to replicate. This does not mean, however, that valid results cannot be obtained using qualitative methods. Validity and reliability can be ensured by having various individuals perform assessments of the data and to test for the correspondence among the judges. Although this latter method of reliability testing is being adopted more frequently, a great deal of research employing manual maps lacks this approach.

In all fairness, it must be stated that research which lacks estimates of reliability does not necessarily present false results. Lynch for example, did not employ a methodologically sound research design, yet he was able to obtain valuable information which has proved consistently true in many other studies.

Regardless of the pros and cons presented for various types of research, this dissertation attempts to develop a methodology by which manual maps can be analyzed quantitatively in addition to qualitatively. The success of the experiment is relative. If the attempt is positive, then future researchers can look forward to employing a new technique in their analysis with the knowledge that it appears to have some validity. If the attempt is negative it will at least illustrate some of the pitfalls for other researchers who may wish to assail the same problem.

There is certainly an appeal for developing a quantitative method. It would mean that data obtained by one researcher could be analyzed consistently anywhere by any number of other researchers. It also means that studies could be replicated and that the results of various studies could be objectively compared. Such is presently not the case.

1.3 Research Setting

The research setting devised to achieve the goals was to have people sketch a floor plan of their home. A unique feature of the experiment was that all homes had identical floor plans. Although some concern might be expressed about the interpretation of a floor plan being a cognitive map, there does not appear to be any evidence in the current literature to disqualify such an approach. In terms of spatial behaviour, individuals must have some form of cognitive map in order to navigate themselves about their home. Their maps must not only contain information on the relative location of each room but also information on its size, orientation, usage, contents, etc. In other words a cognitive map of the home exists because individuals "behave as if a cognitive map exists" (Downs & Stea, 1973, p. 10). In a discussion on "mental" maps Stea also says "... all persons form conceptions of those significant environments that are too large to be perceived, i.e. apprehended at once. (1969, p. 229)." It is argued here that the home is a significant environment; and that it cannot be apprehended at once.

There are several methodological advantages in using the home as the subject of a cognitive mapping experiment. Most of these have to do with the measurement and interpretation of the manual map used to communicate the individual's cognitive map. The advantages are as follows:

1. Subjects are familiar with the environment. One criticism leveled at researchers who have subjects draw maps of the city is that the degree of familiarity or lack of knowledge influences the resulting manual map to a degree that cannot be estimated. In the home it is assumed that everyone has at least been in all the rooms.

2. Manual maps of the home are finite. Requesting subjects to produce a map of the city or neighbourhood can result in an infinite amount of variation and detail. In the home there are a fixed number of rooms and walls. It makes the problem of what to measure more manageable.

3. The problem of measurement is simplified. The length of the walls and the area of the floors can be measured on the manual map and compared to the actual floor plan to give the amount of deviation between the cognitive map and the real world. The exact size and orientation of the real map is already known.

A detailed description of the complete research design will, of course, be given in a following chapter. The unique feature of having a large number of families living in essentially the same home affords the opportunity of investigating a number of other interesting relationships in people's spatial perception. For this reason the dissertation also reports findings which may not bear direct relevance to the main arguments of the experiment, but nevertheless seem important and significant in themselves.

1.4 Research Context

In 1970, Stea and Downs combined their efforts to produce an article which outlined the state of the art (at that time) in cognitive mapping. Their article "From the outside looking in at the inside looking out" is used here as a basis for the context of this dissertation.

The Stea and Downs' (1970) article was intended to act as an introduction to a group of original papers in cognitive mapping. As such, Stea and Downs attempted to construct a typology to describe the types of research being conducted in cognitive mapping. They suggested that there were two general research strategies:

1. The holistic approach was concerned with overall system identification, and description. "On this level, a major concern is the establishment of purely functional relationships between, for example, socio-economic status variables and the cognition of different segments of the environment (p. 7)." Research typifying this is that of Ladd (1970), Ley (1974), Appleyard (1970), and Everitt & Orleans (1971). This type of research usually employs manual maps, with most data analysis being of a qualitative nature.

2. "The second strategy involves a search attempt to analyze the system interactions which have been isolated previously. Thus the focus is on the interactions between sets of variables

together with the specification of the system parameters" (p. 7). Examples of this type of research are Lee (1964), Lowerey (1970), and Briggs (1969). This second strategy makes extensive use of "quantitative methods of data analysis (p. 8)" and has, until this dissertation, never employed manual maps in the research design.

Stea and Downs go further by claiming that there have been three major research foci:

1. Elements

   Cognitive categories into which information from the spatial environment is coded. Loosely interpreted, elements refer to the objects or landmarks in the spatial landscape.

2. Relations Between Elements

   Distance and directional system used to define cognitive representations i.e. cognitive distance.

3. Surfaces Resulting from the Relationship Between Elements

   Overall cognitive representations of a portion of the spatial environment, i.e. manual maps.

In previous research the holistic approach has usually dealt with surfaces, hence the popular technique of manual maps. The system interaction approach has been limited to elements and relations between elements. Figure 1 provides a schematic diagram of the different strategies and research foci. Along each arrow connecting the strategies and foci are examples of researchers whose work falls into the various categories. Some of the research designations are given by Stea and Downs. Other research appearing since the time of their article have been classified by myself. The typology, as constructed by Stea and Downs, provides a useful method of categorizing the various pieces of research in cognitive mapping.

Where does this dissertation fall? Figure 2 represents the research covered in this dissertation. The various numbered arrows are described below:

1. First it must be stated that the essential foci of the research is with "surfaces". Subjects were requested to draw a manual map of their home. The entire spatial environment of the home is the subject of enquiry. The primary research strategy was that of systems interaction. A series of psychometric tests and measurements was employed as well as basic psychophysical techniques. This approach is highly quantified and represents the first time in geography (to my knowledge) that quantitative methods have been used to analyze surfaces, i.e. manual maps. The present dissertation therefore, differs from all other previous geographic research.

2. A large number of socio-economic variables as well as psychological variables was collected and related to the manual maps.

3. Tests to determine psychophysical functions for cognitive distance and cognitive area (another first in geography) were performed.

FIGURE 1:

STEA-DOWNS TYPOLOGY OF COGNITIVE RESEARCH - PREVIOUS STUDIES

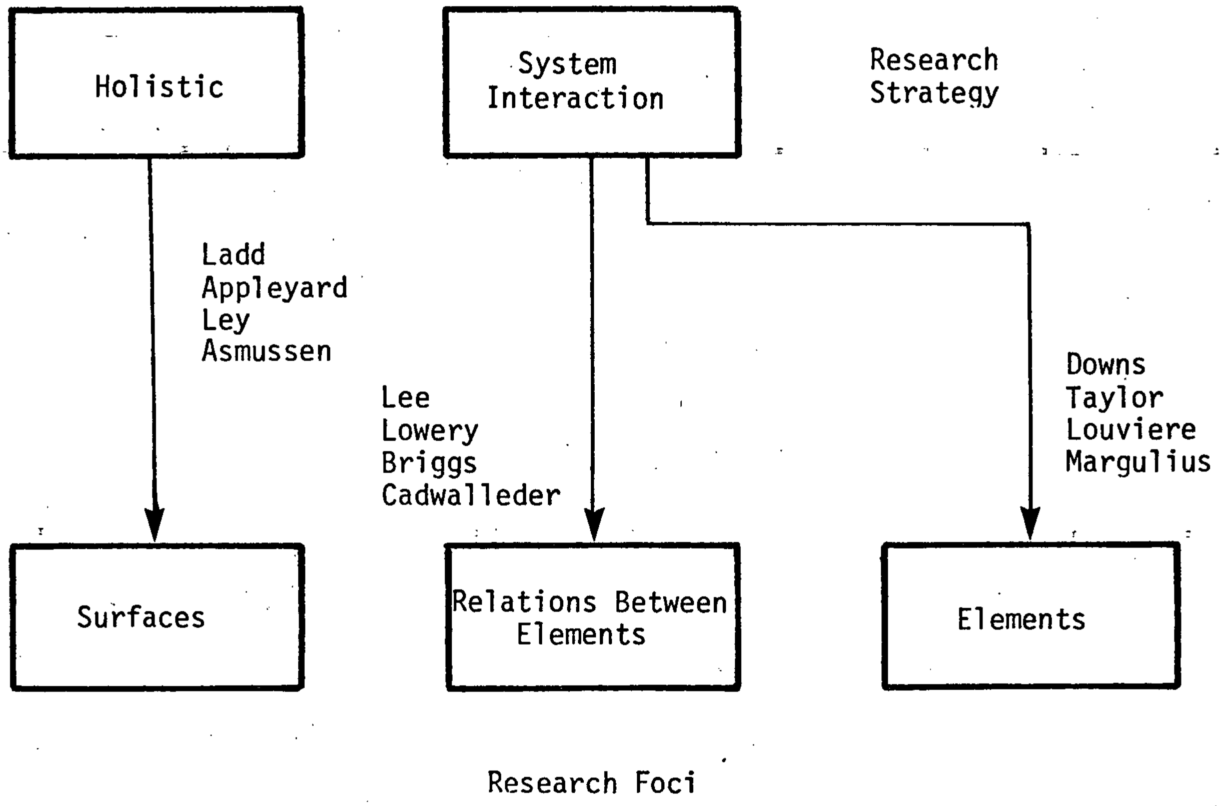
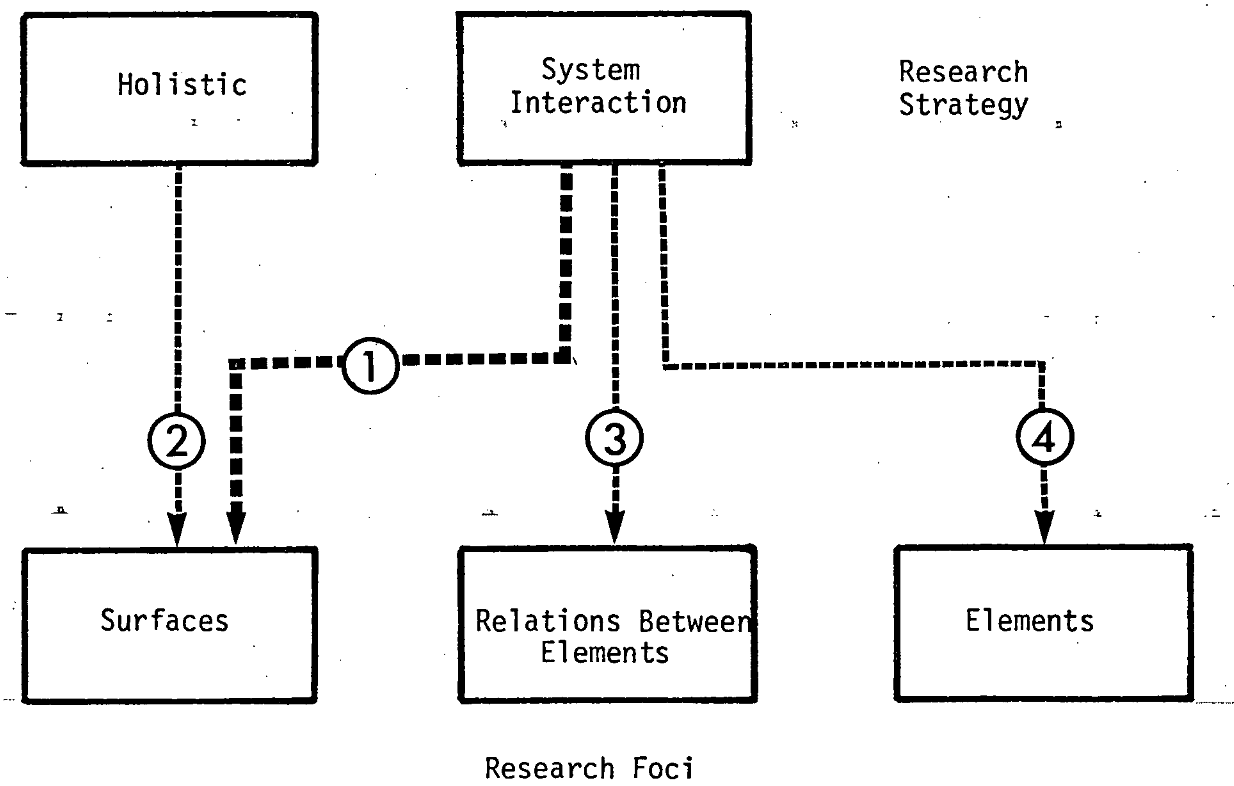


FIGURE 2:

STEA-DOWNS TYPOLOGY OF COGNITIVE RESEARCH - PRESENT DISSERTATION



4. A semantic differential was administered and analyzed using factor analysis to determine the underlying cognitive structure of the home. Individuals' factor scores were related to the manual maps.

To date, the best representative selection of literature on cognitive mapping occurs in Image and Environment (Downs & Stea, 1973). The book contains a number of "historical milestones" in cognitive mapping literature. Each major section of the book also presents a discussion of other relevant works not included in the book.

Although Image and Environment does not contain some of the more recent works in the field, it does represent one of the finest and most complete reviews of cognitive mapping literature. Indeed, it is difficult to undertake a review of literature on this topic without subconsciously following the format outlined by Downs and Stea. The only criticism which could be made of this book is that it does not attempt to present an overall theoretical framework for the literature which it contains. Downs and Stea counter this criticism in their preface by stating that they "were more concerned with content areas than with the presence or absence of a theoretical statement. (p. xiv.)." It would appear, however, that if such a statement already existed, it would have been included, at least as one of the many readings. To say that their work lacks a comprehensive framework is perhaps a commentary on the state of the discipline, rather than on Downs and Stea.

2.0 METHODOLOGY AND PROCEDURES

This chapter provides a detailed outline of the research design including sample selection, interview procedures, questionnaire design, psychological tests, and statistical techniques.

2.1 Design Overview

A total of 70 families agreed to participate in the experiment. Everyone in the household over the age of three was asked to draw a floor plan or map of his home. All homes had identical floor plans.

Members of the family were divided into two groups - adults and children. An adult was defined as a person of age 14 years or older. The reason for this age designation will be explained in more detail later. It can be said now, however, that in terms of spatial aptitude a 14 year old person is considered psychologically equivalent to an adult.

The adults were asked to complete:

1. A free hand floor plan of their home.

2. A graphic ability test.

3. A spatial aptitude test.

4. A questionnaire containing background information and socio-economic data as well as a semantic differential designed to determine their attitude towards their home.

The children (less than 14 years) were asked to complete:

1. A free hand floor plan of their home.

2. The Goodenough-Harris Draw-a-Man Test.

For the adults, the manual map of their home was digitized to produce "XY" coordinates for each wall intersection. The lengths of all walls and areas were subsequently reduced to ratio measures using psychometric statistical techniques. Simply expressed, this procedure converted everyone's drawing to a common and comparable scale. Differences were then calculated between:

1. The subjects' ratio and the real ratios from the building plan.

2. The subjects' ratios and the mean ratios of all the respondents.

In effect, these difference scores measured, for each manual map, the deviation from the real world and from the world as generally perceived by the respondents.

These difference scores (amount of error) were then used as input data to the statistical analysis performed with the spatial aptitude scores, graphic ability scores, other variables taken from the questionnaire and factor scores from the semantic differential.

Other data were taken from the manual maps and included in the statistical analysis of variables. These other data were more qualitative in character and included a quality rating score for each manual map, the number and types of errors in the map, and additions or anomalies in the manual maps.

Figure 3 is a schematic diagram illustrating the inter-relationship among the various data used in the adult section of the dissertation.

For the children, it was not possible to digitize the manual maps. Most drawings, especially for the younger children, were so distorted that it was difficult to recognize them as house plans let alone treat them quantitatively. Instead, all the children's drawings were ranked independently by four separate judges. The average rank was then used as input into an analysis containing data on chronological age, mental maturity, graphic ability, and qualititative data derived from the drawings.

2.2 Pre-Test

A pre-test of 15 families was done prior to the main experiment to train in the use of the various tests and to minimize any difficulties which might arise in the research design.

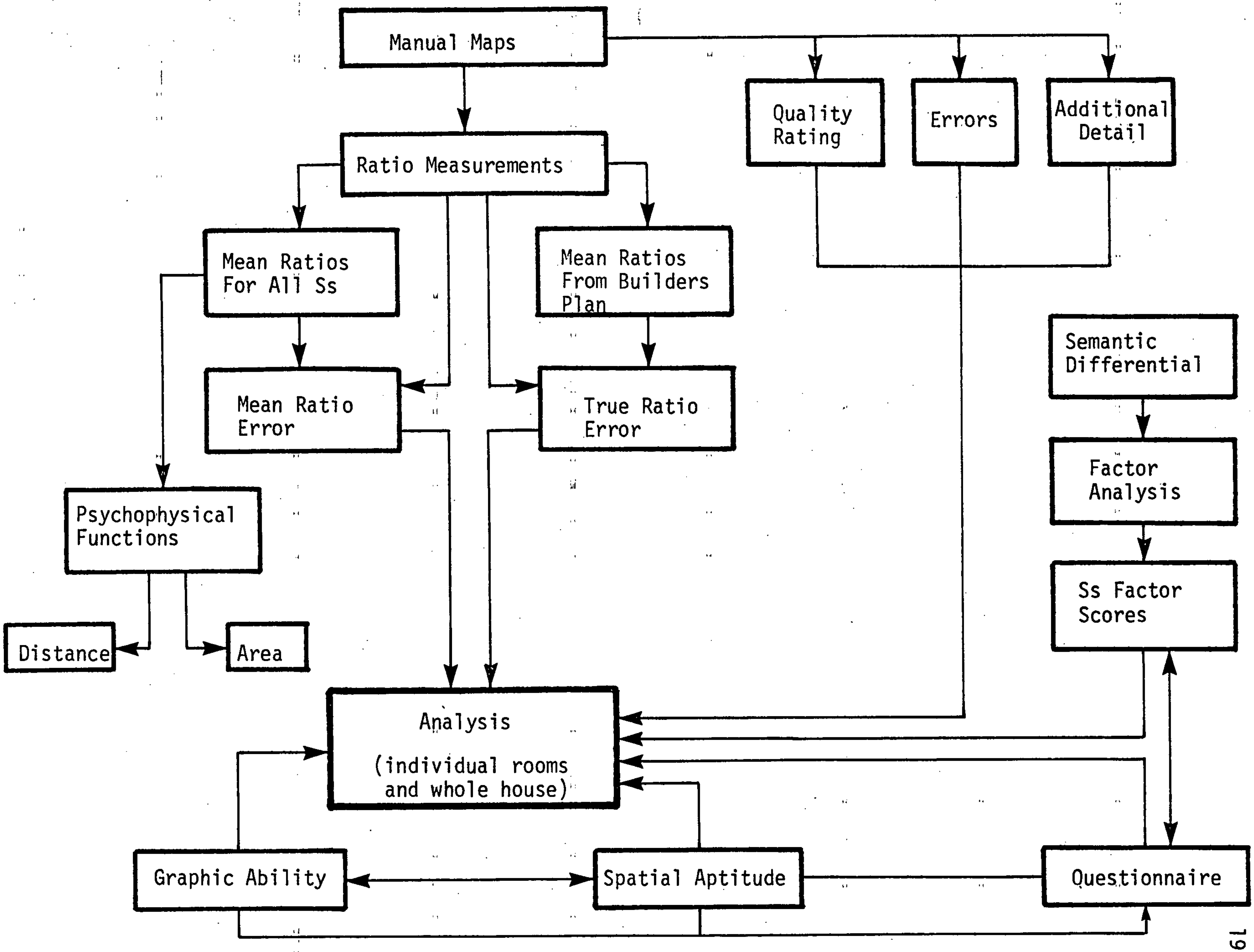


FIGURE 3: Flow chart of research design.

The data from these interviews were not used in the main analysis as the homes in the pre-test had different floor plans from those in the main experiment. The homes were also in a different geographical area and were considerably newer. The main purpose of the pre-test was to test the research instruments, determine the average length of time to do an interview, determine the order of tests to be done, and provide experience in the handling of both adults and children in a test situation. Several minor tests were run to investigate possible sources of error.

In the final experiment all manual maps were drawn on standard 8-1/2 by 11 paper. In the pre-test several sizes of paper were tried, with no noticeable difference in results, except that large pieces of paper were harder to handle. No noticeable difference in the pre-test results could be found between subjects completing their maps while in the kitchen or while in the living room. In the pre-test subjects were asked to draw two floor plans, one at the beginning and one at the end of the interview. Although there appeared to be a learning experience with practice, the difference in scores was not significant. In several instances the scores on the second try were worse as the subjects seemed to tire or did not see the point. and failed to give the second effort as much concentration as the first.

Subjects in the pre-test had moved into their home in a housing development within a year of the study. The developer of the housing subdivision provided an introduction to each of the home owners. This also differed from the main experiment where each owner was contacted by letter and telephone.

2.3 Sample Selection

The selection of an adequate sample was difficult. The criteria set for the sample was as follows:

1. All homes had to have identical floor plans.

2. The total number of homes had to be large enough to draw a workable sample.

3. Three bedroom homes were desirable so as to ensure a large population of children.

4. Homes had to be of slab construction (no basement) as vertical separation of rooms would be more difficult to handle.

5. Homes had to be at least 10 years old so that length of residence could be tested as a variable in cognitive perception.[1]

Help was given by the Central Mortgage and Housing Corporation, Regional Office, and a number of local builders and developers in the Metropolitan area to locate a sample of the desired homes. Several housing developments were examined with the

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[1]An a priori consideration in the research design was to include the length of residence as a possible variable influencing cognitive mapping.

final choice being a group of homes which met all the above criteria. The homes in the sample are J.S. Wood homes built in 1958-59 in the Pigott-Mowbray area of Richmond. Mr. Wood was kind enough to identify the location of the houses as well as to provide a copy of the floor plan. Figure 4 illustrates the builder's floor plan. All the homes are three bedroom bungalows of 1,310 square feet and all have identical floor plans. In total it was possible to identify 302 houses of the same type. Although there are more homes in the Metro Vancouver area it is extremely difficult to find them.

A search of all Richmond building permits since 1958 revealed that 132 of the original 302 had been structurally altered enough to change the floor plan. Although this number may appear high it must be remembered that these homes have no basement so that storage and utility space is very small. The most common practice has been to append a utility room, covered garage, etc. to the side or back of the house and to knock down an interior wall next to the kitchen to form a dining area out of the small utility room already in the house. This appears to have been a very common practice, with one builder doing at least 54 homes in this manner.

Subtracting homes with altered house plans left a total of 170 possible sample households. This number was enlarged by eight to increase the possible sample to 178. These eight consisted of new residents who moved into the houses sampled during the

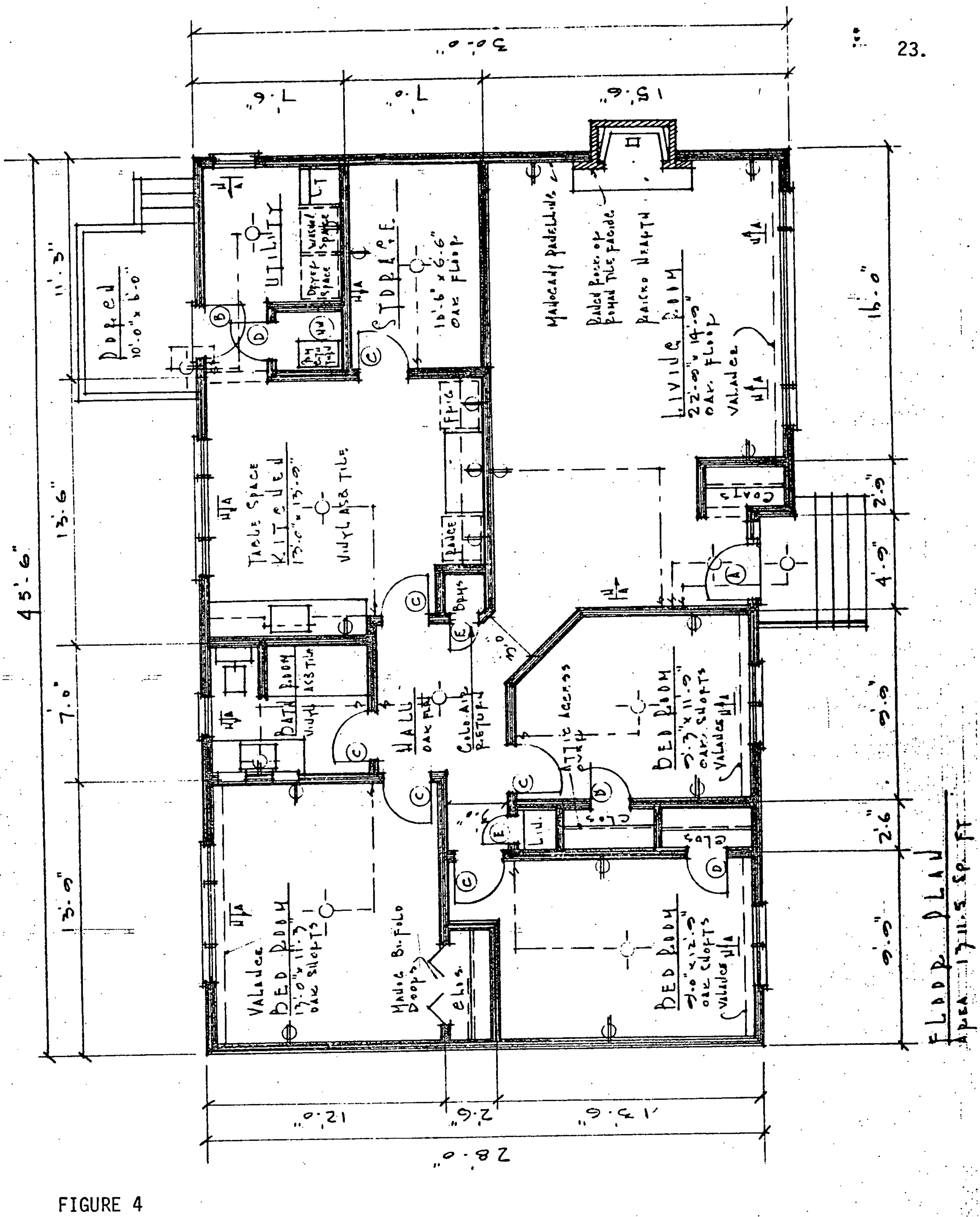

FIGURE 4
BUILDERS HOUSE PLAN

1972-73 sample year. This meant it was possible to sample the same house twice but with two different households. Because of rejections this actually occurred only once.

When all the possible sample homes were identified, names of the occupants were obtained through the City Directory, voters' lists, and the Municipal Assessment Department.

Letters were sent to each occupant asking if they would participate in a housing study being conducted by the University of British Columbia (see letter Appendix 1). Postcards were included in each letter with instructions to return the card if the person did not want to participate, otherwise someone would phone him to set a suitable time for the interview.

Table 1 illustrates the actual household sample through the two sampling seasons. Interviewing was suspended during the summer because of an extremely high rejection rate. Many valuable samples were lost prior to the suspension of sampling during the summer of 1973.

A brief explanation of each category follows:

<u>decline</u> - respondents who did not wish to participate.

<u>accept</u> - respondents who were interviewed.

reject - interviews which could not be used (house plan altered without permit, incomplete interviews, did not or could not follow interview instructions).

unavailable - could not locate resident or resident did not have listed phone number.

TABLE 1

HOUSEHOLD SAMPLE

	Sample Year		
	1972-73	1973-74	Total
Decline	52	47	99
Accept	32	38	70
Acceptance Rate	38.1%	44.7%	41.4%
Reject	2	3	5
Unavailable	-	4	4
Total	86	92	178

In total the 70 households have yielded 222 valid respondent samples. Only five interviews proved to be totally unusable or not valid. This means that there was an average of 3.17 respondents per household. In the majority of cases all family members participated, with the most general exception being high school children who were attending activities during the time of the interview. It was frequently very difficult to schedule interviews so as to fit households with several children. The largest single household sample was nine.

The following table (Table 2) outlines the number of respondents by sex and test category. A brief outline of each category follows:

1. Adult Male Head of Household - usually the husband.

2. Adult Female Head of Household - usually the wife (includes all married women).

3. Male Child - child less than 14 years of age.

4. Female Child - child less than 14 years of age.

5. Other Male Adult - any household member 14 years of age or over but not head of household.

6. Other Female Adult - any household member 14 years of age or over but not head of household.

TABLE 2

RESPONDENT SAMPLE SIZE

	Number	Percent
Male Head (Husband)	61	27.5
Female Head (Wife)	70	31.4
Male Child	34	15.3
Female Child	23	10.4
Male Adult	17	7.7
Female Adult	17	7.7
Total	222	100.0

There were nine more female heads (70) than male heads (61). This is due to the fact that there were 2 divorced, 1 separated, 1 widowed, 2 single, 1 husband not home at time of test, and 2 female heads who could not be classified. The 2 single are spinster ladies of 67 and 73 years of age.

The original goal had been to secure 100 household samples, but unfortunately this could not be done. The number of homes with altered floor plans out of the original 302 was almost 44 percent. Of the remaining valid sample, the acceptance rate of 41 percent was too low to achieve the goal. Considering the fact that it was often difficult to get families together at one time, and that no financial remuneration was offered, the acceptance rate was quite high.

In the types of statistical analysis that were performed, mainly correlation and t-test, the sample sizes were large enough to produce valid results. In the factor analysis that was performed there was a total of 165 subjects with 25 work pairs each. This sample size was sufficiently large to return reliable results.

It must also be remembered that the sample was not collected to be representative of the population as a whole; it was not an attitude or opinion survey. In terms of normal samples for psychological experiments the total of 222 subjects is much higher than most.

2.4 Interviewers and Setting

A total of four interviewers were used. Table 3 indicates the number of interviews conducted by each person as well as the percentage of total interviews.

TABLE 3

NUMBER OF INTERVIEWS BY INTERVIEWER

Interviewer	Number	Percentage of Total
Rothwell	22	31.4
Caviglia	29	41.4
Clarkson	18	25.7
Gill	1	1.5
Total	70	100.0

All the interviewers were trained by myself. L. Caviglia worked in the 1972-73 sample year while J. Clarkson worked in the 1973-74 sample year.[1] The training sessions for the two interviewers consisted of a thorough briefing and their attendance at two interviews before they proceeded on their own. In the first of these two interviews, they merely observed. On the second, they conducted the session with myself in attendance as an observer. A series of telephone call backs for every fourth household was also initiated to ensure that the interviewer was courteous and that instructions were followed.

To test whether the investigators had different effects upon the research results, a correlation analysis was performed between the interviewers and all other numerical variables. Except for one instance, there was no significant correlations (α = .05) between the interviewers and other variables. The only variable which seemed to be related to the interviewer was the respondent's occupation (α = .03). A cross tabulation of results indicated that Rothwell had a propensity for lower job status respondents. One possible explanation for this was that since I made the telephone calls to set up the interviews and assigned the person to do the interviewing, I somehow allotted myself more low job status people.

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[1] W. Gill, a geography graduate student, who was familiar with the research design, was able to fill in on one occasion.

This may be due to the fact that when I perceived that the interview might be difficult (i.e. the respondent was reluctant to participate or seemed not to understand what was being asked) I took the interview myself. When people were friendly, open, and cheerful over the telephone I usually assigned another interviewer. It may be possible then, that persons of lower job status respond differently over the telephone for requests to participate in research experiments.

Except for the single anomoly of occupation, none of the variables was influenced to a significant degree by the interviewers.

The interview setting was in the respondent's home, with the living room (90 percent) the usual location. An attempt was made early in the research design to have respondents gather at a neutral location but this proved infeasible. The pre-test indicated that there was no difference between the living room or kitchen in interview setting. Final analysis also indicated that even though most respondents were in the living room, the kitchen was generally drawn with less error. Although it can be argued that there might be a difference if the respondents were in a neutral setting, the experimental situation was uniformly consistent for all subjects.

On a theoretical basis, it should be pointed out that the interview setting for other cognitive mapping studies is usually located within the area being mapped. It should also be noted that the manual map of the house is not simply a visual perception. The home environment is so constructed that it "cannot be apprehended at once". In the interview situation very few subjects looked up to guage the size of the room and none got up to walk around and refresh their perception although they were not told to refrain from this.

The actual interview lasted between 45 minutes and one hour, although conversation following the interview sometimes lasted several hours. Each person in the household was presented with a clip board containing all the material in the test. Children were very responsive and presented no problems to the interview. If the children finished their tasks before their parents (which frequently happened) the interviewer would discuss with them what they had drawn and perhaps ask them to draw something else. Except in one or two instances, all families were very friendly and helpful. Respondents who asked to have their tests returned were granted their requests after the tests were marked and photocopied.

2.5 A Statistical Note

2.51 Data constraints. The data contained in this dissertation are at all four levels of measurement:

1. nominal: sex, handedness, etc.
2. ordinal: income, education, etc.
3. interval: age, spatial aptitude, etc.
4. ratio: ratio measurements of walls and floors.

It was therefore, frequently necessary to employ non-parametric tests of association and significance. Even when interval and ratio data were used, tests for normality[1] in distribution revealed that some variables did not meet the assumptions of parametric tests. Parametric tests were employed only where the data permitted.

Because of the nature of the data (several levels and non-normal distributions) it was not possible to use tests of analysis of variance. Unfortunately, a non-parametric analysis of variance employing several levels of data has not yet been discovered. Multiple correlation (for non-interval data) was another analytic tool which could not be used.

For the most part, analysis of data consisted of various forms of correlational analysis and t-tests (or the non-parametric t-test equivalent, the Mann-Whitney U Test). The following table (Table 4) names the various correlation coefficients and their tests of significance:

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[1] Tests for normality were tests based on skewness and kurtosis.

TABLE 4

CORRELATION COEFFICIENTS AND SIGNIFIANCE TESTS[1] FOR DIFFERENT LEVELS OF MEASUREMENT

Data Level of Measurement	Coefficient	Test of Significance
Interval-Interval	Pearson product moment coefficient (*r*)	F-test
Interval-Nominal	Correlation ratio (*R*)	F-test
Interval-Ordinal	Jaspen's coefficient of multi serial correlation (*M*)	F-test
Nominal-Nominal	Guttman's symmetric coefficient of predictability (λ)	Chi-Square
Nominal-Ordinal	Freeman's coefficient of determination (Θ)	Chi-Square
Ordinal-Ordinal	Goodman's and Kruskal's coefficient of rank association (*G*)[2]	Test of G = 0

It should be noted that the above correlation coefficients are not tests of association which are numerically equivalent. For example, a Pearson *r* of .90 will not be equivalent to a Jaspen's *M* of .90. The only way to compare the actual coefficients is through the various tests of significance. Because the reporting of actual coefficients tends to be misleading, only the results of tests of significance will be given (except where otherwise important).

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[1] See Freeman (1965) and UBC CORN (1973).
[2] Similar to Spearman's r_s but easier to calculate for ties.

Unless otherwise stated the level of significance has been chosen to be $\alpha = .05$. This will ensure that the relationship between variables is statistically significant.

In almost all instances, the lower the level of analysis (i.e. nominal-nominal being the lowest and ratio-ratio the highest) the greater the loss of information and thus the greater the risk of overlooking significant relationships among variables. The analysis therefore runs the risk of omitting some relationships which might exist but are not revealed because of the manner in which the data were measured.[1] It does have the benefit, however, of indicating that those variables which are shown to be inter-related are, in fact, significantly so.

2.52 Reliability. Reliability refers to the accuracy of data in terms of stability and repeatability. Reliability has been defined as "the ratio of the true score variance to the variance in the scores as observed (Helmstadter, 1964, p. 61)." Where applicable such methods as test-retest, parallel form, split-half and Kuder-Richardson techniques are used and reported. Reliability of published tests (spatial aptitude, graphic ability, and Draw-a-Man) will be reported from the test manuals.

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[1] Variables like sex (male-female), however, cannot be measured other than at a nominal level.

2.53 Validity. Validity refers to the extent to which the instrument actually measures what it is designed to measure. The validity of an I.Q. test, for example, is that it measures intelligence. In a sense then this entire dissertation is an attempt to determine the validity of manual maps as a measure of cognitive maps. Other researchers have relied upon face validity (Helmstadter, 1964, p. 89) stating that a cognitive map exists when the individual behaves as if the map exists, i.e. because we can draw manual maps, cognitive maps must also exist. A more complete discussion of validity in manual maps will follow in a later section where there are statistics to verify the analysis.

The validity of published tests will be reported from the test manuals.

2.54 Sources of error. Despite the most rigorous research designs there is always some error introduced when reactive (as opposed to unobtrusive) measures are used. Webb et al (1966) classify four types of error resulting from the respondent:

1. Awareness of being tested.
2. Role selection.
3. Measurement as an agent of change in the subject.
4. Response sets.

Except for the first error type, it is difficult to imagine how these errors could influence to any great extent the results of the experiment. To help reduce the first error - awareness of being tested - interviewers were instructed to engage in a period of conversation before the actual experiment to help ease any tension. The first few questions of the first questionnaire were very easy, some having the sole purpose of getting the subjects into the right frame of mind.

Error can also be introduced by the investigator. There is overwhelming evidence that a large number of biases are introduced by the interviewer (Webb et al, 1966). In the present study, however, the correlation analysis indicated that investigator error did not vary significantly among the interviewers thus indicating little influence on the data.

2.6 Adult Data

This section discusses each of the four data sets that were used in the experiment. Each data set is discussed in the order in which it was complted by the respondents. Each data set is in turn discussed in two sections, the instrument and the analysis.

2.61 Housing attitude survey. The Housing Attitude Survey as shown on the following pages is identical to the one presented to the respondents. There are four basic groups of variables:

HOUSING ATTITUDE SURVEY

university of british columbia

FOR OFFICE USE ONLY	
DATE ______	FID ☐☐☐☐☐☐
TIME ______	SID ☐☐☐☐
INTERVIEWER ______	TRS ☐
COMMENTS ______	P ○ M ○
______	S ○ W ○

1. How long have you lived at your present address? ______ years.

2. How many times have you changed your place of residence in the last 10 years? ______

3. How do you feel about the amount of living space in your present residence. It is:

   a. much too small ☐
   b. small but adequate enough ☐
   c. just right ☐
   d. more space than really needed ☐

   If you answered - a. "much too small" - which rooms in particular do you find too small? ______

4. Are you satisfied with the arrangement of rooms in your present home?

   a. yes ☐
   b. no ☐

5. How many bedrooms would be adequate for your family? ______

6. Do you feel you are getting your money's worth out of your present residence?

   a. yes ☐
   b. no ☐

7. From what you have learned and experienced about housing, what do you feel are the most important considerations in choosing a home?

____

____

8. In comparison to other places in the Lower Mainland, how would you rate your neighborhood as a place to live:

a. excellent ☐
b. very good ☐
c. good ☐
d. fair ☐
e. poor ☐

9. Do you anticipate moving within the next two years?

a. yes ☐
b. no ☐

10. We would like to know how you feel about your present house. For each of the following pairs of words, mark on a scale of 1 to 7 how the words best describe your feelings toward your home.

	1	2	3	4	5	6	7	
good	___	___	___	___	___	___	___	bad
dirty	___	___	___	___	___	___	___	clean
light	___	___	___	___	___	___	___	dark
empty	___	___	___	___	___	___	___	full
complicated	___	___	___	___	___	___	___	simple
gloomy	___	___	___	___	___	___	___	bright
cramped	___	___	___	___	___	___	___	roomy
private	___	___	___	___	___	___	___	public
peaceful	___	___	___	___	___	___	___	disturbing
dangerous	___	___	___	___	___	___	___	safe
depressing	___	___	___	___	___	___	___	happy
feminine	___	___	___	___	___	___	___	masculine
warm	___	___	___	___	___	___	___	cold
dull	___	___	___	___	___	___	___	interesting
hard	___	___	___	___	___	___	___	soft
unusual	___	___	___	___	___	___	___	conventional
formal	___	___	___	___	___	___	___	informal
forbidding	___	___	___	___	___	___	___	welcoming
light	___	___	___	___	___	___	___	heavy
invigorating	___	___	___	___	___	___	___	boring
small	___	___	___	___	___	___	___	large
open	___	___	___	___	___	___	___	closed
discordant	___	___	___	___	___	___	___	harmonious
substantial	___	___	___	___	___	___	___	thin
ordinary	___	___	___	___	___	___	___	imposing

At this point we would like to ask you a few questions about yourself so that we can properly classify our information:

11. Age _____

12. Occupation ____________________

13. Your father's occupation ____________________

14. Education (check highest level)

Grade School				University		Technical Training	
Grade 1	☐	Grade 8	☐	Years 1	☐	Years 1	☐
2	☐	9	☐	2	☐	2	☐
3	☐	10	☐	3	☐	3	☐
4	☐	11	☐	4	☐	4	☐
5	☐	12	☐	BA, BSc	☐	Diploma	☐
6	☐	13	☐	MA, MSc	☐	Other	________
7	☐			PhD	☐		
				Other	________		

The following two questions need only be answered by the head of the household.

15. Income (total family income)

a. less than $4,000 ☐
b. $4,000 - $6,000 ☐
c. $6,000 - $8,000 ☐
d. $8,000 - $10,000 ☐
e. $10,000 - $15,000 ☐
f. $15,000 - $25,000 ☐
g. $25,000 - $50,000 ☐
h. more than $50,000 ☐

16. First name and ages of children living at home.

	Name	Age	Grade
1.	____________	____	______
2.	____________	____	______
3.	____________	____	______
4.	____________	____	______
5.	____________	____	______

1. Unobtrusive variables such as handedness, eye glasses, nationality, marital status, difficulty with interview, etc. were recorded in the "comments" section of the first page. The SID number on the first page identified the respondent's sex and position in the household (husband, wife, child, and other relatives).

2. Questions 1 to 9 are general background variables designed to collect information and to get the respondent in the right frame of mind. Most of the questions also appear in Sanoff and Sawhney (1971) and Sanoff et al (1971).

3. Question 10 is a semantic differential designed to determine the cognitive structure of the respondents' attitudes toward their home. The actual adjective word pairs used in the questionnaire were taken from a study by Honikman (1971). Although there were a number of studies from which to borrow a semantic scale for architectural structures[1], Honikman's paper offered the advantage that the semantic scale had been used in a study on living rooms. There was, therefore, the opportunity to compare the factor structure of Honikman's study with the factor structure in the present experiment.

4. Questions 11 to 16 dealt primarily with socio-economic variables.

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[1] See Craik (1968), Collins (1969), Canter (1969), and Hershburger (1970).

Because of the method of response for education and income categories, these variables were treated as ordinal variables

Analysis (except for the semantic differential) consisted of calculating correlations between each variable and all other variables in the study. Descriptive statistics (means, standard deviations, medians, distributions) and cross tabulations were completed as a matter of course.

The semantic differential was analyzed using a principal axis factor model with varimax rotation (UBC FAN). As will be seen in the next chapter the program extracted three unrotated factors with eigenvalues greater than one. The respondents' factor scores on each factor were then calculated and correlations were performed between the factor scores and all other variables.

2.62 <u>Manual maps</u>. The manual maps or floor plans were very simple in concept. Each adult was asked to make a free hand drawing of the floor plan of his home. He was told that it was a very important part of the study and therefore to draw it the best he could trying to put the rooms in the right location and of the correct relative size. It was also stated that doors, windows, and furniture were not required. There was no time limit and respondents could try as many times as they desired.

Although the instrument was simple the analysis is complicated. The basic concept relies on a psychophysical technique known as ratio estimation.

In ratio estimation "the subject is instructed to adjust a variable stimulus so that it appears subjectively equal to a certain fraction of the standard (Ekman, 1958, p. 287)." A common practice in subjective distance experiments is to have the subject mark a line so that it is proportional to a line representing a fixed distance.

Ratio estimation is a standard technique used by both psychologists and geographers in studies on cognitive perception of geographic distances[1]. Recent Ph.D. theses in geography employing this technique are Louviere (1973) and Cadwallader (1973).

The usual method of ratio estimation involves the matched pair comparison of two distances (i.e. perceived distance and a standard distance). Earlier research (Rothwell, Bottomly and Forbes 1971) indicated that subjects could

---

[1] See Lee (1970), Golledge, Briggs and Demko (1969), Kunnapas (1960) Ekman and Bratfisch (1965), Bratfisch (1969), Lowerey (1971), Briggs (1969), Teghtsoonian (1971), Cadwallader (1973), and Howard, Chase and Rothman (1973).

estimate six distances simultaneously with high reliability. In this experiment no standard distance was given as the subjects merely marked on a line the distance between themselves and a group of targets.

Research by Howard, Chase, and Rothman (1973) employed the simultaneous ratio scaling of eight geographic points. This research is interesting in the fact that subjects "were asked to draw a partial map of the environment which would indicate the location, shape, orientation, and main door (if relevant) of the eight points which were listed for them (p. 258)." This is very similar to the maps in this dissertation except for the fact that the subjects (in Howard et al) "were given a reference line representing the distance between points 1 and 5 (p. 258)." This research would also seem to indicate that the general method of using manual maps in a ratio estimation technique may work in a broader environmental setting.

This dissertation also employed ratio estimation. The walls depicted in the manual maps were treated as subjective distance estimates. The respondents supplied their own reference line in the form of the outside walls of the house[1].

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[1] An earlier experiment (Rothwell, 1970) was conducted to determine if subjects could complete the interior walls of a building more accurately if they were supplied with a scaled outline of the exterior walls than if they drew the whole building free hand. Results indicated that there was no significant difference between the groups although the group supplied with the outline had <u>more</u> error than the free hand group.

Although the actual measurements were made on individual walls, when the drawing was completed it represented the entire cognitive map of the house. This, of course, was the advantage of the research design - the number of possible measurements was finite.

Figure 5 is a schematic diagram of the sample house. This diagram was used in the process of digitizing and coding the data. Each of the 24 wall intersections was labelled with a letter (A through X). These letters were used to designate the XY coordinates when the manual map was digitized. All walls could then be described using the letter designations of the intersections, for example the bathroom walls were BC, CG, GF and FB. All rooms in the house were given number designations 2 to 10 with the number 1 reserved for the whole house. Appendix 2 gives a complete list of all wall designations and room designations. There was a total of 41 discreet distances and 10 areas.

The ultimate task was to convert the free hand drawings to error measurements. Figure 6 outlines the tasks involved in the conversion process. Each step in the process will be described below:

1. Intersection Designation

   The intersection of each wall with all others had to be marked and identified with a letter. The location of the intersection point was sometimes a matter of interpretation, especially

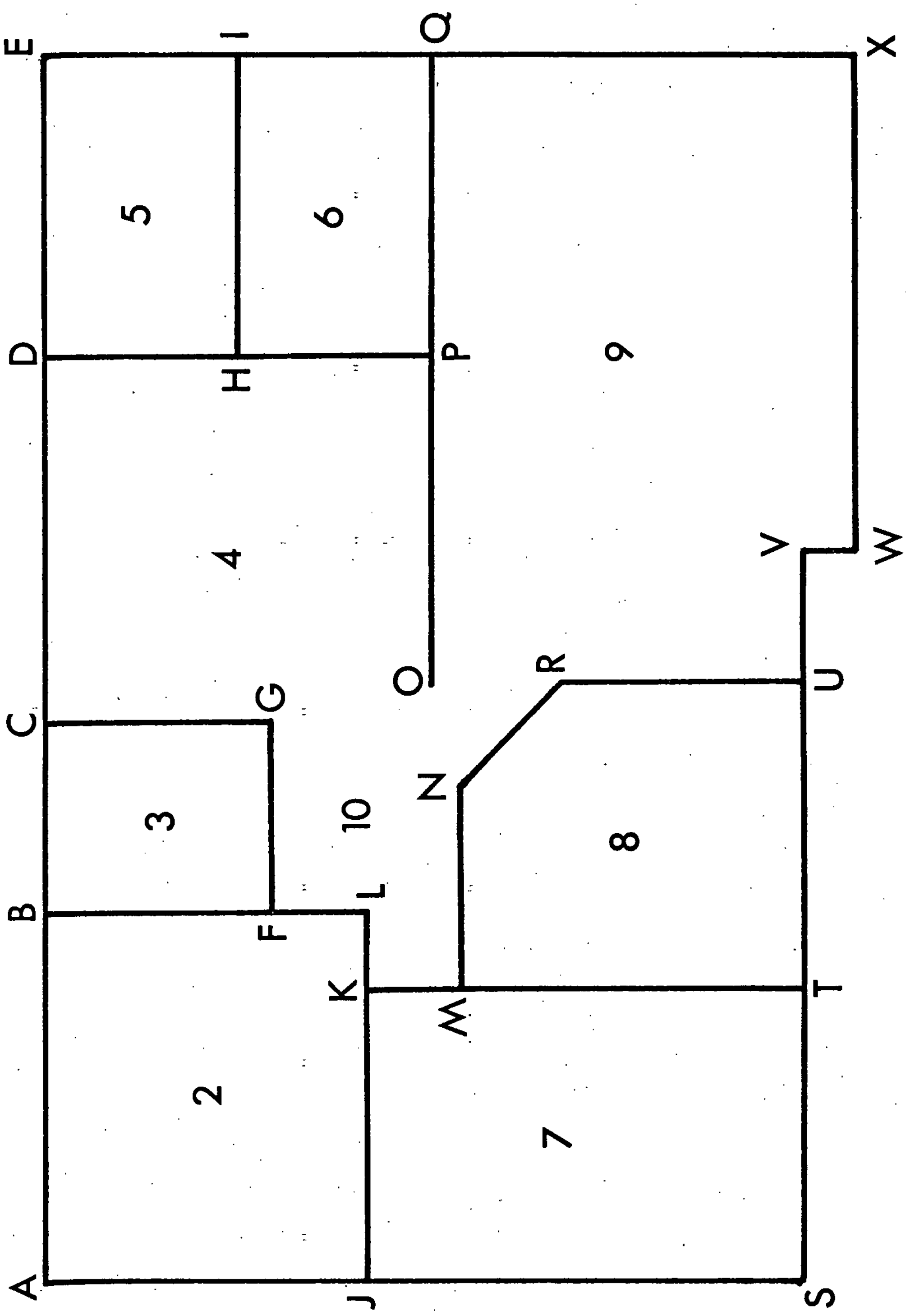

FIGURE 5: Schematic diagram of house floor plan

when lines were not joined or corners were rounded. The following criteria were established for subjective judgements:

a. Where walls did not join, the lines were continued by the marker in the same direction as the subject until an intersection was formed.

b. On rounded corners any marked deviation inthe direction of the curve was considered a corner, or for symmetric curves the center of the arc was chosen.

Of the approximate 165 maps processed[1], about 50 percent were marked by myself and the other 50 percent by Mrs. C. Wood. To determine the amount of subjective error which might occur, 51 maps (31 percent) were processed independently by both markers. When digitized, there was a mean difference between the estimates of .042 inches (s.d. .007) on 1,224 simulatenous observations[2]. The differences were normally distributed about the mean. The average manual map had 46.74 inches of line.

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1 A small number of adult maps (17) could not be digitized because of gross errors.

2 Actual digitizing tolerance by eye is small, .001 inch.

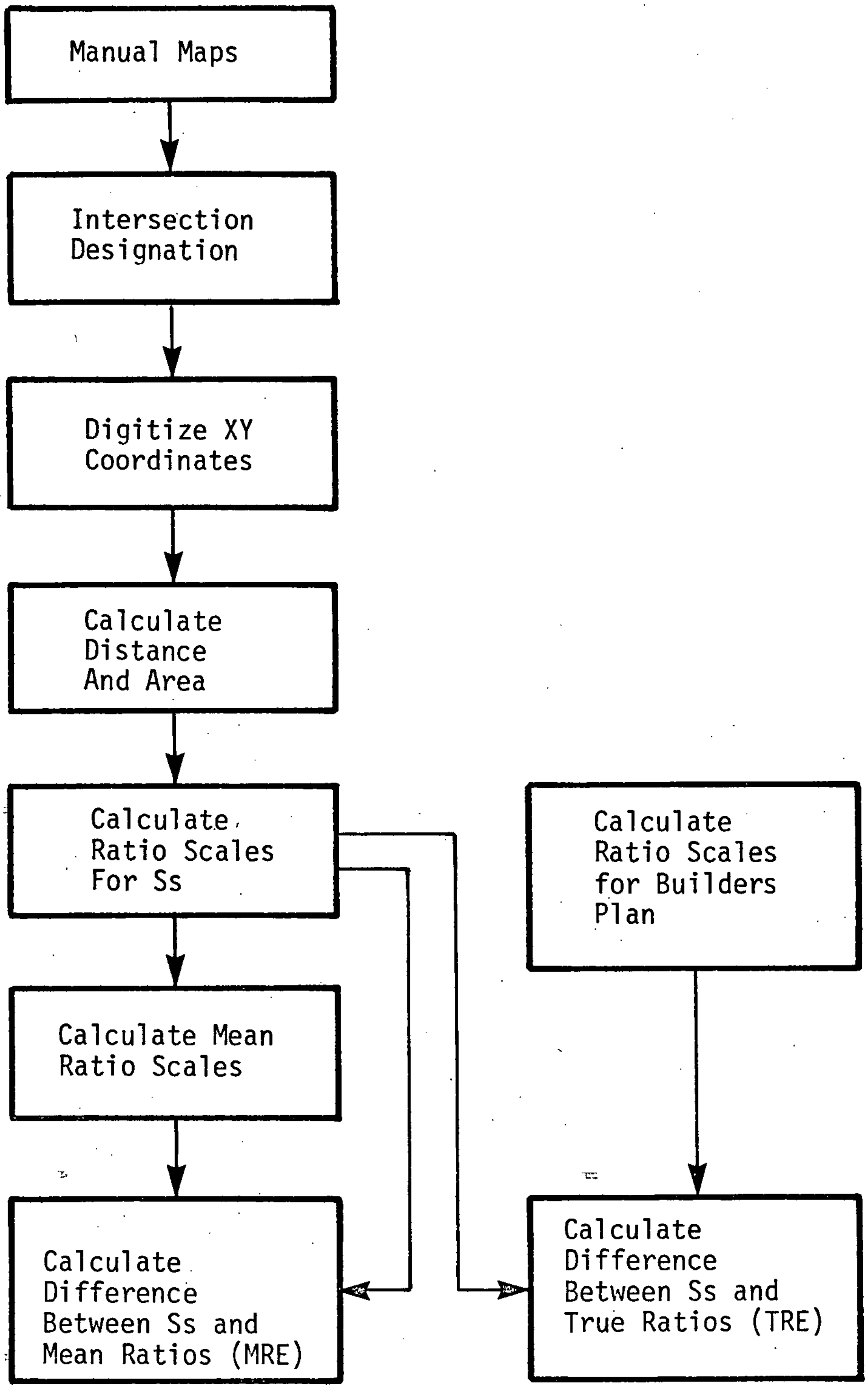

FIGURE 6: Flow chart of Mean Ratio Error (MRE) and True Ratio Error (TRE) calculations.

Error, if accumulated on all 24 points, would represent only 2.4 percent of this total line length. Because error was Distributed normally about the mean, it would not have a cumulative effect. Some error would therefore balance out the other producing an average error of less than 2.4 percent.

2. Digitize XY Coordinates

The UBC Gradicon digitizer was used to produce XY coordinates for all 24 wall intersections. The accuracy of the digitizer is .001 inch or about the limit of the human eye to detect differences in location.

3. Calculate Distance and Area

The XY coordinates were stored on a cassette tape. A Wang 600 was programmed to calculate the 41 distances and 10 areas from the coordinates. The algorithms to calculate distance and area from polar coordinates were those given in Davis et al (1966, p. 483).

4a. Calculate Distance and Area Ratio Scales

The purpose of this calculation was to standardize the distances and areas so that all maps were equivalent to the same scale. The methodology for calculating the geometric mean ratio scale, Ri, (of any wall or area) is described by Ehman (1958). A matrix is constructed in which any cell contins the ratio of the value of the row, Rai, to the value of the column, Raj.

The row and column values were the 41 distance measurements (for distance ratios) or 10 area measurements (for area measurements). The sums of any row, ri, and any column, cj, are given by the equations:

$$ri = Rai \; \Sigma (1/Raj)$$

$$cj = (\Sigma Rai)/Raj$$

The ratio scale of any single distance or area is then calculated by Ekman's formula 14:

$$Ri = \sqrt{\Sigma ri / \Sigma ci}$$

The ratio scales for 41 distances and 10 areas were calculated for all manual maps.

4b. Calculate Ratio Scales for Builder Plan

In order to compare the true distance to subjective distance (i.e. cognitive map to the real world), the equivalent ratio scales for all walls and floor areas were calculated for the building plan.

5. Calculate Mean Ratio Scales

In order to compare individuals' manual maps to the group of respondents as a whole, the mean ratio scales for all walls and areas for all subjects were calculated.

6a. Calculate Difference Between Individual Ratio Scales and Mean Ratio Scales

To determine the deviation between individuals and the norm, the absolute difference between individual and mean ratio scales was calculated to produce a mean ratio error (MRE) for each individual. The MRE was the sum of the absolute differences on each wall and on the whole area of the house. MRE figures were also calculated for each room.

6b. Calculate Difference Between Individual Ratio Scales and the True Ratio Scales

The same procedure was followed as above to produce true ratio error (TRE). (For detailed example see Appendix 8.)

The output of this exercise produced, for each subject, MRE and TRE figures for the total house and nine rooms.

A brief mention should be made about codable responses. If an individual omitted more than two walls from his drawing, the map was designated as non-codable and not digitized. There were 17 or 10.3 percent non-codable adult manual maps.

There were many individuals who omitted a wall. In fact 64.2 percent of subjects neglected to draw the wall VW (see Figure 4) which was a short wall producing a small "L-shape" in the living room. The frequency of wall omissions is shown in

Table 5. Although other walls were also omitted, this only occurred in non-codable maps.

TABLE 5

FREQUENCY OF WALL OMISSIONS

Wall	Percent of Subjects (N = 148)
VW	64.2
NR	7.3
UV	3.2
BC	0.7
FG	0.7

This omission of walls, however, necessitated the use of a correction factor in the ratio measurements. A missing wall did not invalidate the ratio scales (the matrix was 40^2 instead of 41^2) but did tend to produce relatively lower ratio scores depending upon the length of the wall. Of course, for the true builder's plan, the sum of the ratios equals 41. To account for missing walls, correction factors were calculated for any single wall or combination of two walls. Each ratio scale for the walls that were drawn was then multiplied by the correction factor to make it equivalent to the case where no walls were missing. The ratio scale value of the missing wall was zero so that the MRE or TRE for the wall was, in fact, the value of the mean ratio or true ratio.

In addition to MRE and TRE values, other data were also extracted from the manual maps - quality rating, errors, and additions and anomalies:

1. <u>Quality Rating</u>

After extensive study of all the manual maps, it seemed possible to categorize them according to the "quality" of the drawing. There is no objective definition of quality here. Rather, quality seemed to mean the ability to graphically portray a floor plan. Quality ratings were assigned on a four point scale: non-codable (1), poor (2), average (3), excellent (4). Appendix 3 illustrates actual floor plans which fall into these categories.

Since I was the only person to subjectively determine quality there is no available method of checking the reliability of this measure. When the quality ratings were correlated against all other variables, however, the analysis tended to reveal my own biases in the rating of quality in manual maps. In some ways it acts as a measure of my objectivity.

2. <u>Errors</u>

In addition to the missing wall code[1], a binary code was established for drawings which did not have corners joined.

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[1] Missing Wall code 1 = none, 2 = VW, 3 = NR, 4 = UV, 5 = VW and NR, 6 = UV and NR, 7 = BC and FG, 9 = non-codable.

3. Additions and Anomalies

Since the subjects were given a blank piece of paper, they could draw their manual map in any orientation they wished. Subjects were also asked to write the names of the rooms on their map. From this the orientation (i.e. map drawn as if the person was looking towards the street, or drawn as if the person was looking towards the backyard) of the manual map was coded. If the subject indicated which bedroom was theirs, the number of the bedroom was coded. Although respondents were told that doors, windows, and furniture were not necessary, almost all included additional information. It appeared from subjective assessment that subjects who had better quality drawings also had more additional information on their map. This hypothesis was examined by coding the presence of any additional information. This data had a simple nominal code - present/absent. If there was any indication that the subject attempted to draw a certain thing the variable was coded as present. In the adults' manual maps the following additional items were observed:

- doors
- closets
- bath tub
- toilet
- kitchen sink
- stove
- refrigerator
- furnace
- washer
- dryer
- kitchen counter
- kitchen table
- steps
- bathroom sink
- windows
- fireplace

Appendix 4 presents manual maps which contain some of the above items.

In summary, then, the data obtained from the manual maps were:

- MRE and TRE values for:

1.	the total house	6.	utility
2.	bedroom A	7.	bedroom J
3.	bathroom	8.	bedroom N
4.	kitchen	9.	living room
5.	storage	10.	hall

- quality ratings
- errors
- additions and anomalies.

2.63 Graphic ability. The object of this test was to gain some measure of the subjects' eye-hand coordination and facility with a pencil. Although there are several manual dexterity tests available (for example, Bennett Hand-Tool Dexterity Test, Stromberg Dexterity Test, Crawford Small Parts Dexterity Tests), these did not appear to be really suitable. Various forms of printing tests which measured graphic ability were also available, but these were designed for small children and appeared unsuitable for adults.

The eventual choice was the Lurcat Test of Graphical Abilities (Lurcat and Kostin 1970). The following page (Figure 7) shows the five figures used in the test. Subjects were instructed to reproduce exactly in size and shape the figures they saw on the test page. No straight edges and no copying were allowed.

The test was marked by using a transparent key which was fitted over the figures. Graduated scales on the key allowed the marker to measure the amount of deviation in both size and shape to produce a total score. Since the marking was a visual exercise and somewhat subjective, two markers were used. Mrs. C. Wood and myself marked 50 common tests. A correlation between the two sets of marked scores yielded a significant r value of .97 indicating the high reliability of the marking.

One problem with the Lurcat Test of Graphical Ability is that it is not a widely used test and most work with it has been done on French school age children (Lurcat, 1966), although it is now being used to some extent in the United States (Lurcat and Kostin 1970). Reliability measures take the form of test-retest and in France have produced a mean reliability coefficient of .78[1]. Lurcat (1966) seems to demonstrate that her test does have predictive validity, but again this was for children.

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[1] No reliability coefficients for the American tests.

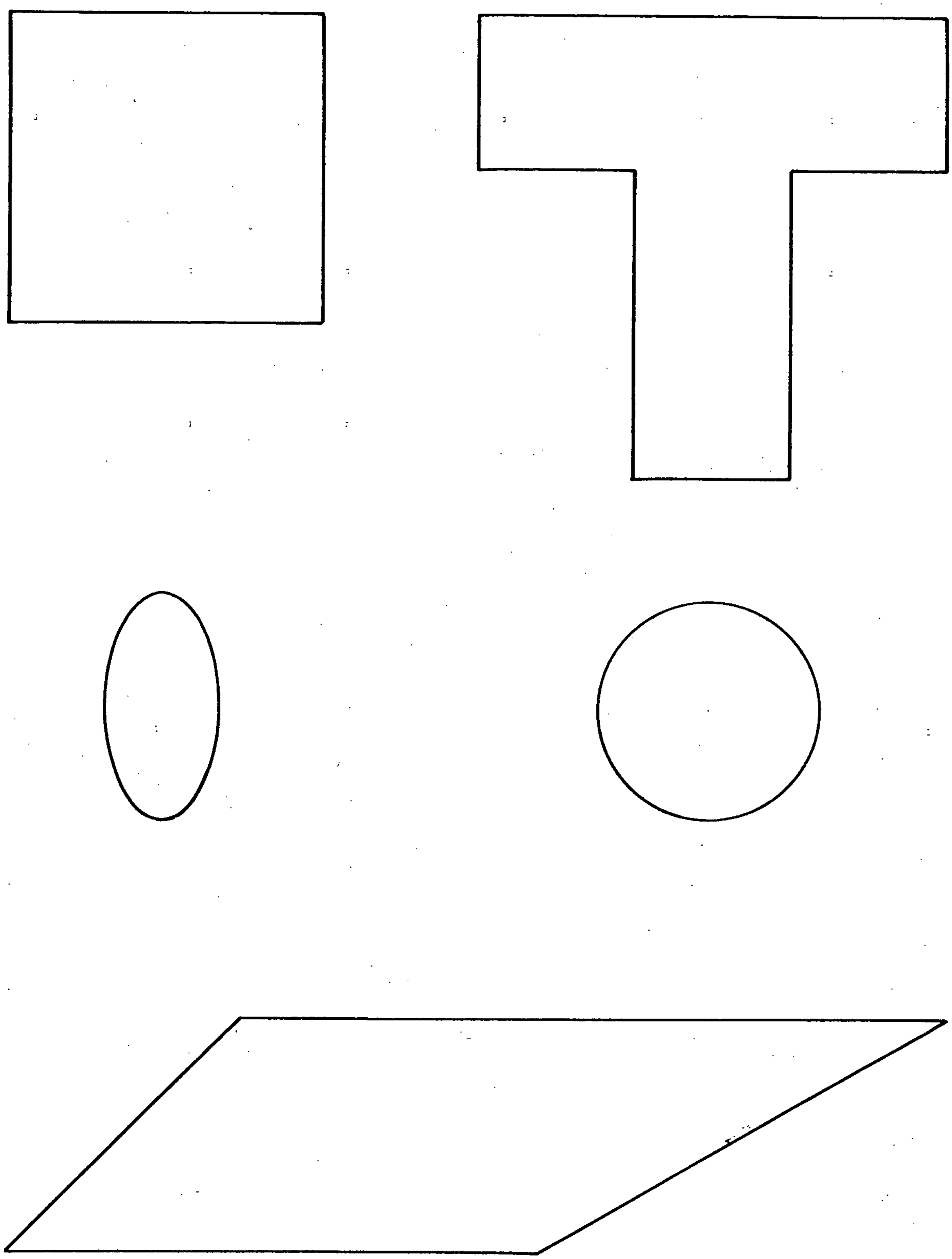

FIGURE 7

LURCAT GRAPHIC ABILITY TEST

To obtain some indication of reliability the Lurcat Test was administered twice to 94 undergraduate geography students between the ages of 17 and 49 with a week separating the test periods. A test-retest procedure described by Helmstadter (1964) produced a significant reliability coefficient of .89.

The only type of validity that can be assumed is content validity. Content validity "refers not to what the test actually measures, but what it appears on the basis of subjective evaluation to measure (Helmstadter, 1964, p. 89)." "It is of some importance that the items and the test as a whole appear to be plausible and relevant to the stated purpose (p. 90)." It would appear that the Lurcat test - graphic reproduction of geometric forms - does at least have content validity.

2.64 Spatial aptitude. The spatial aptitude test used was the Revised Minnesota Paper Form Board Test (1970 edition) with series AA being used. Appendix 5 contains a copy of the test.

As a test of spatial aptitude the MPFB has gained widespread usage in both education and industry. The reliability and validity of the test is well established. An example of alternate form reliability is illustrated in Table 6 while Table 7 illustrates some test-retest reliabilities for children as young as 10 years of age.

TABLE 6

Alternate Form Reliability Coefficients and Standard Errors of Measurement for the Revised Minnesota Paper Form Board Test

Group [a]	Series	N	First Testing Mean	First Testing SD	Second Testing Mean	Second Testing SD	r_{12}	SE_M [b]
1. Grade 10 and 11 boys (Louisville, Kentucky)	AA-BB[c]	172	43.9	9.5	47.5	9.3	**.78**	**4.5**
	MA-MB[d]	175	44.3	7.0	49.0	7.5	**.73**	**3.7**
2. Grade 11 boys and girls (Salt Lake City, Utah)	AA-BB[c]	180	44.9	8.6	48.2	8.6	**.78**	**4.1**
	MA-MB[d]	123	44.9	8.4	47.7	8.7	**.77**	**4.0**
3. Engineering students (University of Michigan)[e]	MA-MB[d]	98	48.6	6.4	52.7	6.2	**.77**	**3.1**
4. High school students (Michigan)[f]	MA-MB[d]	164	49.2	6.4	53.5	6.8	**.71**	**3.4**

[a] The time interval between tests was from 2 to 11 days for Group 1, and 4 days for Group 2. Groups 3 and 4 were retested immediately. All testing was conducted in 1969.

[b] $SE_M = SD\sqrt{1 - r_{12}}$. The SD of the first testing was used to compute the SE_M.

[c] For some students, the test-retest order was *AA-BB*; for others, it was *BB-AA*. Since equivalence of forms has been established (see Table 1), all data from the first testing were combined without regard to form. The same procedure was followed for data from the second testing.

[d] For some students, the test-retest order was *MA-MB*; for others, it was *MB-MA*. Since equivalence of forms has been established (see Table 1), all data from the first testing were combined without regard to form. The same procedure was followed for data from the second testing.

[e] Students were 96% male.

[f] Group 4 consisted of 109 males and 55 females in geometry and drafting courses; 87% of the sample was in Grade 10.

Source: Rensis and Quasha, 1970, p. 13.

TABLE 7

TEST-RETEST RELIABILITY COEFFICIENTS

	Age at Second Testing[1]							
	11 years		12 years		13 years		14 years	
Age at First Testing	N	r_{12}	N	r_{12}	N	r_{12}	N	r_{12}
10 years	109	.87	156	.86	135	.77	73	.81
11 years			208	.90	210	.85	87	.82
12 years					259	.87	91	.80
13 years							87	.79

Other test-retest studies on adults have shown the reliability to be equally high.

A great deal of work has also been done on MPFB validity. The test would appear to have construct, predictive, and factor validity. Appendix 5 also contains coefficients of correlation between the MPFB and other tests as well as coefficients of correlation between MPFB and various criteria. It is important to note that the MPFB has significant correlations with:

[1] The terms "first testing" and "second testing" are relative only to the particular correlation being computed. In actuality, many children took the test three, four, or five times in the course of the longitudinal study.

Source: Rensis and Quasha, 1970, p. 12.

- intelligence (Wechsler-Bellevue and Standford-Binet)
- numeric ability
- spatial ability
- manual ability and manual dexterity
- clerical ability
- drafting and design success
- artistic success
- job success[1].

Factor analysis of intelligence reveals that spatial aptitude is consistently among the first four factors to be extracted in the analysis. Although verbal aptitude is generally the first factor, spatial and numeric aptitude are close behind.

The MPFB is a timed test of 20 minutes and was administered according to manual instructions. There was no correlation between the interviewer and spatial aptitude scores. The test was marked according to the key provided.

2.7 Children Data

Children were asked to complete only two tasks, manual map and Draw-a-Man Test.

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[1] Job success measure in efficiency, performance, rating of job success, rank and salary.

2.71 Manual maps. Instructions to the children were very similar to those of the adults. They were asked to draw a floor plan or map of the house. If they did not seem to understand the interviewer showed them a line drawing of a floor plan, saying "see here is the kitchen, and bedroom, etc.". They were told that it was not a map of their home but someone elses. If this approach did not work the interviewer asked the children to draw a picture to show where the rooms in the house could be found. "If I didn't know where to find your bedroom or bathroom or kitchen could you draw me a map so that I could find my way." If this did not work they were simply asked to draw a picture of their house. A few refused to draw anything.

There were six sets of data derived from the children's manual maps:

1. Rank

   Four judges independently ranked the floor plans[1]. The judges were shown a real floor plan of the house and instructed to:

   rank all of the children's maps into the order which you think they depict reality.

---

[1] N = 47, 10 out of the 57 either refused to do anything or drew an outside view of the house.

2. Elements of Style

In the children's drawings there appeared to be certain styles that emerged. The style types are illustrated in Appendix 6 and described below:

Some older children used a sketching technique of short pencil strokes to form a continuous line. Artists frequently use this style. Thick walls or two dimensional walls was a frequent occurrence. Here the children did not simply put in a line for a wall but showed the thickness of the wall. Many drawings were non-square. The outside walls of the house were not straight lined and rectangular but rather the house was put together like a group of non-uniform blocks. The other extreme to this was the box house where a square or rectangle formed the exterior walls and rooms were placed inside this perimeter like loose blocks. There was also the appended room houses in which the rooms were drawn separately with no exterior boundary and connected by lines representing hallways. Some young children also had interior side views, which showed one or two rooms with doors and furniture. And finally two children who did produce floor plans, also put a roof in the drawing (so did one adult, but the response was non-codable).

3. Errors

The wall "NR" seemed to be significant to the children because it was not perpendicular to other walls in the house. The omission of this wall was coded. Missing rooms and rooms out of place were also coded.

4. Orientation

This variable was the same for adults and children except that the orientation for some children was not evident.

5. Size of Rooms

Some children greatly exaggerated certain rooms, particularly their bedrooms and the bathrooms. This was coded if a bedroom was as large or larger than the living room or was as small or smaller than the bathroom, if the bathroom was larger than at least two other rooms, and if the hall occupied about one fifth or more of the house area.

6. Details

Like the adults the children frequently included other details. These were noted and coded as with their parents. The following is a list of details:

- wall VW present
- furnace
- master bedroom[1]
- house codable
- doors
- closets
- fireplace
- kitchen sink
- bathroom sink
- bath tub
- stove
- refrigerator
- windows
- washer
- kitchen table
- kitchen counter
- beds
- steps
- toys

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[1] The word "master" written in.

2.72 <u>Draw-a-Man Test.</u> The Goodenough-Harris Draw-a-Man Test (Harris, 1963) was used to determine the children's mental age and graphic ability. The test is very easy to administer. The child is simply asked to draw a picture of a man. The test takes only five to ten minutes.

The test focuses on the child's accuracy of observation and on the development of conceptual thinking, rather than artistic skill. The number of scorable items or points is 73. Appendix 7 contains a test booklet and short scoring guide. The scoring items were selected from a pool of about 100 on the basis of age differentiation, relation to total scores on the provisional form, and relation to group intelligence test scores. Raw scores are converted to standard scores with a mean of 100 and standard deviation of 15. This means that the children's score is roughly equivalent to a standard I.Q. score.

Score reliabilities are usually over .90. In part, such interscorer agreement reflects the fullness of the scoring instructions and the care exercised in selecting items that can be scored with a minimum of uncertainty. Split-half reliabilities are in the .70's and .80's. Retest reliabilities obtained over intervals as long as three months fall mostly in the .60's and .70's. Short term fluctuations in performance are negligible. Examiner variance has proved insignificant, as has the effect of art training in school upon test scores.

An alternative way of evaluating performance utilizes the Quality scale. (This scale technique was not used in the present research.) These scales substitute a simplified, global qualitative assessment of the entire drawing for the detailed point scoring. The score simply chooses one of twelve sample drawings that most closely matches the performance level of the subject's product and assigns the scale value of that sample to the drawing (see Appendix 7). Interscore reliabilities for the Quality scales are mostly in the .80's.

Harris (1963) summarizes correlations obtained between Draw-a-Man tests and the Stanford-Binet, WISC, WAIS, PMA, and a few other intelligence and special aptitude tests. Nearly all these correlations are significant and most are substantial (see Appendix 7). The principal evidence for the validity of the Draw-a-Man Test derives from the item analysis procedures followed in developing the scales.

In the test, items 63 to 69 can be used as a subtest for graphic ability. Harris says that these items "concern the quality of the child's control of the pencil. These items evaluate the firmness and sureness of line, quality of line junctions, corners, etc." These items require "the child's deliberate direction of the pencil to produce a good form. The child's work must show that he has exercised control, firmly and surely. (pp. 262-623)".

3.0 ADULT RESULTS

Results of the adult data will begin with a brief description of the data broken down according to:

1. - TRE and MRE scores
   - other map data
2. spatial aptitude
3. graphic ability
4. socio-economic data.

Where applicable, the data will be broken down into the categories male head, female head, and others.

Following a description of the data, various analyses were used to test the reliability and validity of the manual map as a research instrument. The next section contains the correlation analysis between error scores and other sets of data (socio-economic, factor scores, spatial aptitude, graphic ability, etc.) The final section deals with the psychophysical relationships in distance and area perception.

3.1 Data Description

3.11 TRE and MRE scores. Table 8 shows the means and standard deviations for absolute TRE and MRE scores for

TABLE 8

MEANS AND STANDARD DEVIATIONS OF TRE AND MRE FOR WALLS BY ADULT GROUPS[1]

	Total				Male Head				Female Head				Other			
	TRE		MRE		TRE		MRE		TRE		MRE		TRE		MRE	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bedroom A	.70	.41	.68	.40	.69	.33	.69	.36	.64	.37	.61	.35	.84	.46	.81	.41
Bathroom	.61	.56	.58	.55	.66	.78	.62	.75	.60	.40	.57	.42	.56	.30	.54	.35
Kitchen	.85	.59	.78	.57	.83	.69	.77	.67	.86	.49	.78	.47	.87	.50	.75	.49
Storage	.74	.32	.58	.38	.76	.30	.59	.40	.73	.23	.57	.34	.74	.26	.60	.35
Utility	.58	.43	.55	.42	.57	.55	.54	.55	.61	.29	.58	.30	.51	.32	.50	.29
Bedroom J	.75	.38	.69	.38	.79	.39	.73	.36	.68	.29	.60	.33	.82	.32	.80	.37
Bedroom N	.84	.51	.79	.48	.84	.57	.83	.55	.86	.46	.78	.41	.82	.32	.74	.32
Living Room	1.04	.57	1.03	.56	1.02	.54	1.02	.50	1.09	.54	1.07	.53	.98	.50	.84	.50
Hall	.94	.59	.71	.47	.85	.51	.68	.50	1.06	.59	.76	.47	.96	.39	.82	.37
Total House	8.52	3.56	8.05	3.33	8.48	2.94	8.06	2.92	8.76	2.61	8.12	2.61	8.12	2.46	7.93	2.45

[1] Room error is the sum of the absolute error of all walls of a room, total error is the sum of all wall errors for the house.

all rooms and the total house. For the most part the TRE and MRE analyses were concerned solely with the subjects' wall distance error.[1] The error in the area of a room was generally omitted. This was done because error in area was found to be a direct linear combination of the error in walls. (This made sense since the area of a room was defined by the walls). To report both linear area and area error would, therefore, have been redundant.

On the basis of error scores male household heads produced manual maps which were closer to reality than their female counter parts. The male heads, however, were in turn out done by their children. A series of t-tests was performed among the three groups and revealed no significant differences in the means. A paired comparison t-test between husbands and wives revealed no significant difference in the means.

The conclusion here must be that there was no significant difference between male household heads, female household heads, and others.

A paired comparison t-test was also performed to determine if there existed a significant difference between TRE and MRE values. Table 9 presents the means and

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[1] Total room error was the sum of the absolute errors for all walls of any room.

significance levels for the absolute total house error, indicating that there was no significant difference.

TABLE 9

MEANS AND SIGNIFICANCE LEVELS OF PAIRED T-TEST FOR ABSOLUTE TOTAL HOUSE ERROR

	Male Head	Female Head	Other
TRE	8.4795	8.7578	8.1206
MRE	8.0616	8.1246	7.9322
t Significance	.5182	.2360	.7947

The above table is significant. It indicates that in terms of people's ability to communicate cognitive maps of the home environment there is little difference between the real world and the world as people perceive it (i.e. the norm approximates the real thing). In this instance, the respondent's error from reality and error from the norm were about equal; TRE = MRE.

So far only absolute error has been examined. Absolute error is the difference between the standard (true ratio or mean ratio) and the individual observation, regardless of sign. Absolute error is used because it represents the total sum of all committed errors. If relative error were used the positive and negative errors would tend to cancel one another out. In the case of absolute error the total average absolute house error of 8.52 represents 20.8 percent of the summated real ratios (41).

Relative error, however, can be used to determine if some rooms are perceived to be larger or smaller than reality. Relative errors were computed for all rooms for the three subject groups. A t-test was then performed to determine if there was a significant difference between relative error and zero. If there was no error or if a group was dicotomously split the relative error would be zero. This t-test also indicates the direction of the error. The t-test revealed that there was no significant difference between the relative room errors and the mean of zero, except for the hall, where the significance of the results were different for the various groups (Table 10). It would appear that all groups perceive the main hall as larger than reality. It is important to note, however, that the difference was marginal and occurred only for one room. In general, when relative error is considered, TRE = MRE = 0. This also indicates that the cognitive map is a close approximation of the real world.

TABLE 10

SIGNIFICANCE LEVEL OF T-TEST TO TEST THE DIFFERENCE BETWEEN ERROR IN THE SIZE OF HALL AND ZERO

	Significance Level
Total	.037
Male Head	.057
Female Head	.024
Other	.031

3.12 Other map data. Table 11 outlines the quality rating for the adults' manual maps.

TABLE 11

QUALITY RATING OF ADULTS' MANUAL MAPS IN PERCENT

	Total (N=165)	Male Head (N=61)	Female Head (N=70)	Others (N=34)
Non-codable	10.3	12.8	17.0	4.3
Poor	24.7	23.4	22.6	17.4
Average	52.0	51.1	50.9	56.5
Good	13.0	12.8	9.4	21.7

Orientation of drawings appears in Table 12.

TABLE 12

ORIENTATION OF ADULTS' MANUAL MAPS (percent)

	Total	Male Head	Female Head	Other
Wall				
AS (towards the bedrooms)	5.7	4.3	5.7	8.7
AE (towards the backyard)	40.7	42.6	34.0	52.2
SE (towards the street)	46.3	48.9	50.9	30.4
XE (towards the utility room)	7.3	4.3	9.4	8.7

Other variables from the map which may appear interesting are the details included by the adults. Table 13 is a list of these details and the percent of times they were drawn by the total sample of 165.

TABLE 13

MANUAL MAP ADDITIONAL DETAILS

Detail	Percent Occurrence	Detail	Percent Occurrence
Doors	81.3	Washer	15.4
Closets	52.8	Dryer	14.6
Bath Tub	16.3	Counters	17.1
Toilet	14.6	Kitchen Table	7.3
Kitchen Sink	16.3	Steps	26.0
Stove	10.6	Bathroom Sink	13.8
Refrigerator	10.6	Windows	19.5
Furnace	57.7	Fireplace	30.9

3.13 Spatial aptitude. Table 14 presents the means and standard deviations for the MPFB test.

TABLE 14

SPATIAL APTITUDE SCORES[1]

	Mean	SD
Total	39.34	12.91
Male Head	37.70	14.00
Female Head	40.66	12.08
Other	39.65	12.64

A series of t-tests revealed no significant differences among the groups in their spatial aptitude. As a whole the group tested did relatively poorly. Their average scores are well below the 50th percentile of all educational and industrial groups. The others (which are primarily high school students) score in the 25th percentile for their particular norm.

The frequency distribution of spatial aptitude scores when analyzed proved to be normal.

3.14 Graphic ability. Table 15 outlines the means and standard deviations for the Lurcat Test.

TABLE 15

GRAPHIC ABILITY SCORES[2]

	Mean	SD
Total	12.95	6.41
Male Head	13.15	6.54
Female Head	12.81	6.50
Other	12.87	6.22

[1] Higher scores represent a greater spatial aptitude.
[2] Higher scores represent a lower graphic ability.

Again there were no significant differences among the group scores. The graphic ability scores also approximate a normal distribution.

3.15 Questionnaire. The questionnaire can be broken down into three sets of data - general information, socio-economic information, and the semantic differential.

1. General Information

The housing development is approximately 15 years old. The mean length of residence (8.7 years) and median length of residence (8.5 years) are very close. However, the mode of this distribution is 15 years. There appear to be two distinct groups - the established group who are still the original owners (14 years[1] or more residence, 34.2 percent) and the newly purchased group (3 years or less residence, 23.6 percent). It is also interesting to note that 52.1 percent of the others (mostly high school children) have lived there 14 or more years. The community sampled is not very mobile with the average change of residence being two times in the 10 years and the median being one time (47.2 percent have never moved). Only 8.1 percent of respondents were left handed, 14.6 percent wore eye glasses to do the test, 12.2 percent were non-Canadian, and 15.4 percent in the opinion of the interviewer seemed to experience some difficulty in understanding or completing the tasks.

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[1] Because the sample period spanned two years the development was only 14 years old in 1972.

The remainder of the general information is probably best conveyed by replicating the questionnaire format:

- How do you feel about the amount of living space in your present residence. It is:

a.	much too small	16.3%
b.	small but adequate enough	43.9%
c.	just right	37.4%
d.	more space than really needed	1.6%

- Are you satisfied with the arrangement of rooms in your present home?

a.	yes	82.9%
b.	no	16.3%

- How many bedrooms would be adequate for your family? (mean 3.1, median 3.0).

- Do you feel you are getting your money's worth out of your present residence?

a.	yes	95.1%
b.	no	4.9%

- In comparison to other places in the Lower Mainland, how would you rate your neighborhood as a place to live:

a.	excellent	20.3%
b.	very good	44.7%
c.	good	27.6%
d.	fair	7.3%
e.	poor	0.0%

- Do you anticipate moving within the next two years?

  a. yes 13%

  b. no 87%

2. Socio-Economic

Table 16 illustrates the age breakdowns for the various groups.

TABLE 16

AGE BREAKDOWNS OF ADULT SAMPLE

	N	Mean	SD	Median	Range
Male Head	61	38.9	10.65	39	24 - 71
Female Head	70	37.3	12.17	36	22 - 73
Others - Male	17	18.4	2.31	16	14 - 20
Others - Female	17	19.4	3.45	16	14 - 72

Occupations were coded according to the Blishen Scale (1958). Male household heads had an average score of 51.59 and female household heads an average score of 53.30 (only 32.1 percent were employed). Of those not employed, 55.7 percent were housewives, 34.4 percent were students, 8.2 percent were retired and one person was unemployed.

For male heads of household their father's occupation had an average score of 46.47, significantly lower than their own and for female heads their father's occupation had an average score of 49.21, significantly lower than their own or their husband's occupation. There was no significant difference between husband and wife's father's occupations.

Table 17 provides a breakdown of the subjects' educational level.

TABLE 17

ADULTS' EDUCATION LEVEL

	Male Head	Female Head	Other
Grade 8 or Less	4.3	1.9	17.4
Grade 9 - 13	55.3	56.6	74.3
Some University or Technical Training	19.2	34.0	8.3
BA, B.SC., Diploma	17.0	7.5	-
MA or above	4.3	-	-

Table 18 provides a family income breakdown for the 70 families in the study.

TABLE 18

TOTAL FAMILY INCOME

Income (total family income)	Percent Families
less than $4,000	-
$4,000 - $6,000	1.4
$6,000 - $8,000	1.4
$8,000 - $10,000	19.1
$10,000 - $15,000	51.1
$15,000 - $25,000	21.3
$25,000 - $50,000	2.8
more than $50,000	-
no answer	2.8

One third (33 percent) of households did not have children while 19.5 percent had one, 26.0 percent had two, and 13.0 percent had three.

3. Semantic Differential

The semantic differential was analyzed with a principal axis factor model with varimax rotation. The lower limit on eigenvalues was set at 1.

Three unrotated factors with eigenvalues greater than one emerged from the analysis. Table 19 contains a list of variables and their correlations with factors. The independence of the factors is shown in Table 20 which contains a correlation matrix calculated from the factor scores.

TABLE 19

MATRIX OF CORRELATION OF FACTORS WITH SEMANTIC DIFFERENTIAL VARIABLES

Variable	Factor 1	Factor 2	Factor 3
1. gloomy - bright	.68*	-.03	-.07
2. dull - interesting	.66*	-.18	-.06
3. depressing - happy	.59*	-.06	-.04
4. forbidding - welcoming	.54*	.26	.01
5. discordant - harmoneous	.53*	-.09	-.19
6. dangerous - safe	.47*	.13	.03
7. hard - soft	.36	.08	-.03
8. dirty - clean	.36	-.13	-.18
9. private - public	-.34<	-.34<	.31<
10. heavy - light	-.34<	-.26<	.05
11. light - dark	-.38<	-.22<	.23<
12. substantial - thin	-.50*	-.22	.02
13. invigorating - boring	-.59*	.06	.15
14. good - bad	-.60*	-.08	.25
15. warm - cold	-.62*	-.21	-.01
16. unusual - conventional	-.19	.51*	.02
17. formal - informal	.09	.48*	.09
18. complicated - simple	.03	.43*	-.09
19. feminine - masculine	-.15	-.21	-.03
20. open - closed	-.24<	-.32<	.26<
21. ordinary - imposing	.14	-.69*	.06
22. empty - full	.37<	.23<	.39<
23. peaceful - disturbing	-.32<	-.28<	.36<
24. small - large	.06	-.09	.72*
25. cramped - roomy	.20	.02	.85*

*indicates a magnitude greater than or equal to .40
<variables correlated with two or more factors almost equally.

TABLE 20

CORRELATION MATRIX AMONG FACTORS CALCULATED FROM THE FACTOR SCORES

Factor	1	2	3
1	1.000		
2	.035	1.000	
3	-.050	.005	1.000

Although a number of variables could possibly be used to describe two or more factors (variables 9, 10, 11, 20, 22, 23), the factor structure of semantic differential variables appears to be fairly straight forward. Putting names to these factors they could be described as:

1. mood (gloomy, dull, warm, good, depressing, invigorating, forbidding, discordant, substantial, dangerous).

2. aesthetic (unusual, formal, complicated, ordinary).

3. space (small, cramped).

Although the factors do not coincide very well with Honikman's (1970) factor structure, they do fit very well into the factor classifications developed by Hershberger (1972) and Seaton and Collins (1972).

The factor scores for all individuals on each factor were calculated and used as input to further analysis. This provided a means of comparing the subject's cognitive structure of the home to other variables.

3.2 Reliability and Validity

3.21 Reliability. The main concern for reliability in this experiment is for the reliability of the manual maps. Nunnally (1970) states that "reliability of a test can be estimated from the internal consistency of the items within it. If the average correlation between the items within a test is high, the internal consistency is high (p. 550)".

In the case of the manual maps, correlations were calculated between each room TRE and MRE and the total house TRE and MRE. Table 21 reports the correlation coefficients (Pearson r) which were all significant at the α = .001 level.

TABLE 21

CORRELATIONS BETWEEN TOTAL HOUSE TRE AND MRE AND ROOM TRE AND MRE

	House TRE	House MRE
Bedroom A	.40	.39
Bathroom	.50	.53
Kitchen	.66	.69
Storage	.48	.56
Utility	.35	.41
Bedroom J	.44	.42
Bedroom M	.50	.45
Living Room	.65	.67
Hall	.59	.66

The internal consistency for items by group was examined using Cronback's (1951) alpha coefficient:

$$\alpha = \left(\frac{n}{n-1}\right)\left(1 - \frac{\Sigma V_i}{V_t}\right)$$

where V_i = variance of test item i

V_t = variance of total score

n = number of parts.

Table 22 presents the reliability coefficient alpha for each analysis showing that the manual map has reliability through internal consistency.

TABLE 22

ALPHA COEFFICIENTS[1] FOR INTERNAL CONSISTENCY OF MANUAL MAPS BY GROUP FOR ADULTS

	Male Head	Female Head	Others
TRE	.63	.69	.70
MRE	.64	.70	.70

The pre-test also allowed for a test-retest situation to determine reliability. On 31 manual maps the correlation between total TRE scores was .72 and MRE scores .77.

It can be concluded that the manual maps used in this experiment did represent a reliable test instrument.

[1] Maximum α = 1.0.

3.22 <u>Validity</u>. The most important question, of course, is whether manual maps measure cognitive maps. Is a manual map a valid tool for representing what might be contained in a cognitive map?

As mentioned previously, an article by Howard et al (1973) dealt with this question. Examining the various forms of validity they correctly point out that "<u>Predictive validity</u> requires that we know precisely what a cognitive map is good for and <u>content validity</u> requires that we know what a cognitive map is. Since none of us is capable and most of us are unwilling to meet these conditions, predictive and content validity ... (p. 255)" cannot be considered appropriate tests. <u>Construct validity</u>, however, can be used as a test.

In their research, Howard et al conclude that:

> Since the attribute being measured in this example is subjective distance, the better the relationship between the true distance and the subjective distance, the better we might suppose the method, as it is very unlikely that these distances should be approximated by the subject unless the true distances were present in the cognitive map. (p. 256).

If this statement is correct, then a clearly definable relationship between objective and cognitive distance would indicate that the manual map did have validity.

Section 3.11 has already shown (Table 9) that there is little difference between the real world and the world as people perceive it (at least in terms of their ability to draw a house plan).

Further analysis was conducted by performing a correlation analysis between the true ratios for all 41 walls and the mean ratio for corresponding walls by subject groups. Table 23 reports the results. (Appendix 8 contains a list of ratios.)

TABLE 23

INTERCORRELATIONS[1] BETWEEN REAL RATIOS
AND MEAN RATIOS (WALL BY WALL)

	Real	Total	Male Head	Female Head	Others
Real	1.000				
Total	.9815	1.000			
Male Head	.9899	.9951	1.000		
Female Head	.9865	.9936	.9978	1.000	
Others	.9907	.9957	.9946	.9921	1.000

[1]Pearson r.

It is evident from the table that there is a very strong correspondence between real and cognitive distance. This correspondence is also very strong across the group.

It can be concluded here that this form of manual map represents a valid research tool.

This validity is confirmed by the Howard et al (1973) study in which the method of ratio estimation was shown to be a valid research technique in cognitive mapping research.

3.3 Correlation Analysis

It has been determined so far that the manual map can be a reliable and valid research tool, something which has not been demonstrated to date by other research.

On an individual subject basis, however, there are variations in the amount of deviation from the real world. It remains to be seen what variables may influence individual differences in manual maps.

The analysis will be presented as the correlation between TRE (and MRE) scores[1] and other sets of data. Intra-correlation of variables in a data set will be examined in another section.

3.31 TRE vs spatial aptitude and graphic ability. The perception of space and the ability to communicate that perception in graphic form would seem to depend to some

---

1 TRE and MRE are very similar; the results of one analysis being almost identical to the other. For this reason the MRE analysis is henceforth omitted.

extent upon the individuals' abilities in these areas. There has, however, been no research relating spatial aptitude (or even intelligence) to manual mapping. (Beck, 1967 is perhaps the closest.) Most previous research has tried to relate environmental, cultural, socio-economic or role variable to differences in maps. Ladd (1970), Assmusen (1971), de Jonge (1962), Gulick (1963), Ley (1972), Michelson (1970). Very little work has been spent in the search for psychological or physiological variables which might influence cognitive maps. It is quite possible that psychological variables have more influence than cultural variables.

It should be pointed out that related work including psychological variables does exist, especially for those concerned with finding the psychophysical function for cognitive distance perception and by those whose interest focuses upon attitude formation and its influence.

Correlation analysis of the spatial aptitude scores and graphic ability scores shows that they are both highly related to each other ($\alpha = .000$). Both scores also correlate with TRE. Table 24 presents the significance levels of correlations of spatial aptitude and graphic ability for the sample groups.

TABLE 24

SIGNIFICANCE OF CORRELATION BETWEEN TRE (TOTAL HOUSE) AND GRAPHIC ABILITY AND SPATIAL APTITUDE FOR ADULT GROUPS

	Graphic Ability	Spatial Aptitude
Total	.047	.014
Male Head	.106	.030
Female Head	.089	.029
Others	.108	.034

Although spatial aptitude is significantly related to error scores across all groups, graphic ability appears to be significant only for larger sample sizes.

It can be concluded here that spatial aptitude is a variable which may strongly influence an individual's cognitive map. To a lesser degree graphic ability may also influence the manual map. It would appear that the quality of the cognitive map may be dependent, to some degree, upon the recording instrument (i.e. spatial aptitude) and that the quality of the manual map may be dependent, to some degree, upon the quality of the playing instrument (i.e. graphic ability). Future research employing the use of manual maps should perhaps take into account these qualities.

It is interesting to note that spatial aptitude and graphic ability are also significantly related to a number of socio-economic variables. Table 25 illustrates the significance of various socio-economic variables with spatial aptitude and graphic ability.

TABLE 25

SIGNIFICANCE LEVELS OF CORRELATIONS BETWEEN SPATIAL APTITUDE AND GRAPHIC ABILITY, AND SOCIO-ECONOMIC VARIABLES

Variable	Spatial Aptitude	Graphic Ability
Age	.000	.000
Occupation	.000	.005
Education	.004	.001
Income	.025	.048

It should be remembered that spatial aptitude has been significantly related in previous studies to job status and income levels. It would also appear in the present study that the higher the spatial aptitude the more education, the higher the income, and the greater the job status for individuals. There is a significant negative correlation between age and spatial aptitude and graphic ability. This is consistent with the fact that mental faculties tend to decrease with increasing age starting at about 18.

3.32 TRE vs quality rating. As explained previously the quality rating (scaled 1 to 4) was a subjective judgment based on the experience gained in examining the manual maps. The quality rating scale, however, did produce highly significant correlations with TRE (see Table 26).

TABLE 26

SIGNIFICANCE LEVEL OF CORRELATIONS BETWEEN TRE AND QUALITY RATING FOR ADULT GROUPS

	Significance Level
Total	.000
Male Head	.004
Female Head	.013
Others	.111

Although the previous section indicated that the quality of manual maps may be influenced by psychological variables, the analysis here indicates that a qualitative approach to the analysis of manual mapping may still be a valid method of investigation and research.

In geographic literature there is little research dealing with the validity of subjective evaluation of manual maps. The above analysis would suggest, however, that there was some justification for previous research based on a qualitative approach.

The quality rating variable also correlated highly with a number of other variables (see Table 27).

TABLE 27

SIGNIFICANCE LEVEL OF CORRELATIONS BETWEEN QUALITY RATING AND OTHER VARIABLES

Variable	Significance Level
Spatial Aptitude	.000
Graphic Ability	.000
Length of Residence	.015
Age	.000
Number of Children at Home	.001
Closets	.000
Furnace	.000

Since spatial aptitude and graphic ability were also related to TRE it is easy to see why these variables are also related to quality rating.

For length of residence the longer people had lived in the homes the lower the score they generally received. [Although there was no significant correlation between TRE and length of residence $\alpha = .247$ there existed a negative correlation[1].] The older they were and the more children they had the lower were their scores.

---

1 Because quality rating is a nominal variable there can be no direction in the correlation coefficient, hence no negative correlations.

Examining my own impressions, I find that if the subjects included either a furnace room or closets they tended to receive higher quality ratings. As will be shown later, however, both these variables were also significantly correlated with the TRE.

3.33 <u>TRE and socio-economic variables.</u> There were no significant correlations between TRE and socio-economic variables except for number of children at home, which had a significant negative correlation ($\alpha = .03$) with TRE.

It should be noted that the community was very homogeneous in socio-economic status (especially income). If there was greater diversity then perhaps some relationship between the socio-economic variables and manual maps would have emerged. All that can be said is that subjects from the same socio-economic level tended to have similar responses on the manual maps.

3.34 <u>TRE and information variables.</u> Only one general information variable was significantly correlated with TRE - amount of living space ($\alpha = .000$). Those individuals who responded that their home was "much too small" tended to have more accurate manual maps (TRE lower). Presumably, this awareness of need for space has made them more conscious of their environment and able to perceive it more accurately.

3.35 TRE and factor scores. There was no significant correlations between TRE and factor scores. It would appear that the cognitive structure of the home (as measured by the semantic differential) was not related to their spatial cognitive map.

3.36 TRE and map errors. A significant correlation existed between TRE and the missing walls variables. If subjects had omitted a wall they tended to have more general error in their maps. This occurrence showed a marked difference between groups of subjects with both male and female household heads (α = .002 and .046 respectively) showing a significant correlation but others (mostly high school children) showing no correlation at all (α = .597).

Missing walls, as would be expected, correlated highly with spatial aptitude (α = .000), graphic ability (α = .000) and age (α = .000), with older persons making more mistakes. This relatively simple measure could be used to predict accurately the total error in the maps. This would tend to support (in some degree) a qualitative approach to manual map analysis as this variable is very noticeable and produces an immediate impression on the viewer who is familiar with the house plan.

3.37 TRE and added detail. As noted earlier, there were a number of significant correlations between TRE and additional detail included in the maps. Table 28 indicates the variables and their significance levels.

TABLE 28

SIGNIFICANCE LEVELS OF CORRELATIONS BETWEEN TRE AND ADDED DETAIL

Variable	Significance Level	Variable	Significance Level
doors	-	washer	.020
closets[1]	.082	dryer	.039
bath	.011	kitchen counters	.002
toilet	.006	kitchen table	-
kitchen sink	.008	steps	-
stove	.055	bathroom sink	.006
refrigerator	.055	windows	-
furnace[1]	.002	fireplace	-

Total occurrences of added detail had a significance level of $\alpha = .000$. TRE and added detail were completely independent in terms of what they actually measured. In fact all respondents were told that they did not have to include doors, windows, or furniture and only did so under their own initiative.

---

[1] Identified by quality rating scores.

The conclusion to be reached is that those individuals who endeavoured to make their maps more complete through the addition of detail also had a more accurate perception of their environment. This result supports other researchers in cognitive maps who claim that the amount of detail illustrated in manual maps is a measure of the quality of the subjects' cognitive maps of specific areas (Everitt and Orleans, 1973; Asmussen, 1971). The qualitative approach is also supported by this finding.

3.4 Other Correlational Relationships

There are a number of interesting correlations among the various sets of data themselves. Although they do not bear directly upon the main focus of research, their interest deserves reporting.

3.41 Information and socio-economic variables.

Table 29 contains the cross correlations of information and socio-economic variables. Actual correlations are given because it is interesting to see the direction of the correlations for interval variables.

In examining the information variables, those persons who had lived there a longer time thought they needed more bedrooms. People who had moved a lot also thought they needed more bedrooms but were also planning to move in two years.

TABLE 29

INTER-CORRELATION OF INFORMATION AND SOCIO-ECONOMIC VARIABLES

	1	2	3	4	5	6	7	8	9	10	11	12
1. length of residence (I)												
2. change of residence (I)	-.74											
3. amount of living space (N)	.02	.14										
4. arrangement of rooms (N)	.12	.10	.02									
5. number of bedrooms (I)	.43*	.35*	.07	.02								
6. money's worth (N)	.05	.10	.07	.04	.04							
7. neighborhood (N)	.15	.19	.02	.06	.02	.01						
8. move in two years (N)	.07	.23*	.12	.11	.09	.02	.02					
9. age (I)	.09	-.14	.29*	.00	.38*	.13	.21	.21*				
10. occupation (I)	.03	.03	.25	.01	.43*	NC	.12	.01	-.04			
11. education (O)	-.16	.30*	.12*	.04	.16	.51	.21	.28	.08	.49*		
12. income (O)	.34*	.32*	.05	.07	.07	.04	.01	NC	.56*	.53*	.57*	
13. number of children (I)	.38*	-.25*	.48*	.78*	.78*	.01	.17	.06	.07	.14	.12	.28

*significant at $\alpha = .05$

NC no correlation available; this happens with nominal variables where one cell has less than 5 percent of the observations.

I interval variable

N nominal variable

O ordinal variable

Among the socio-economic variables, it is not surprising to find that income correlated highly with age, occupation, education, and number of children. Occupation and education were also related.

In addition, those persons living in the house the longest had higher incomes and more children. Those who changed their residences more frequently had higher incomes, more education, but fewer children. Respondents who indicated that the home was too small were generally older, had more education and more children. Persons who wanted more bedrooms were older, had higher job status, and had more children. Finally, the older the people became, the less likely they were to move.

3.42 Factor scores. As indicated previously, factor scores did not correlate with TRE or quality rating. The factor scores did, however, correlate with a number of other variables when taken group by group. Factor 1, mood, did not correlate with anything. Table 30 outlines the significance levels of the variables that did correlate with the aesthetic factor and space factor.

The space factor appears to be the most important for all groups. Various aspects of the plumbing fixtures in the house appear to be related to the young adult's cognitive structure of the home. No explanation is offered

TABLE 30

SIGNIFICANCE OF CORRELATION OF FACTOR SCORES AGAINST OTHER VARIABLES FOR ADULTS

Variable	Factor 2 - Aesthetic			Factor 3 - Space		
	Male	Female	Other	Male	Female	Other
Spatial Aptitude	-	.034	-	-	-	-
Graphic Ability	.005	-	-	.006	.000	-
Living Space	-	-	-	.025	-	.000
Number of Bedrooms	-	-	.022	.000	.000	.002
Number of Children	-	-	-	.002	.000	-
Quality Rating	-	-	-	-	.021	-
Education	-	.009	.049	-	-	-
Furnace	-	-	-	-	.037	-
Doors	-	-	-	-	-	.029
Bath Tub	-	-	.000	-	-	-
Toilet	-	-	.000	-	-	-
Bathroom Sink	-	-	.006	-	-	-
Kitchen Counters	-	-	.005	-	-	-
Kitchen Sink	-	-	.000	-	-	-

here for this occurrence.

A correlation analysis was performed between husbands and wives to determine if their cognitive structures of the home were similar. The analysis indicated no significant relationship between husbands and wives on the mood or aesthetic factors. Their space factor, however, was highly correlated ($\alpha = .004$). The data did not allow for an adequate analysis between children and parents.

3.43 Map details. Table 31 indicates the significance level of the intra-relationship of map details. Closets and furnaces appear to be the most important details with steps and fireplaces close behind. No explanation is offered here as to why these variables are intercorrelated.

3.44 Non-codable maps. Non-codable manual maps were significantly correlated with spatial aptitude, graphic ability, and age. Table 32 indicates the significance of these correlations and the means for this group[1].

It would appear that the ability to communicate cognitive maps is impaired in older people. This imapirment also occurs in other psychological attributes.

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[1] Since no "others" had non-codable responses only male and female heads are included.

TABLE 31

SIGNIFICANCE OF CORRELATIONS AMONG MAP DETAILS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Doors																
2. Closets	.00															
3. Bath	-	.00														
4. Toilet	-	.00	-													
5. Kitchen Sink	-	.00	-	-												
6. Stove	-	.00	-	-												
7. Fridge	-	.00	-	-	-											
8. Furnace	-	.00	.00	.00	.01	.02	.02									
9. Washer	-	.00	-	-	-	-	-	.01								
10. Dryer	-	.00	-	-	-	-	-	.01	-							
11. Kitchen Counters	-	.00	-	-	-	-	-	.00	-	-						
12. Kitchen Table	-	-	-	-	-	-	-	-	-	-						
13. Steps	-	.00	.00	-	.00	-	-	.00	-	-	.00					
14. Bathroom Sink	-	.00	-	-	-	-	-	.00	-	-	-	-				
15. Windows	-	-	-	-	-	-	-	.03	-	-	-	-	-	-		
16. Fireplace	.00	.00	.00	.00	-	-	-	.03	.00	.00	.00	-	.00	-	.00	

TABLE 32

SIGNIFICANCE LEVEL OF CORRELATION BETWEEN NON-CODABLE MAPS AND OTHER VARIABLES FOR ADULTS

Variable	Significance Level	Non-Codable Means	Group Means
Spatial Aptitude[1]	.000	16.6	39.9
Graphic Ability[2]	.000	22.0	13.0
Age	.000	61.4	39.1

3.5 Psychophysical Relationships

Based on Steven's psychophysical power law[3], a number of researchers have attempted to empirically determine the power function for visually perceived indoor distance (Kunnapas, 1960 and Teghtsoonian & Teghtsoonian, 1969) and outdoor distance (Gibson, et al, 1954, 1955; Gilinsky, 1951; Harway, 1963; Luria, et al, 1975; Teghtsoonian & Teghtsoonian, 1970) by estimating the value of the exponent n. The results thus far seem to indicate that indoor experimental situations yield accelerating power functions ($n > 1$), while outdoor environments tend to have nearly linear or decelerating functions with physical distance ($n \leq 1$).

---

[1] Higher scores indicate greater spatial aptitude.

[2] Higher scores indicate less graphic ability

[3] Stevens psychophysical power law; $\psi = \alpha \phi^n$
where: ψ = is the subjective distance estimate
ϕ = is the physical distance
n = is an exponent that systematically varies
α = is a constant depending on the units of measurement.

In an attempt to uncover the psychological foundations of mental mapping a few researchers have attempted to relate Steven's law to cognitive distance perception. In a study of distance between world cities Ekman and Bratfisch (1965), using a ratio scaling technique and an algorithm similar to Steven's law, produced a power function for the exponent, n, of .78 for log actual distance against log of the ratio estimations of cognitive distance. Later experiments by Bratfisch (1969) produced exponents of .58, .90, and 1.08. These experiments, however, were not concerned solely with "subjectively perceived geographical distance" but were initially designed to test the relation between the subjects' "emotional involvement" towards various cities and their estimation of distance between those cities. The experiment produced a much stronger relationship between emotional and objective distance.

Lowerey (1970) estimated the value of n for subjective and real distances for each subject's mental map of ten different city locations (e.g. school, park, bus stop, etc.) using three different ratio scaling techniques. "The regression coefficients for logs of subjective ratios fitted to logs of real distance ratios ranges from 0.112 to 2.065" (p. 67). He suggests that this wide range of exponent values may reflect different personality characteristics and he also suggests the "Differences in psychophysical functions for facility types could appear in the same way modality function differences have been found in psychophysics".

Rothwell et al (1973), in an experiment comparing visual and cognitive distances, approximated Steven's law and produced cognitive exponents between .42 and .68.

Cadwallader (1973), on the other hand, compared methodological methods in data collection of cognitive and real distance and concluded that the relationship "appears to be linear, with Pearson correlation coefficients of .94 and .96 (p. 194)." Howard et al (1973) tend to confirm Cadwallader's findings. In an experiment using four different scaling and psychophysical methods they concluded that "All four show a strong linear relationship between subjective and actual distance. (p. 263)".

Analysis of the manual maps in this dissertation tends to confirm the linear hypothesis. Several regression models were applied to determine the best fit between real distance ratios (plus area ratios) and mean group ratios. Table 33 presents the results of this analysis.

As the table indicates the best fit belongs to the linear model. Since area in this case relies directly upon the walls of the house, it is not surprising that area and distance follow the same model. The total sample points for area (N = 9) is actually too small to produce a valid model.

Similar analysis performed on the various groups of subjects (male head, female head, and others) produced identical results (see Table 22, Chapter 3.22).

TABLE 33

REGRESSION ANALYSIS OF REAL DISTANCE AND AREA RATIOS AND SUBJECTIVE DISTANCES AND AREA RATIOS

Regression Model	Distance (N = 41)			Area (N = 9)*		
	r	b	a	r	b	a
1. linear ($y = a + bx$)	.98	1.00	-.02	.99	1.00	-.03
2. power curve ($y = ax^{b}$)	.97	1.06	.96	.98	.96	.96
3. exponential ($y = ae^{bx}$)	.88	.44	.69	.88	.43	.69

*Only the nine rooms were used as the area of the whole house was a sum of the rooms.

The one to one slope of the curve in the linear model also indicates that there is a direct relationship between cognitive distance and real distance.

It must be noted, however, that the maximum stimulus range of 45 feet is rather small. This factor could tend to produce a linear model.

This chapter has demonstrated that manual maps can be a reliable and valid research instrument. The psychological variables of spatial aptitude and graphic ability were shown to influence to some degree the process of cognitive mapping. On the other hand, socio-economic, attitude, and environmental variables did not appear to affect significantly the subjects' ability to communicate their cognitive maps. Evidence was presented which also supported the qualitative approach to analysis of cognitive mapping.

4.0 CHILDREN RESULTS

Analysis of the children's data followed a pattern similar to the adults. The first section of this chapter is a description of the various variables followed by an analysis of the reliability of the rank assigned to each child's map.

The main variables in the children's study were:

1. Rank of manual map.
2. Chronological age.
3. I.Q.
4. Graphic ability.

A correlation analysis was performed among these variables (rank, age, I.Q., and graphic ability, RAIG) as well as between the RAIG variables and other variables taken from the manual maps.

4.1 Description

Table 34 presents the age distribution of the children by sex. The mean age of the total group was 8.4 years (boys 8.3 and girls 8.4).

TABLE 34

AGE DISTRIBUTION

Age	Male	Female	Total
13	1	2	3
12	6	2	8
11	2	2	4
10	3	3	6
9	4	3	7
8	4	3	7
7	3	2	5
6	4	1	5
5	5	2	7
4	1	2	3
3	1	1	2
Total	34	23	57

The norms of the Draw-a-Man Test are valid to the age of 15 while the MPFB spatial aptitude test can be validly administered at the age of 10. So as not to overlap, the age of 14 was chosen as a separation point. The age of 14 is usually representative of the age at which children enter grade 9, or high school. In the sample that was selected, all students of 14 were in high school, while only one person of age 13 was in high school.

TABLE 35

CROSS TABULATION OF I.Q. AND AGE FOR CHILDREN

	Age											
I.Q.	3	4	5	6	7	8	9	10	11	12	13	Total
135+					1	1	1					3
131-135	1				1		1	2	1		1	7
126-130												0
121-125			2					1		1		4
116-120						1			1	1		3
111-115	(1)	1	(1)	1		1				2		7
106-110		(1)		2		2	2	1	2	2	1	13
101-105		(1)	(2)	1		1	1	1		1	1	9
96 -100				(1)			1	1		1		4
91 - 95						(1)	1					2
86 - 90					(2)							2
81 - 85					1							1
76 - 80												0
71 - 75			2									2
Total	2	3	7	5	5	7	7	6	4	8	3	57

( ) denotes a subject who did not do a manual map.

TABLE 36

AGE DISTRIBUTION AND ELEMENTS OF STYLE FOR CHILDREN

	Age											
Style	3	4	5	6	7	8	9	10	11	12	13	% of Total[1]
Sketching Technique								1	1	1		6.4
Thick Walls						4	5	2	3	6	2	48.9
Non-Square	1	1		1	2		1	2	2	5	1	34.0
Box			4	2	1	2		1		1		23.4
Appended Rooms	1	1		1	2			2		2		19.1
Side View			3									6.4
Roof			1			1						4.3
Room Size												
Large Bath			1	2	2	2						14.9
Large Hall			1	1	2	1	2	2				19.1

[1]N = 47. Subjects can have more than one style present in their drawing.

A cross tabulation of age and I.Q. is given in Table 35. The children's average I.Q. was 113.4, well above the norm. The frequency distribution of I.Q. did not appear to be normal with the category 131 - 135 having seven children in it[1]. The average graphic ability score was 3.6[2].

Of the 57 children only 47 or 82.4 percent completed or attempted a map. Some refused and some did an outside picture and would not try a floor plan.

Table 36 presents an age distribution for various elements of style and room size discrepancies.

As shown in Table 37 the majority of children oriented their drawings towards the rear of the house.

TABLE 37

ORIENTATION OF DRAWINGS

Direction	Percent of Total
AS (towards the bedroom)	17.5
AE (towards the back)	42.5
SX (towards the street)	17.5
EX (towards the utility room)	7.0
None	17.5

---

[1] This might be expected in such a small sample. In one family (the Andersons) with seven children, six had I.Q.'s 131 or greater.

[2] Scores ranged from 0 to a maximum value of 7.

The following table (Table 38) presents the frequency of occurrence of additional detail in the manual maps.

TABLE 38

OCCURRENCE OF ADDITIONAL DETAIL

Variable	% Occurrence	Variable	% Occurrence
Wall VW	8.5	Bathroom Sink	8.5
Furnace	23.4	Bath Tub	12.7
Master Bedroom	12.8	Stove	17.1
House Codable	23.4	Refrigerator	10.6
Doors	74.5	Windows	6.3
Closets	36.1	Washer	10.6
Fireplace	19.1	Kitchen Table	10.6
Kitchen Sink	8.5	Kitchen Counter	8.5
Toys	4.2	Beds	17.1
Steps	8.5		

4.2 Reliability

The main concern for reliability is with the rankings of the four judges. Table 39 demonstrates the reliability of the judges through a correlation matrix. All correlations are significant at the .000 level.

TABLE 39

INTER-CORRELATION OF JUDGES (n = 47)

Judge	Rothwell	Gill	George	Clarkson
Rothwell	-			
Gill	.80	-		
George	.84	.87	-	
Clarkson	.83	.81	.79	-

The average rank was assigned to each subject for further analysis.

4.3 Correlation Analysis

4.31 Rank, Age, I.Q., and Graphic Ability (RAIG).

The first set of correlations was done to determine the relationship between rank, age, I.Q. and graphic ability. Table 40 presents the correlations and their significance.

TABLE 40

CORRELATION OF RANK, AGE, I.Q. AND GRAPHIC ABILITY

	Rank[1]	Age	I.Q.	Graphic Ability
Rank	-			
Age	-.64*	-		
I.Q.	-.32*	.00	-	
Graphic Ability	-.62*	.58*	.40*	-

*α = .01

[1] Signs are negative because the best drawing was ranked as 1 and the poorest as 47.

It can be concluded that the quality of the children's drawings is significantly related to age, I.Q., and graphic ability.

The analysis also showed that there was no correlation between age and I.Q. If there had been a strong relationship it would have thrown doubt upon the validity of the Draw-a-Man Test. Instead it has shown that the norms used to convert raw score to I.Q. appear to be reliable.

Since raw scores were used in the graphic ability test (nine items out of the I.Q. test) it is not surprising that graphic ability is related to age. This should be the case. Since graphic ability is a subtest of the overall I.Q. test, there is also a correlational relationship between the two.

4.32 Elements of style and size of rooms. Table 41 shows the significance of correlations between RAIG[1] and elements of style and size of room. It can be seen that:

1. Higher ranks tend to draw thick walls while lower ranks tend to have a box style.

---

[1] RAIG (rank, age, I.Q. and graphic ability)

TABLE 41

SIGNIFICANCE LEVELS OF CORRELATIONS BETWEEN RAIG
AND ELEMENTS OF STYLE AND SIZE OF ROOMS

Style	Rank	Age	I.Q.	Graphic Ability
Sketching Technique	-	-	-	
Thick Walls	.002	.002	-	.04
Non-Square	-	.024	-	.02
Box	.000	.001	-	.000
Appended Rooms	-	-	-	-
Side View	-	.033	-	-
Roof	-	-	-	-
Size of Rooms				
Large Bathroom	.000	.001	-	.002
Large Hall	.000	.015	-	.001

2. Older children tend to produce non-square homes with thick walls while younger children have a box style or side view.

3. Children with higher graphic ability tend to draw thick walls and non-square houses while those the less ability have a box style.

4. Young, low ranked children with less graphic ability tend to draw larger bathrooms and bedrooms.

There is little theoretical background on which to base statements concerning the style of drawing. There did not appear to be any basis for using the concept of egocentricity (see Hart and Moore, 1971; Asmussen, 1970) when analyzing the children's drawings[1],

4.33 Additional detail. As with the adults, the more additional detail contained in the child's map the more likely it was to receive a higher rank. Table 42 shows that the furnace and closets (as with adults) correlated highly with all RAIG variables.

---

[1] There are three main systems of geographic orientation: egocentric (based on the position of the person), realistic (the direction of nearby major features) and coordinated (orientation to the cardinal directions). Other researchers have found that young children's manual maps are characterized by an action centered egocentric reference system.

TABLE 42

SIGNIFICANCE LEVELS OF CORRELATIONS BETWEEN RAIG VARIABLES AND AMOUNT OF DETAIL

	Rank	Age	I.Q.	Graphic Ability
Wall VW	-	.021	-	-
Furnace	.000	.016	.021	.000
Master Bedroom	.014	-	-	.014
House Codable	.000	.0407	.002	.000
Doors	-	-	-	-
Closets	.000	.003	-	.000
Fireplace	-	-	-	-
Kitchen Sink	-	-	-	-
Bathroom Sink	-	-	-	-
Bath Tub	-	-	-	-
Stove	-	-	-	-
Fridge	-	-	-	-
Windows	-	-	-	-
Washer	-	-	-	-
Kitchen Table	-	-	-	-
Kitchen Counter	-	-	-	-
Beds	.044	.042	-	-
Steps	-	-	-	-
Toys	-	-	-	-
Total Detail	.000	.000	.000	.000

If the house was codable (i.e. could be digitized) it also correlated highly with the RAIG variables. Again, this is a point for qualitative analysis. It is a fairly easy task to judge whether the drawing comes close to reality at all on the criterion of codability. Most children who drew a codable map were older or brighter. The youngest child to draw a codable map was 8 years old and had an I.Q. of 150, while a 13 year old of I.Q. 96 could not complete the task.

Younger children tended to include their beds into their maps.

4.34 Errors. Number of errors had a significant negative correlation with all RAIG variables.

4.35 Non-significant correlations. There were no significant correlations between sex and any variables. This does not coincide with studies by Asmussen (1973) or Blaut (1969). Orientation of the drawing did not appear to be related to any other variables.

Unfortunately, because of data constraints (nominal-nominal) it was not possible to perform correlations between style and detail variables. (With such a small sample the matrix frequently has cells with 5 or less observations.)

Size of bedrooms was not correlated with any other factors although there was a tendency (not significant) for young children to leave out their parents' bedroom.

4.4 Discussion

The results of this analysis support the findings of other researchers that as a child develops, his awareness of the world around him increases, as does his ability to accurately communicate his perceptions. This study has shown that mental faculties and graphic ability also relfect a child's developmental patterns.

The Goodenough-Harris Test focuses on the child's accuracy of observation and on the development of conceptual thinking. This concept could also be applied to the manual map of the home, where the accuracy of scale and fullness of detail reflect the child's stage of intellectual development.

The results presented here would tend to support the concept of Kaplan (1973) that the entire cognitive structure of the subject may be considered a cognitive map.

It is interesting to note that I.Q. reaches its peak in an individual shortly after puberty and begins to decline after 18 years old. In terms of drawing manual maps it appeared that by the age of 9 or 10 half the subjects could produce a codable map equivalent in quality to the adults. By age 14 all subjects could complete this task; in fact, high school children tended to do better than their parents.

The youngest subject to understand the task and attempt a map was 3 years old (I.Q. 132) while the oldest child to fail the task was 8 years old[1] (I.Q. 91). The youngest child to do a codable map was also 8 years old (I.Q.150). There appears to be a very wide range in children's ability to produce manual maps. This consideration should be carefully weighed in future studies.

---

[1] He refused to try and drew an outside view instead.

5.0 CONCLUSIONS

5.1 Assessment of Goals

The conclusions will follow the format of the four goals as outlined in the introduction.

1. It has been shown that manual maps can be a reliable and valid research instrument in the study of cognitive maps. Several statistical techniques and meausres by which manual maps may be analyzed in a quantitative manner are presented and tested.

   Both spatial aptitude and graphic ability were found to be significantly related to the ability of individuls to communicate their cognitive maps. It would appear from this study that psychological variables exercise considerable influence in the individual's cognitive deviation from the real world. The experiment demonstrated that persons with superior mental faculties have cognitive maps which more closely reflect reality. The research also showed that as mental faculties decline with age the ability to produce a manual map also declines. Most persons over age 65 could only produce maps of similar quality to 6 and 7 year olds in the same study.

   Evidence is also presented which supports the traditional qualitative approach to the study of cognitive maps. Future researchers may wish to rely on these findings to support the validity of their own investigations.

2. Psychophysical functions for subjective distance and area perception proved to be linear.

3. Socio-economic variables, general biographical data, and the subject's cognitive structure of the home as revealed through the semantic differential, did not produce significant correlations with the ability to communicate cognitive maps. It is probable that significant relationships did not emerge because the sample was very homogeneous in character. Greater diversity in these variables may result in significant relationships in future studies.

4. Children's ability to produce a manual map which resembles reality is significantly related to age, spatial aptitude and graphic ability. In a broader context, it would appear that the quality of a child's manual map is a reflection of his general stage of mental development. Ability to communicate cognitive maps increases until puberty when the child approaches full adult development.

5.2 Discussion

The research has shown that manual maps can be a reliable and valid research instrument. This lends credibility and support to previous studies employing this research technique[1] but

[1] Using basically the same research techniques are works by Appleyard (1969, 1970), Saarinen (1969), de Jonge (1962), Gulick (1963), Stea and Wood (1971) and Everitt and Orleans (1971), Lynch (1960, Ladd (1970) and Ley (1972).

which have not dealt with the questions of validity and reliability. This dissertation also supports findings of Howard et al (1973) who tested four methods of ratio estimation for cognitive distance perception and found all of them to be valid and reliable. Cadwallader's (1973) work on the reliability of ratio-estimation techniques in cognitive distance experiements is also supported.

In addition to providing some validity for other studies employing manual maps, evidence is presented for the use of qualitative techniques of analysis. The research has illustrated that a sense of "quality" of the manual map derived from long study and appreciation could also be a good predictor of error. This finding should prove to be significant to those researchers who are endeavouring to employ subjective judgements of quality as input data in other perception studies.

One of the more important results is that spatial aptitude and graphic ability appear to significantly influence an individual's cognitive and manual map. To date, these factors have been ignored. It would appear, however, that the quality of cognitive maps (and presumably the quality of spatial decisions an individual could make) is dependent upon the quality of the recording instrument, i.e. the human brain. Nevertheless, most studies in cognitive mapping have attempted to account for differences in manual maps through such variables as race (Ladd, 1970; Ley 1972) culture

(Stea and Wood, 1971), role (Everitt and Orleans, 1971), socio-economic status (Michelson, 1970), travel patterns (Lee, 1964; Briggs, 1969), and sex Amussen (1971). It is perhaps time that more effort was expended at the level of the individual to determine the psychological parameters of cognitive mapping. Because the brain is the depository of all cognitive maps, it seems reasonable that by understanding the mechanism itself we may hope to understand the processes involved in cognitive mapping.

Numerous socio-economic, biographical, and attitude variables were included in the analysis. None appeared to be significantly related to the manual maps. This does not coincide with the research of Michelson (1970), Appleyard (1969), Ladd (1970) and many others. The sample, however, was so homogeneous on almost all variables that no difference could be detected with the statistical tests which were used. The analysis indicated, however, that when socio-economic variables are held relatively constant, it is the psychological variables which appear to cause differences in individual manual maps. It would be an interesting experiment to maintain consistency in spatial aptitude and vary socio-economic status. Sample selection, however, would be a difficult task.

The psychophysical function for distance and area perception proved to be linear. This supports the findings of both Cadwallader (1973) and Howard et al (1973) who also used ratio estimation as a research technique. The research, however, conflicts with results presented by Lowery (1970), Briggs (1969), and Lundberg (1973) who contend that the psychophysical function for cognitive distance perception approximates Stevens power law. All experiments to date have used slightly different research designs and all use different geographic scales. Although Howard et al (1973) appear to have used the most rigorous research design, only replicative experiments using the same scale of distance will be able to settle the debate between linear and non-linear models. This dissertation supports the linear psychophysical function of cognitive distance perception.

This dissertation generally supports the work conducted by Blaut (1969), Blaut and Stea (1971) and Hart and Moore (1971) in the study of spatial development and learning in young children. As the child develops and matures in his mental faculties, his perception of the world and ability to communicate that perception also improve. The development cognitive mapping closely approximates the development of mental maturity. Unlike other studies (Amussen, 1971), however, significant difference could be detected for sex or socio-economic status.

5.3 Further Research

Although this dissertation accomplished its goals, the scope of study was rather confined. Not only were the variables limited but the actual geographic scale was small. The methodology used in this dissertation and the results obtained should be tested on a larger geographic area. Howard et al (1973) have already shown that this approach may be fruitful. There is need for further research on this topic to determine if geographic scale has an influence upon the basic methodology.

Although cultural variables are important in the development of cognitive maps, not enough attention has been given to the investigation of psychological and physiological variables. As Kaplan says "The ways we deal with the environment are largely dependent upon the sorts of mechanisms that have evolved for this purpose" (p. 64). There is certainly a need for research into the variables that make an individual's cognitive map unique. Only by understanding the cognitive processes at the individual level can we hope to truly understand its significance on behaviour.

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APPENDIX 1

Dear Mr. Rothwell,

I do not wish to participate in your research project and respectfully request that you do not telephone my place of residence.

____

(please print)

APPENDIX 2

WALL AND ROOM DESIGNATIONS WITH TRUE RATIO SCALES

1. House

AE	4.14
AS	2.55
SV	2.43
VW	.18
WX	1.71
XC	2.73

2. Bedroom A

HB	1.25
AJ	1.09
JL	1.25
LB	1.09

3. Bathroom

BC	.64
BF	.77
FG	.64
GC	.77

4. Kitchen

CD	1.23
CO	1.18
OP	1.14
PD	1.32

5. Utility

DE	1.02
DH	.68
HI	1.02
IE	.68

6. Storage

*HI	1.02
HP	.64
PQ	1.02
QI	.64

7. Bedroom J

JK	1.00
JS	1.46
ST	1.00
TK	1.46

8. Bedroom M

TM	1.16
MN	.54
NR	.48
RV	.82
VT	1.00

9. Living Room

UV	.43
*VW	.18
*WX	1.71
XQ	1.41
QO	2.16
OU	1.22

10. Hall

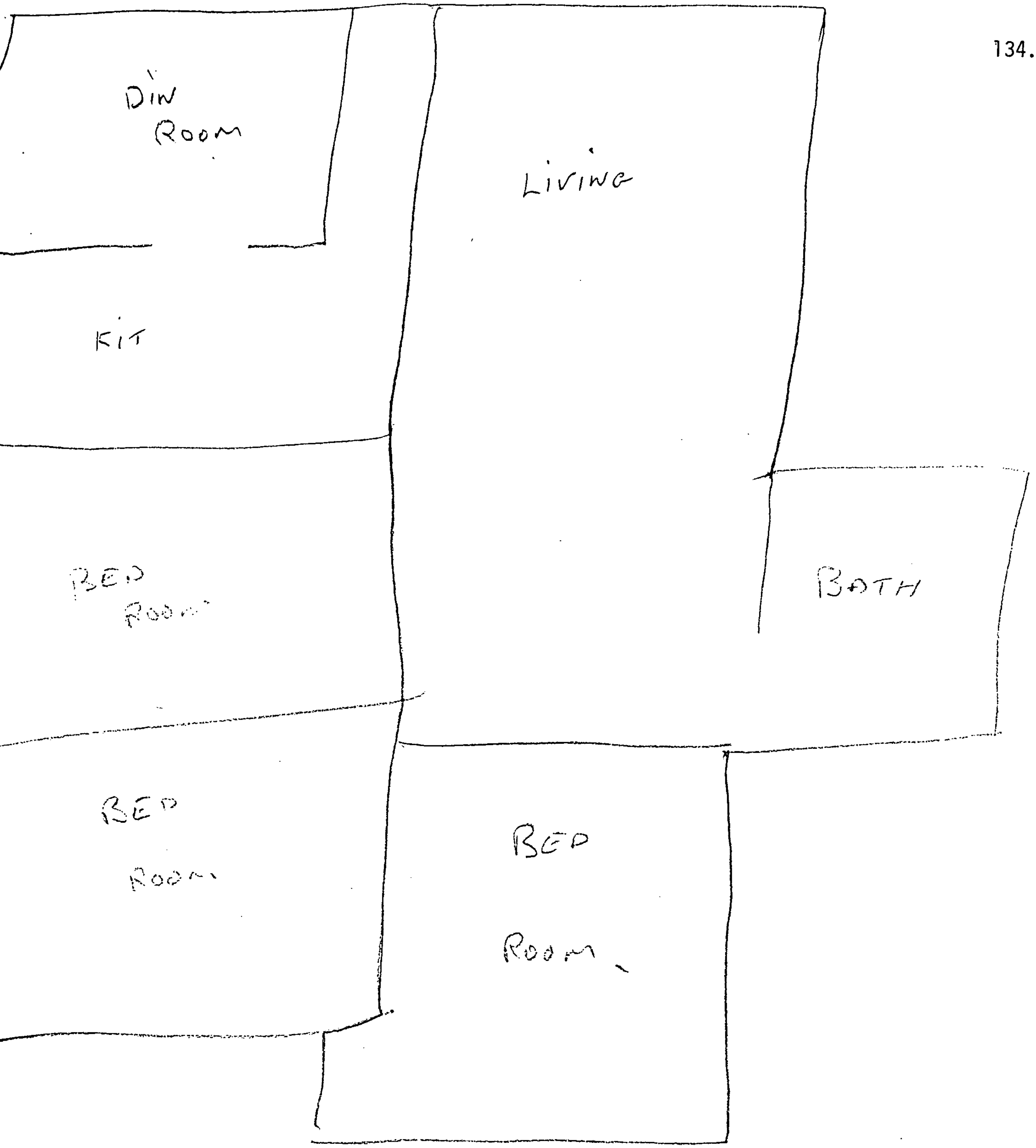
OG	.61
OM	.93
MF	.56
*FG	.64

*Occurs more than once.

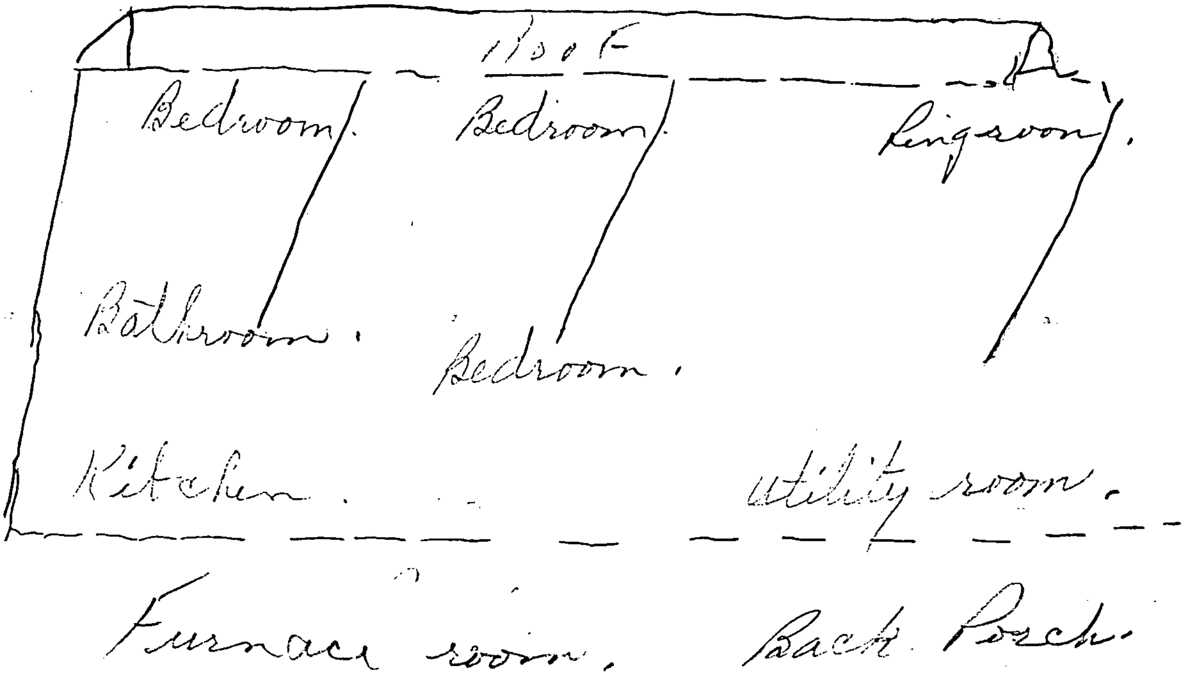
APPENDIX 3

2154

134. b

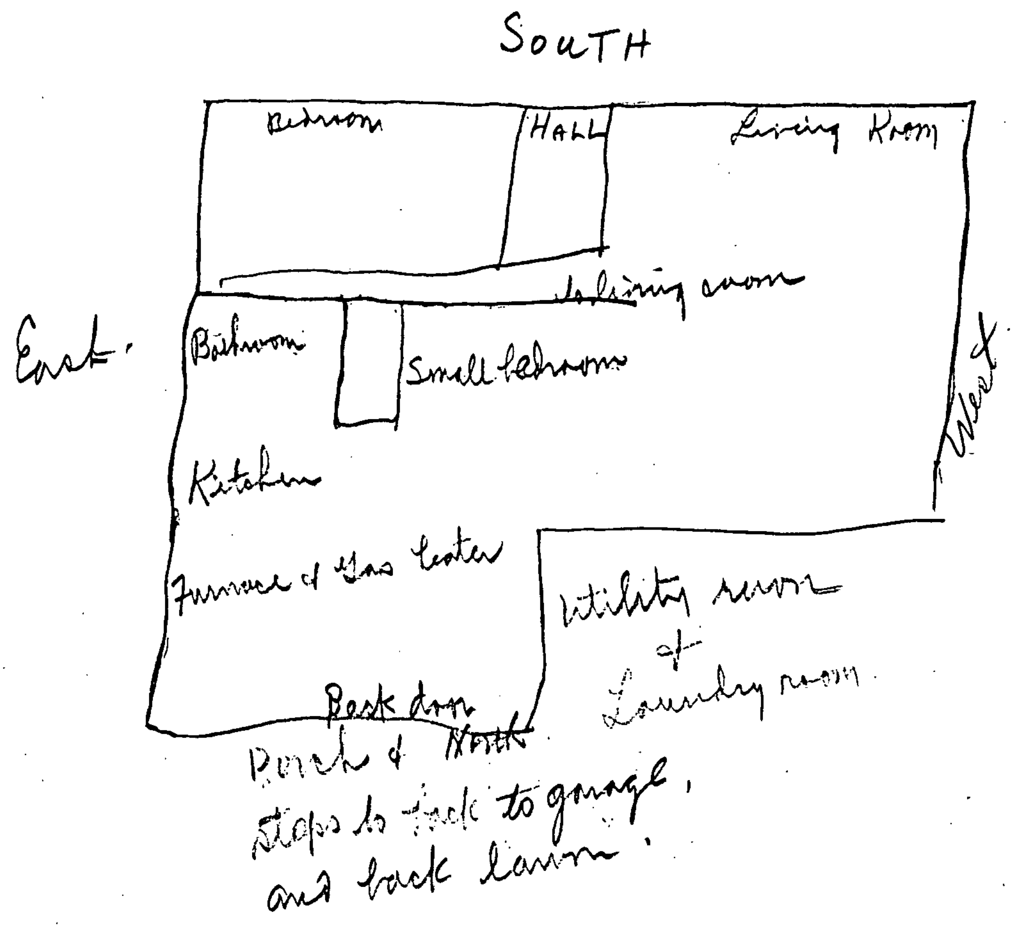


Non-Codable



2090

Non-Codable (Note roof)



Fettock

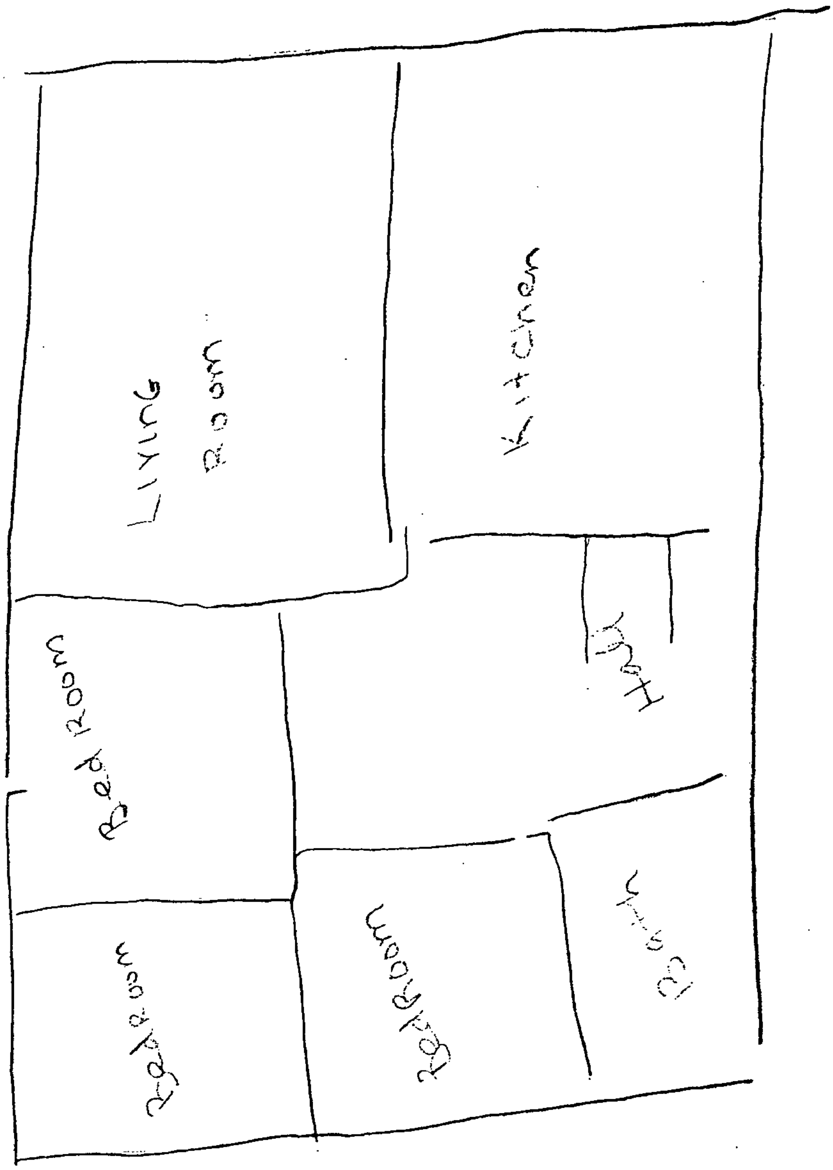
2089

Non-Codable

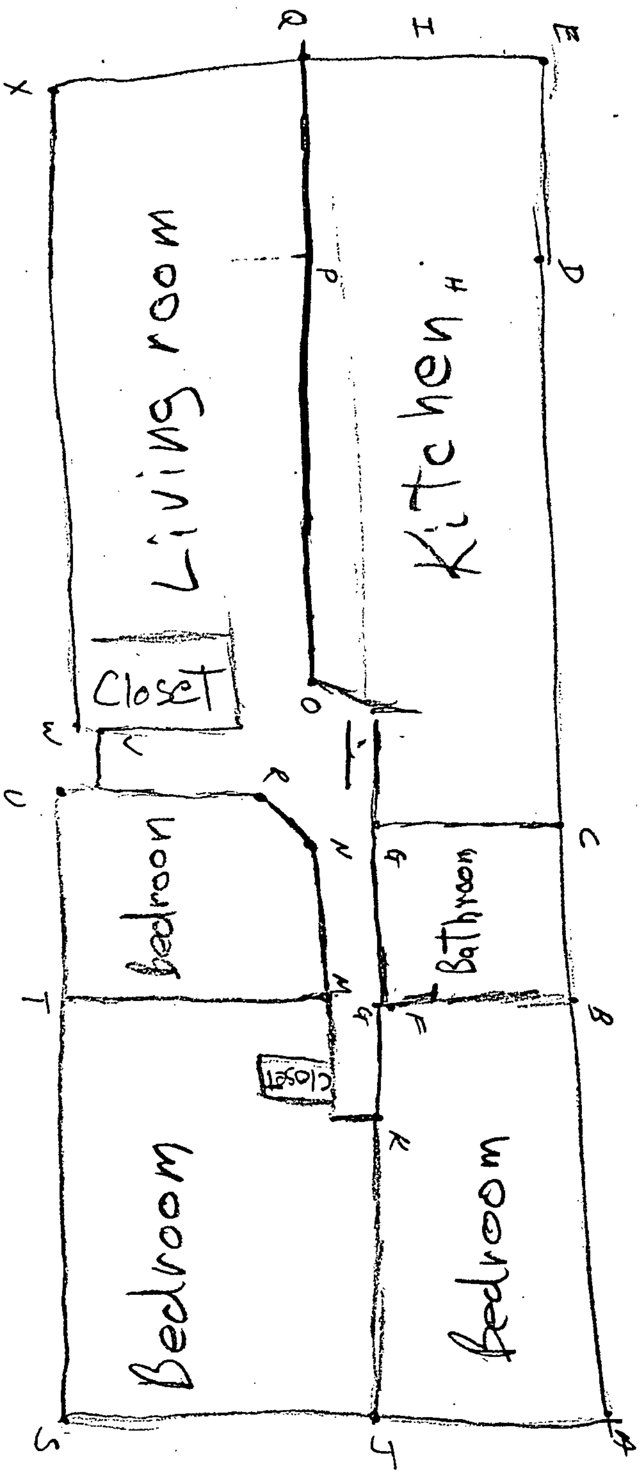
2110

Grayson

couldn't code.

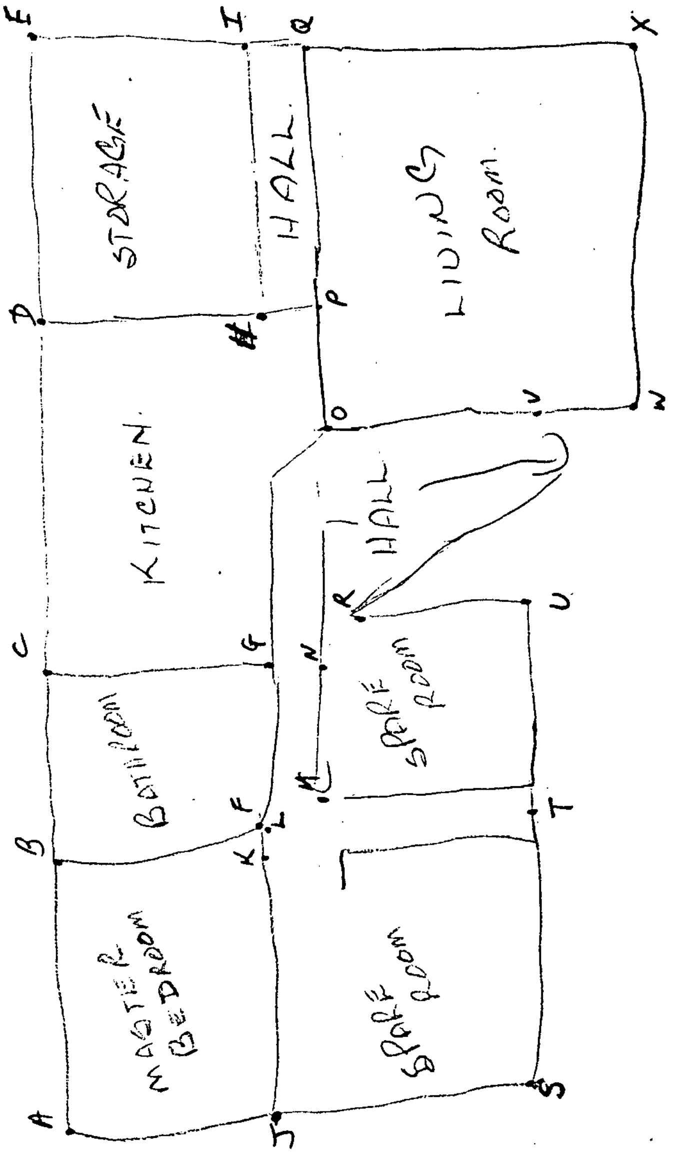


Non-Codable

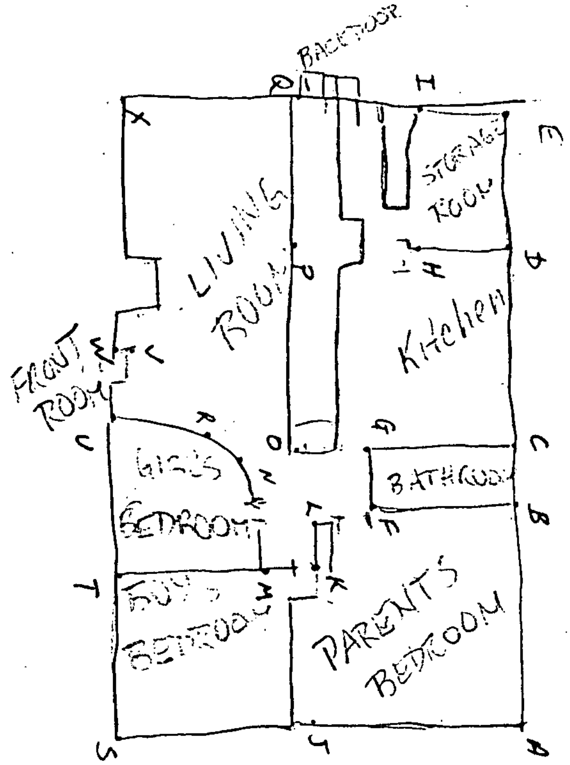

Living room
Kitchen
Closet
Bedroom
Bathroom
Closet
Bedroom
Bedroom

Poor

2007


STORAGE
HALL
LIVING ROOM
KITCHEN
HALL
BATHROOM
SPARE ROOM
MASTER BEDROOM
SPARE ROOM

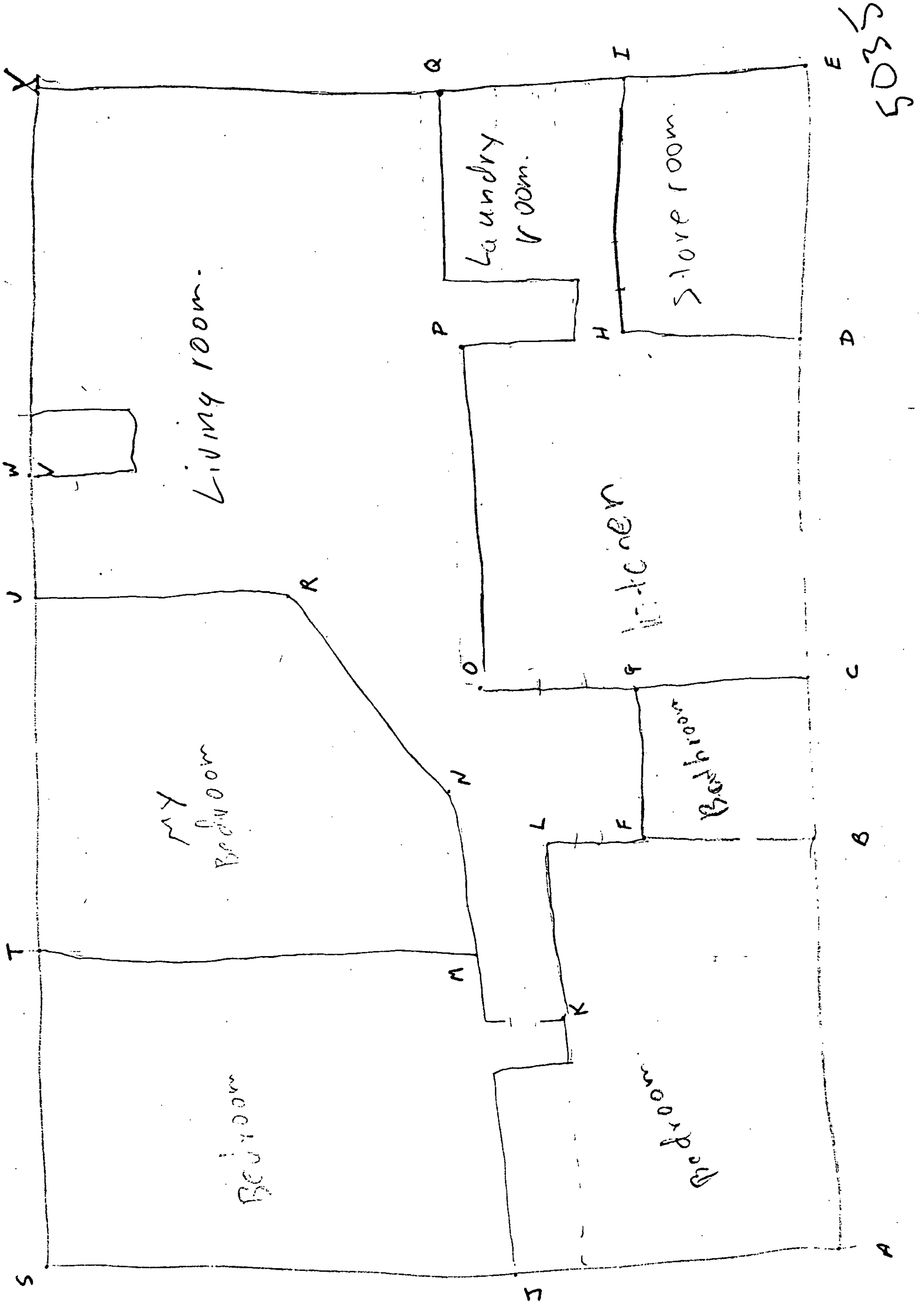
Poor



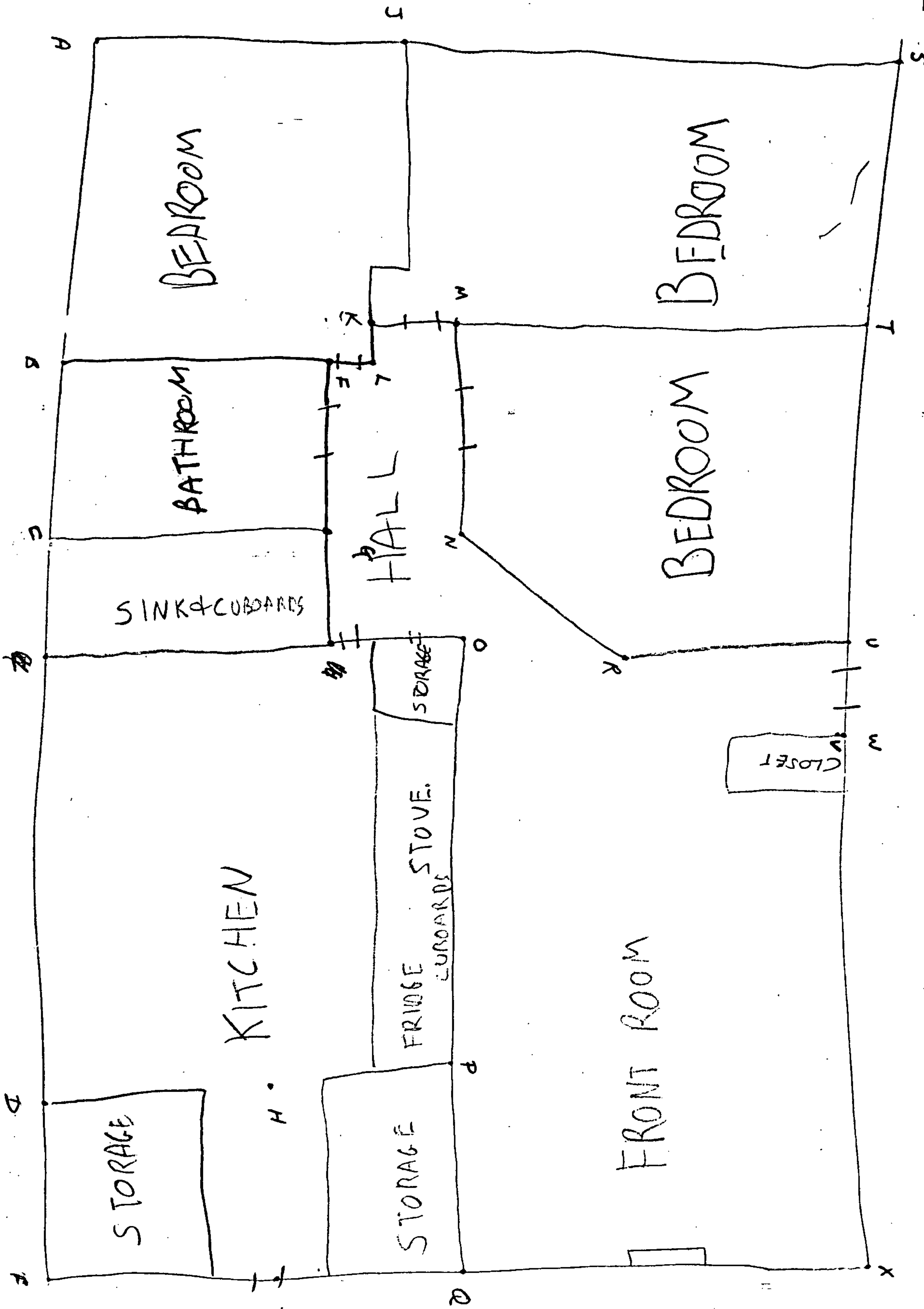
Poor

FAINSTEIN

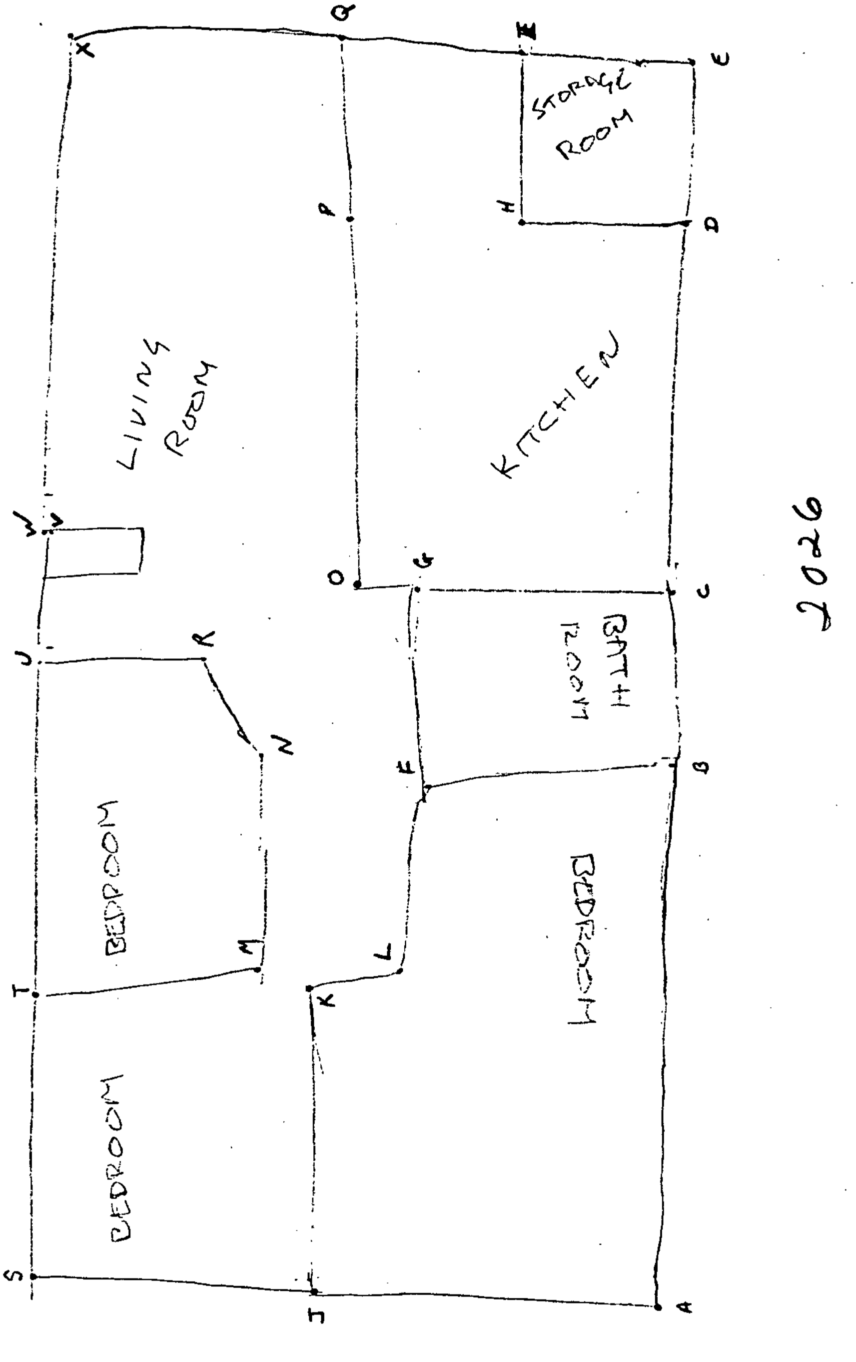
6040


5035
Living room.
Laundry room.
Store room
kitchen
Bathroom
My Bedroom
Bedroom
Bedroom

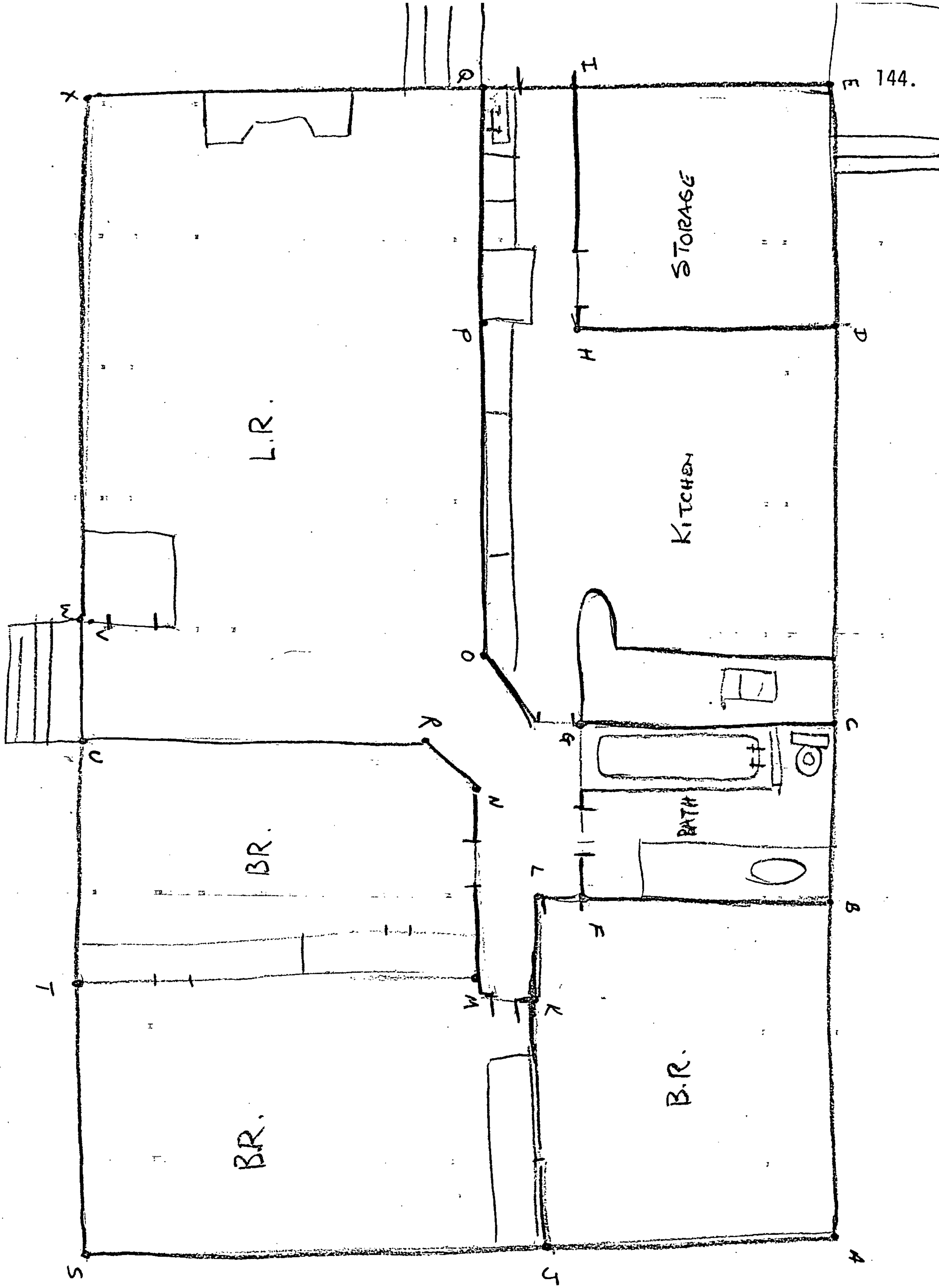
Average


BEDROOM
BEDROOM
BATHROOM
BEDROOM
HALL
SINK & CUBOARDS
STORAGE
CLOSET
STOVE
CUBOARDS
FRIDGE
KITCHEN
STORAGE
STORAGE
FRONT ROOM

Average

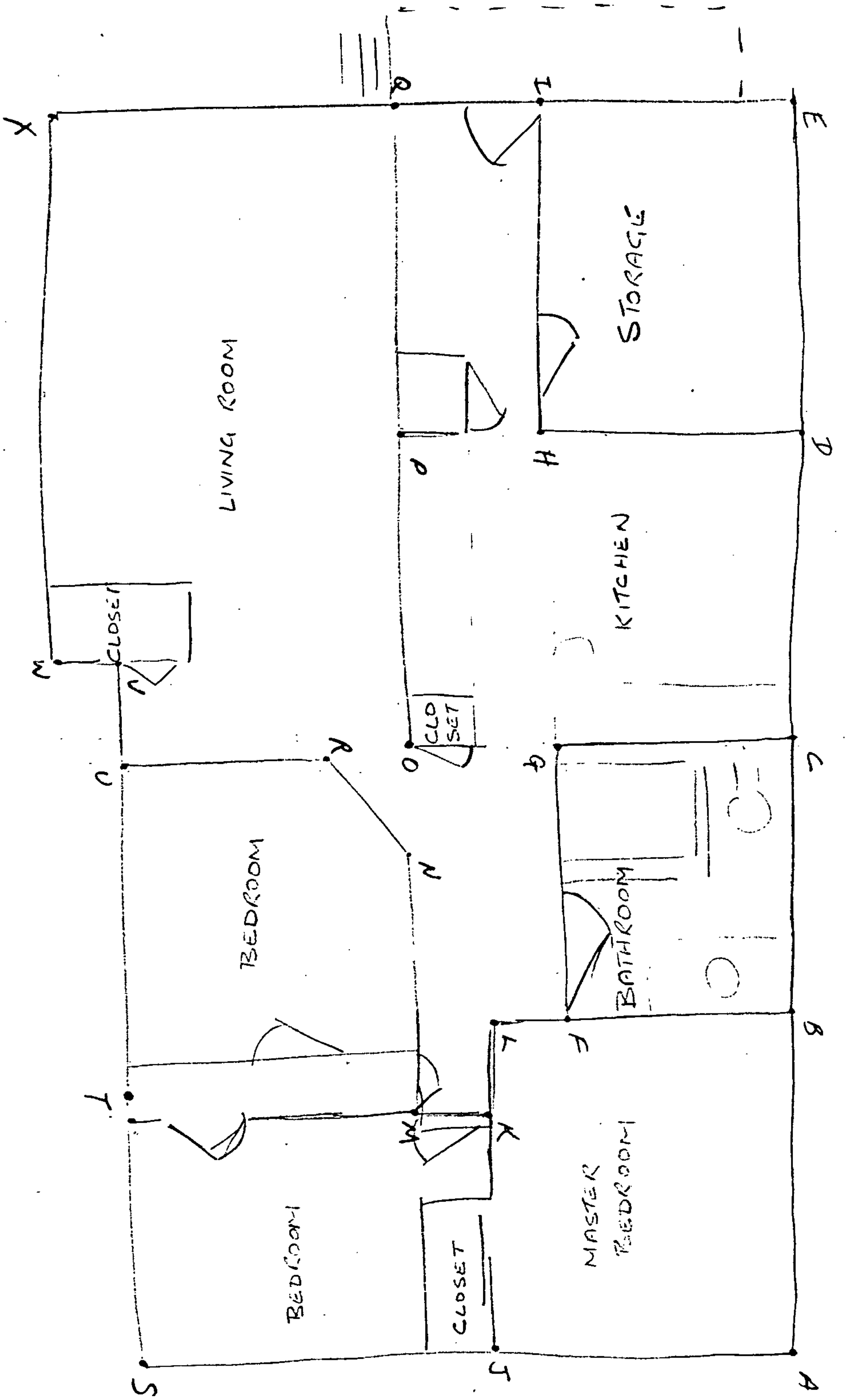

LIVING ROOM
KITCHEN
STORAGE ROOM
BATH ROOM
BEDROOM
BEDROOM
BEDROOM
2026

Average

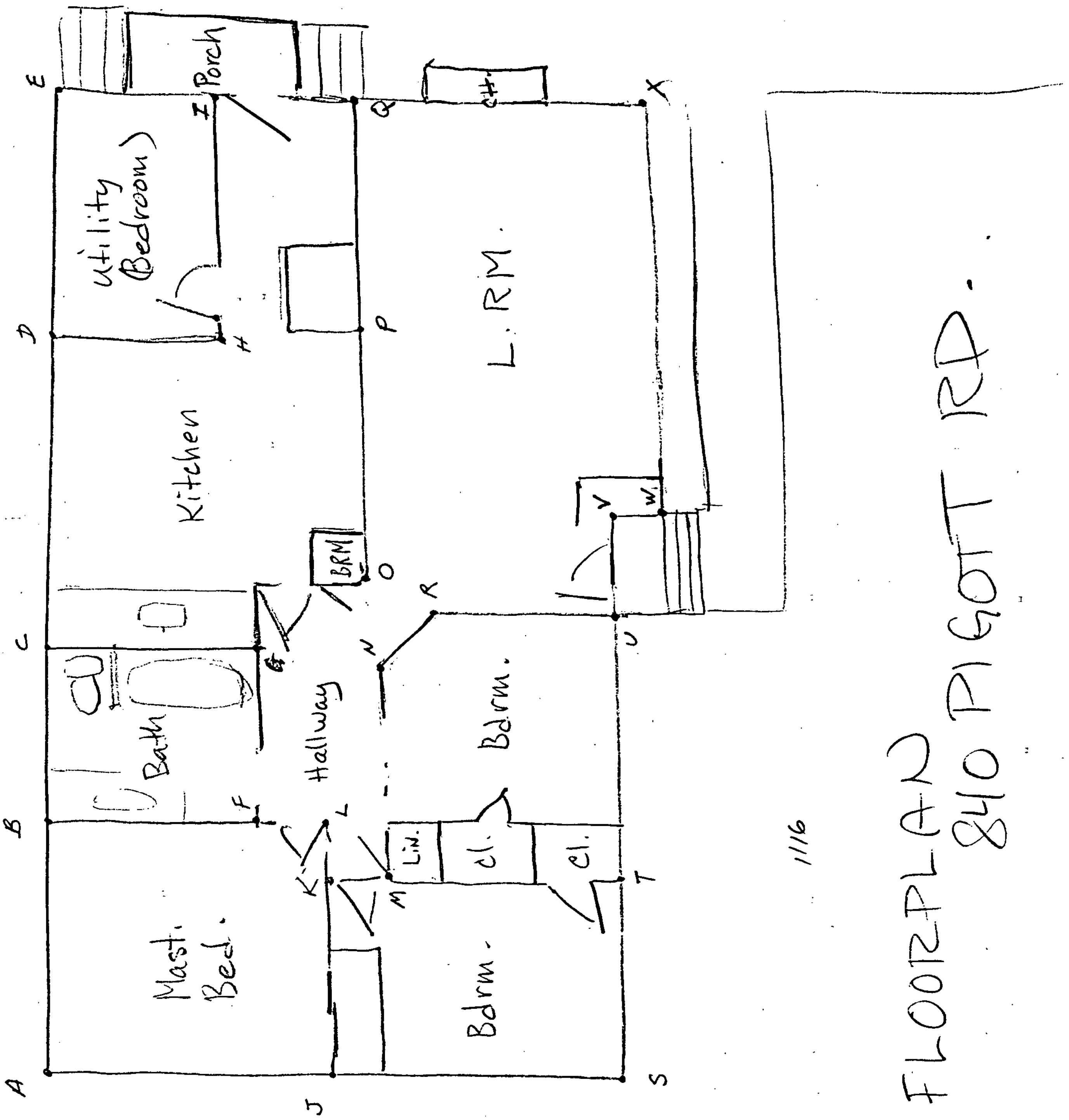


Excellent

2092



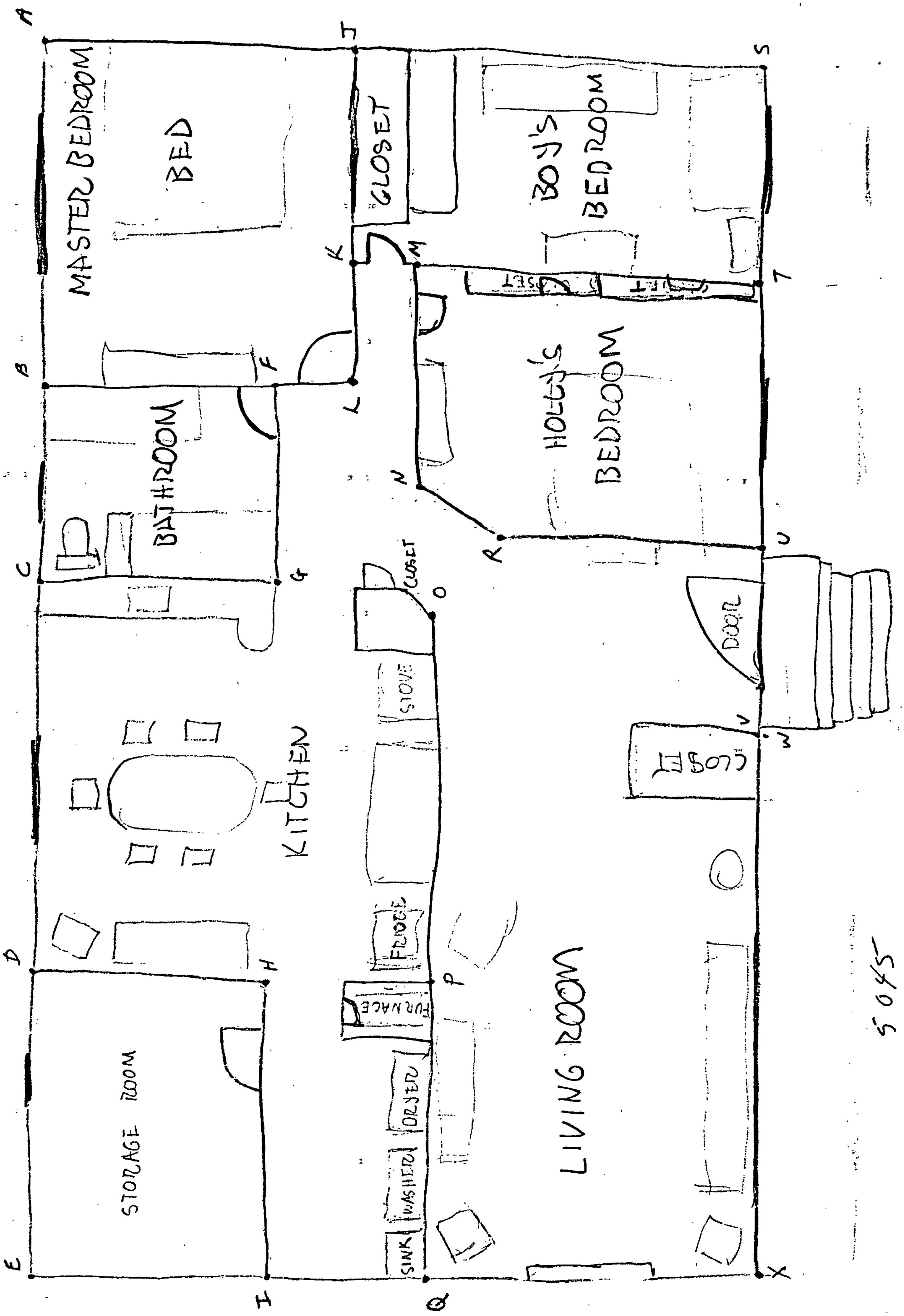
Excellent


Porch
utility
(Bedroom)
Kitchen
L. RM.
BRM
Bath
Hallway
Bdrm.
Lin.
cl.
cl.
Mast.
Bed.
Bdrm.
1116
FLOORPLAN
840 PIGOTT RD.

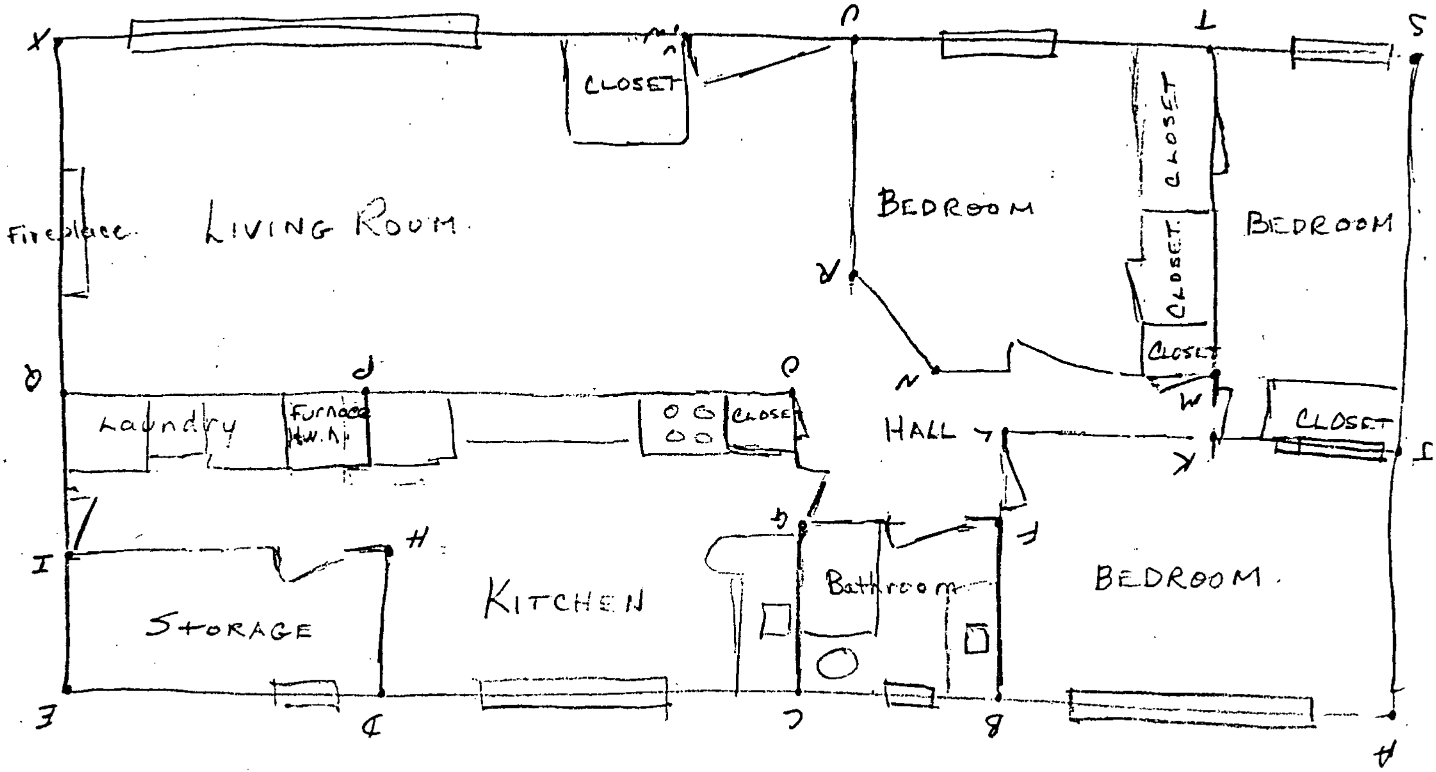
Excellent

APPENDIX 4

147.b



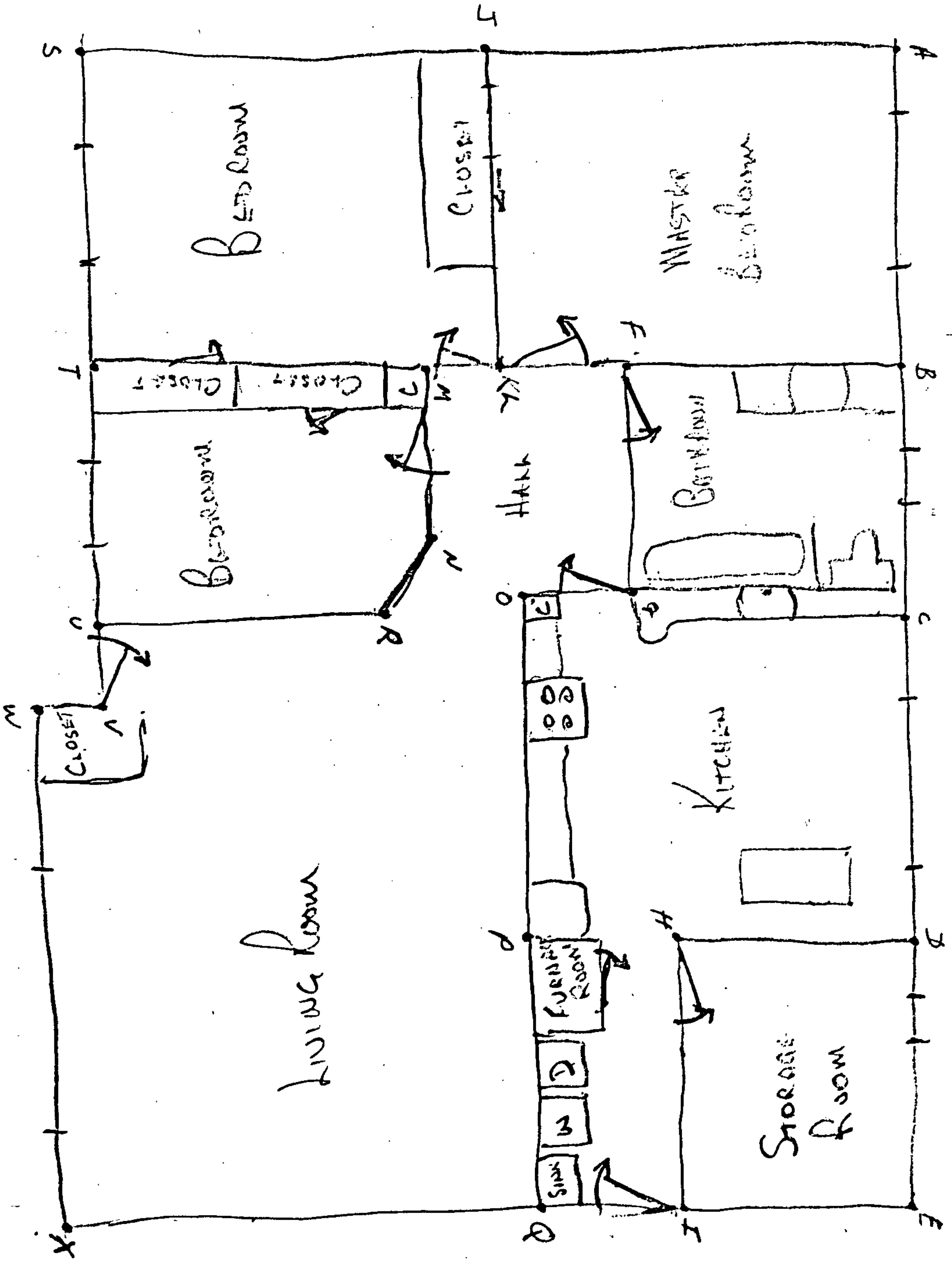
Additional Detail



Additional Detail

2096

1048



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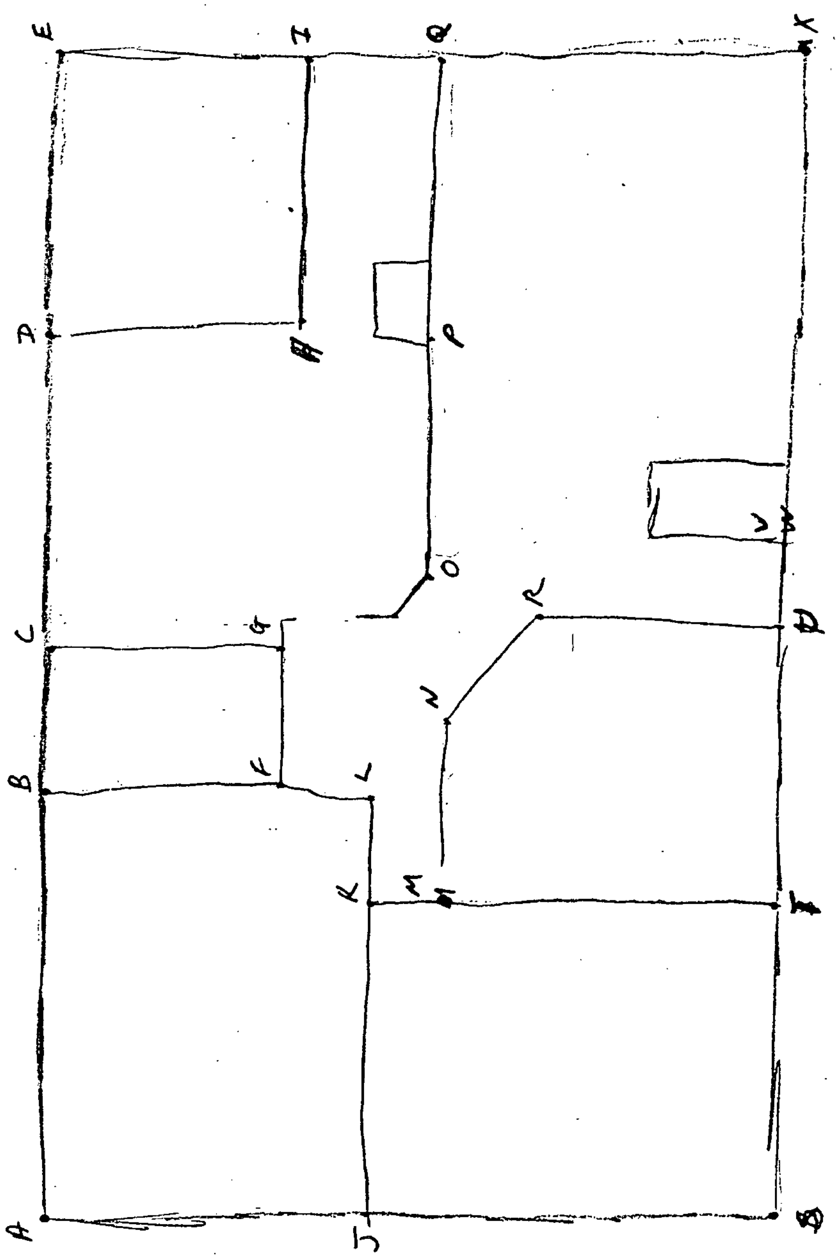


No Detail

9001

APPENDIX 5

DIRECTIONS AND PRACTICE PROBLEMS

E	A	B	D				
1	2	3	4	5	6	7	8

READ THE FOLLOWING DIRECTIONS VERY CAREFULLY WHILE THE EXAMINER READS THEM ALOUD

Look at the problems on the right side of this page. You will notice that there are eight of them, numbered from 1 to 8. Notice that the problems go DOWN the page.

First look at Problem 1. There are two parts in the upper left-hand corner. Now look at the five figures labelled A, B, C, D, E. You are to decide which figure shows how these parts can fit together. Let us first look at Figure A. You will notice that Figure A does **not** look like the parts in the upper left-hand corner would look when fitted together. Neither do Figures B, C, or D. Figure E **does** look like the parts in the upper left-hand corner would look when fitted together, so E is PRINTED in the square above [1] at the top of the page.

Now look at Problem 2. Decide which figure is the correct answer. As you will notice, Figure A is the correct answer, so A is printed in the square above [2] at the top of the page.

The answer to Problem 3 is B, so B is printed in the square above [3] at the top of the page.

In Problem 4, D is the correct answer, so D is printed in the square above [4] at the top of the page.

Now do Problems 5, 6, 7, and 8.

PRINT the letter of the correct answer in the square above the number of the example at the top of the page.

DO THESE PROBLEMS NOW.

If your answers are not the same as those which the examiner reads to you, RAISE YOUR HAND.

DO NOT OPEN THE BOOKLET UNTIL YOU ARE TOLD TO DO SO.

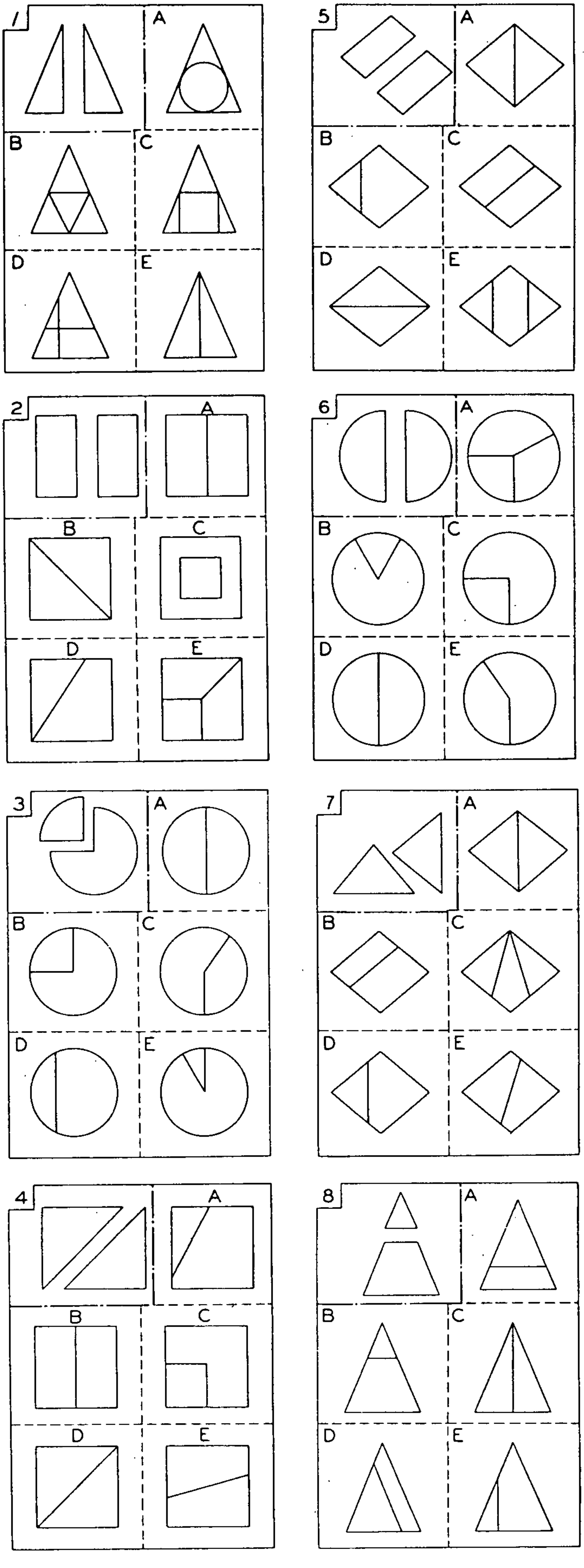
Some of the problems on the inside of this booklet are more difficult than those which you have already done, but the idea is exactly the same. In each problem you are to decide which figure shows the parts correctly fitted together. **Sometimes the parts have to be turned around, and sometimes they have to be turned over in order to make them fit.** In the square above [1] write the correct answer to Problem 1; in the square above [2] write the correct answer to Problem 2, and so on with the rest of the test. Start with Problem 1, and go DOWN the page. After you have finished one column, go right on with the next. **Be careful not to go so fast that you make mistakes. Do not spend too much time on any one problem.**

PRINT WITH CAPITAL LETTERS ONLY.

MAKE THEM SO THAT ANYONE CAN READ THEM.

DO NOT OPEN THE BOOKLET BEFORE YOU ARE TOLD TO DO SO.

YOU WILL HAVE EXACTLY 20 MINUTES TO DO THE WHOLE TEST.



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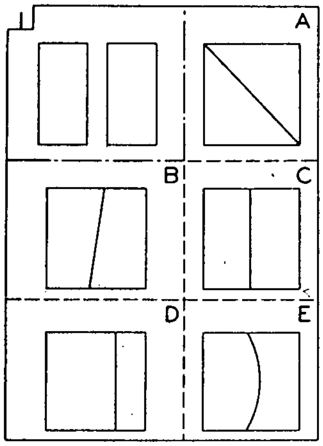

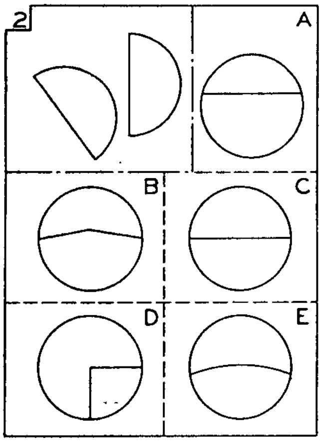

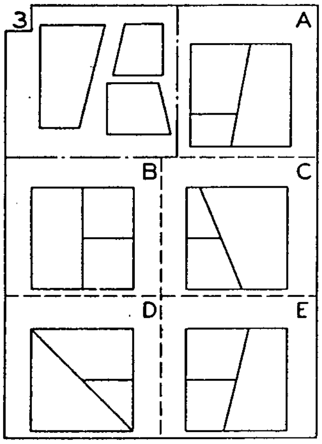

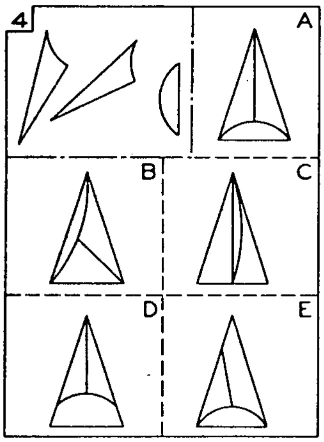

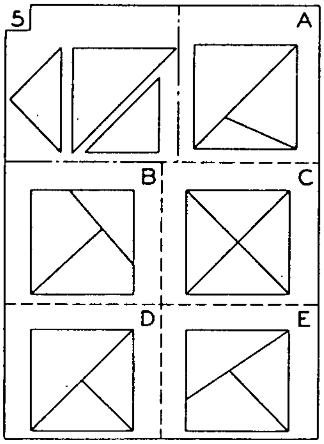

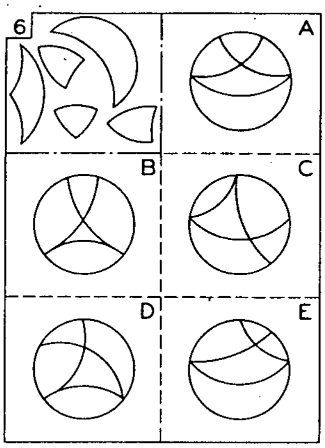

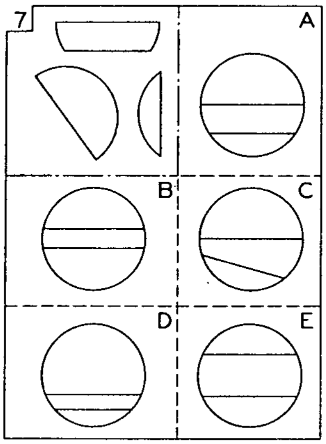

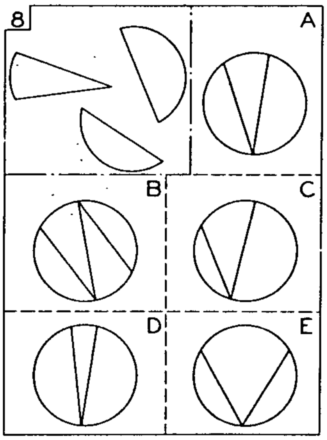

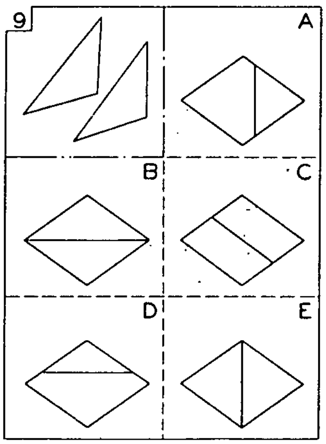

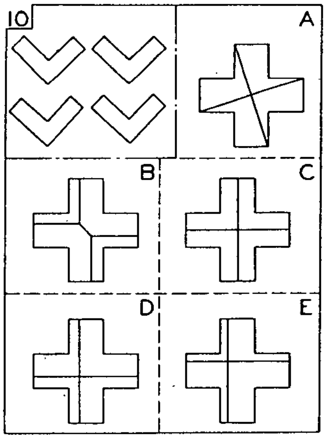

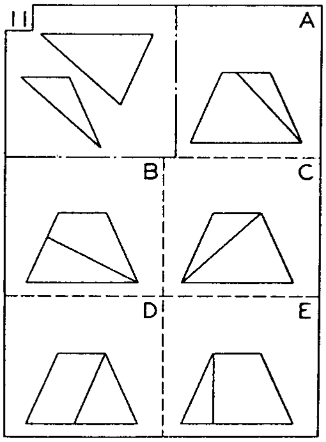

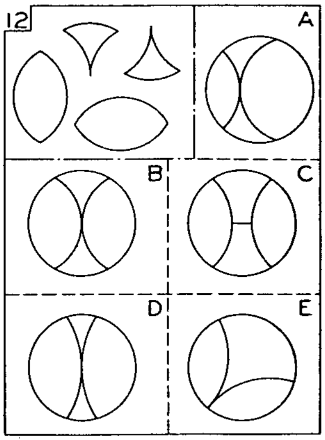

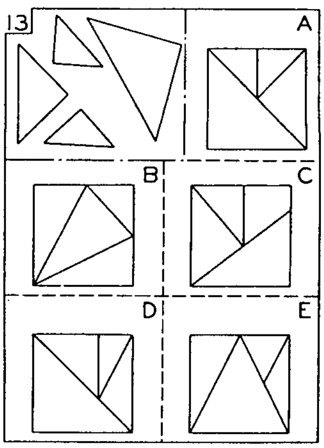

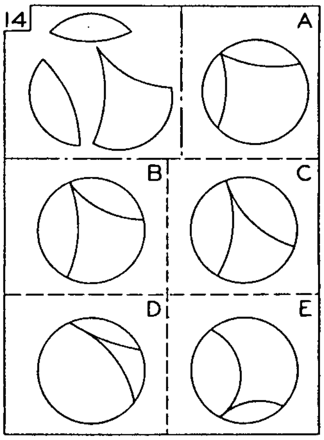

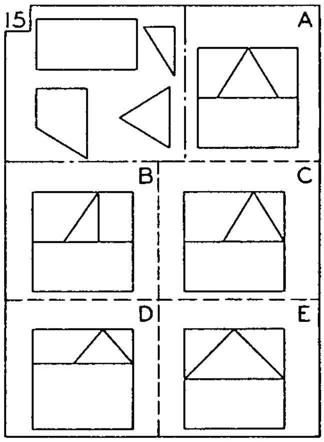

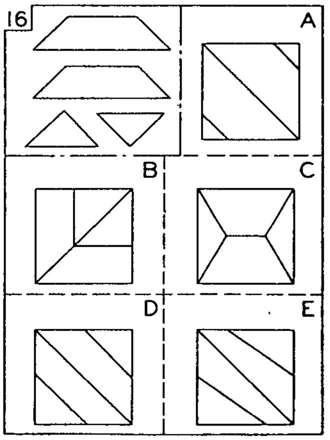

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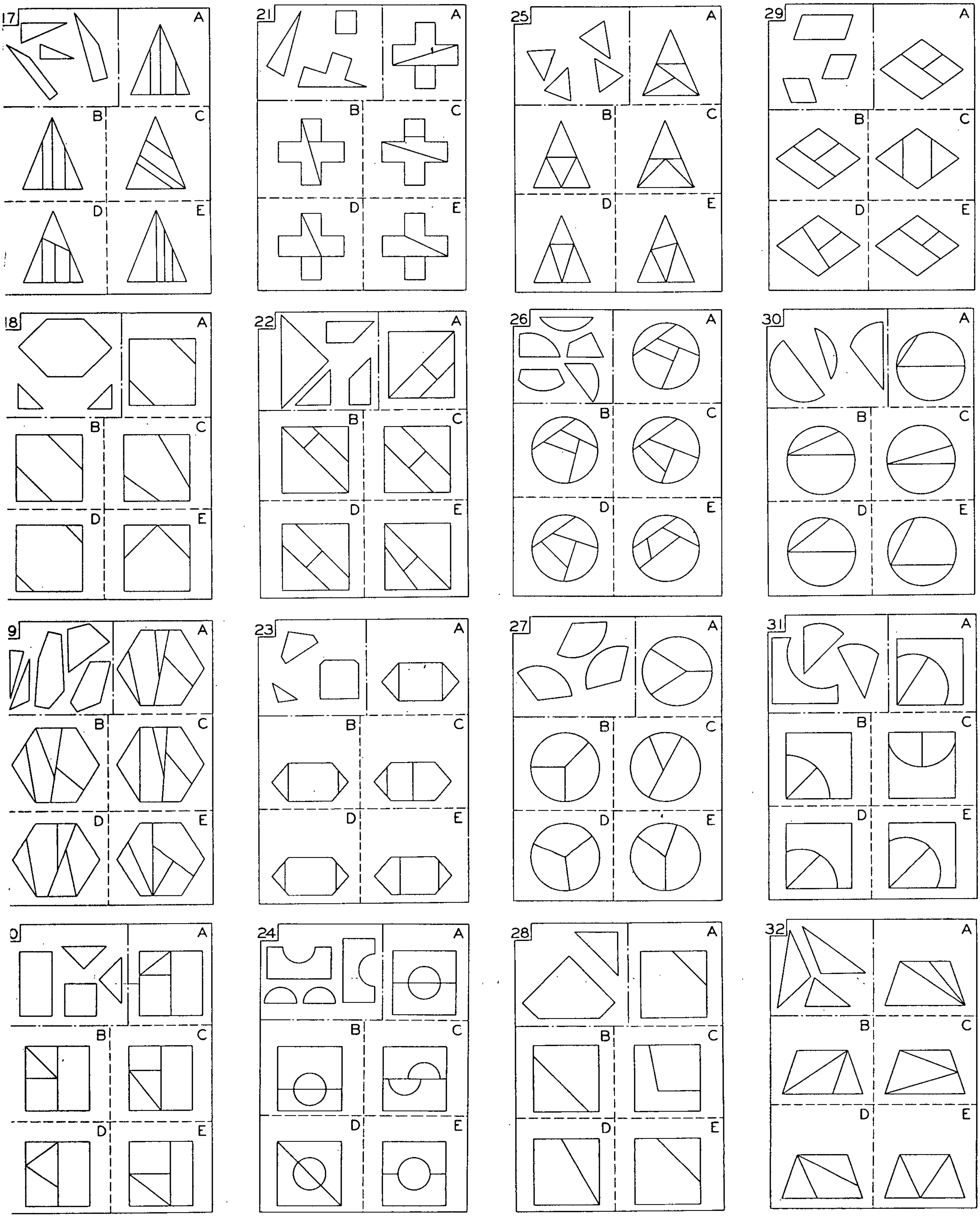

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154.

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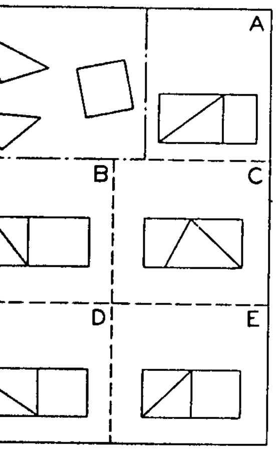

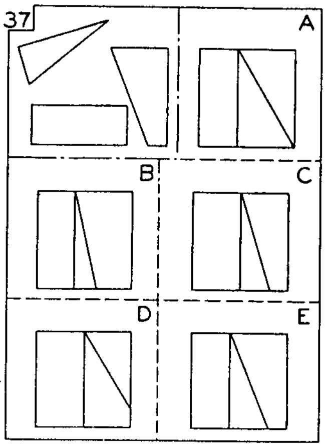

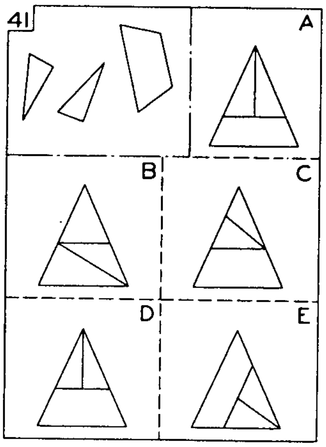

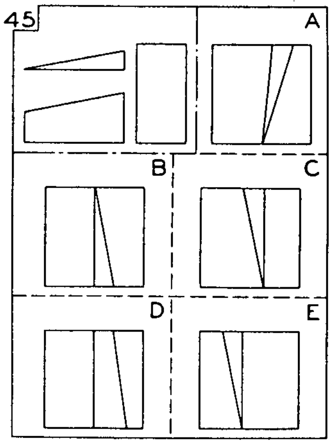

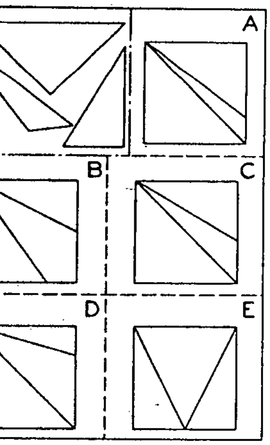

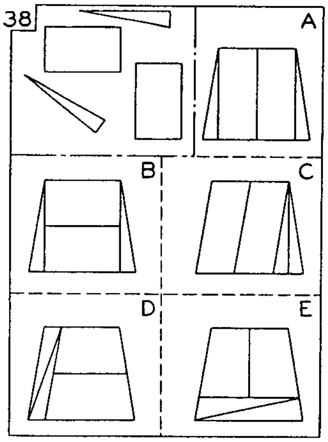

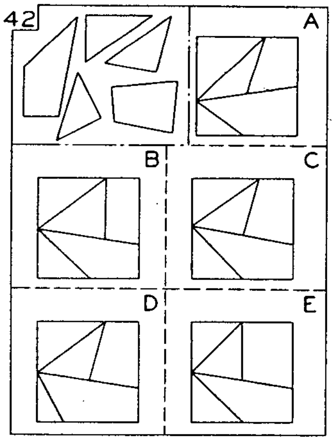

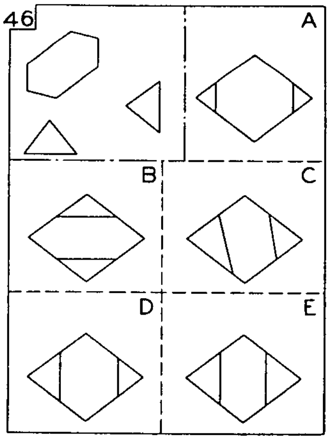

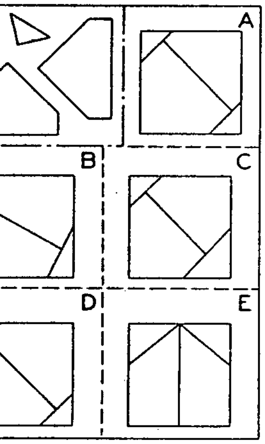

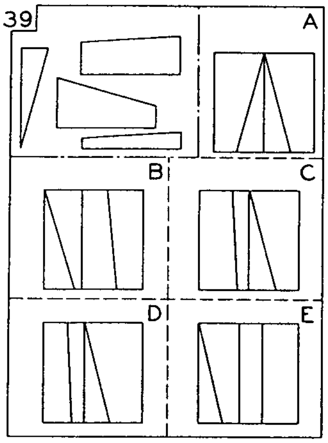

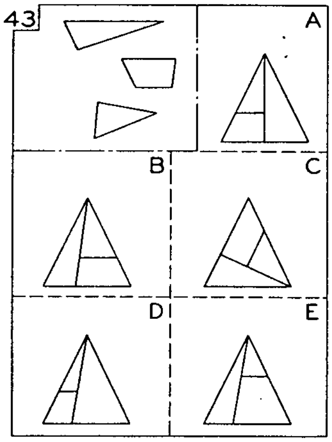

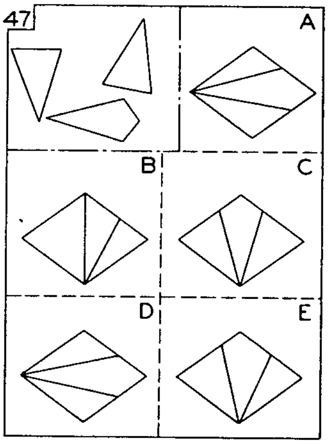

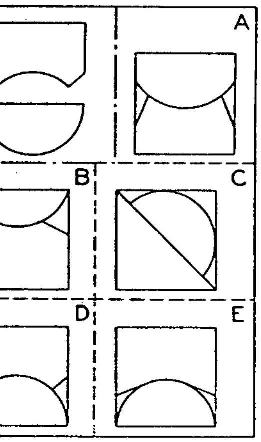

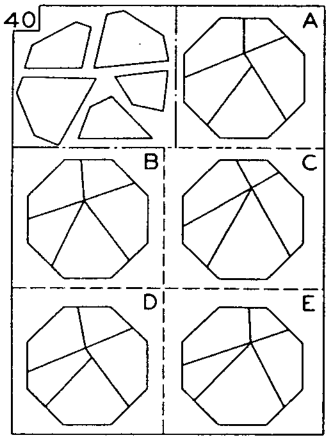

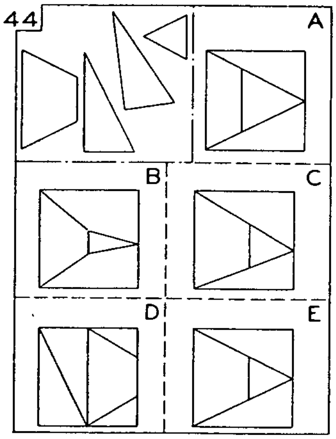

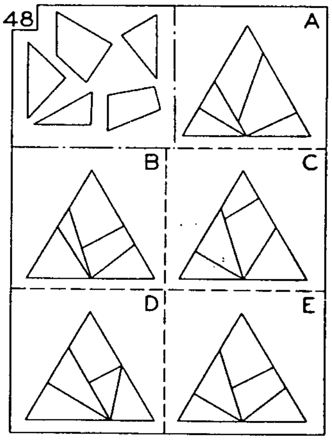

Turn over and go on with page 5.

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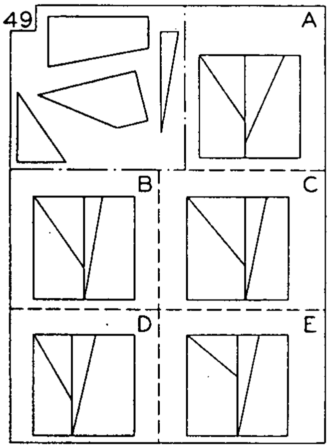

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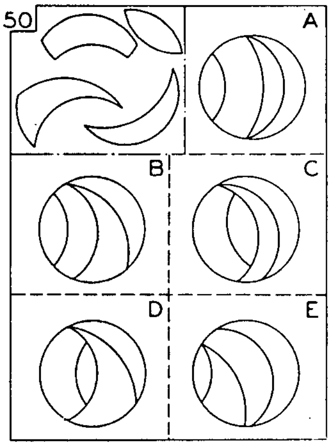

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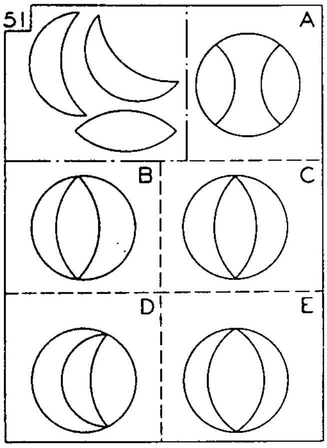

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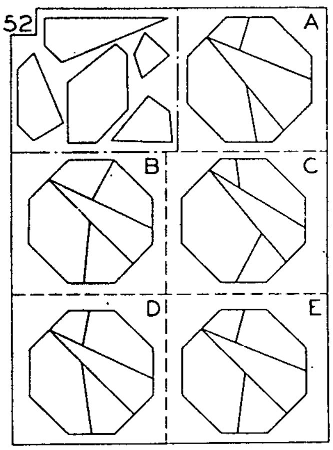

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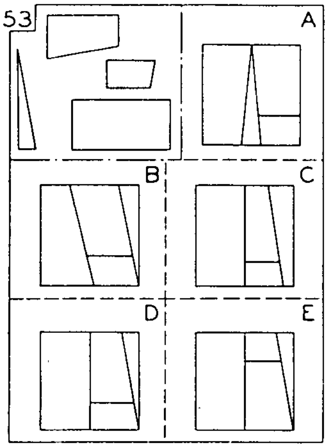

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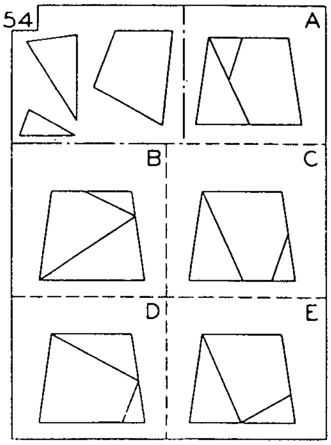

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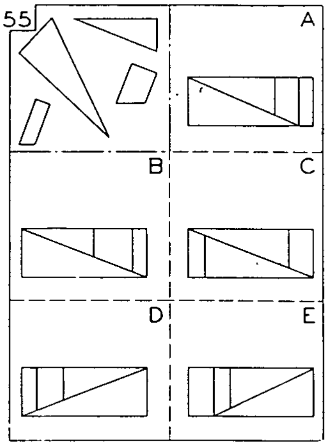

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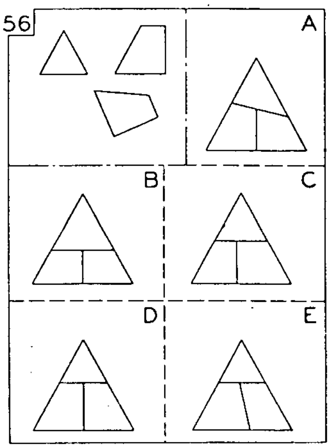

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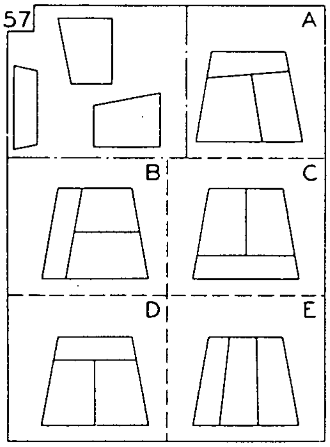

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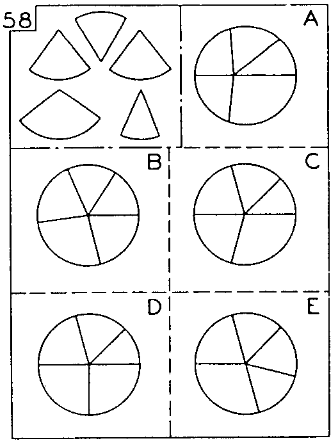

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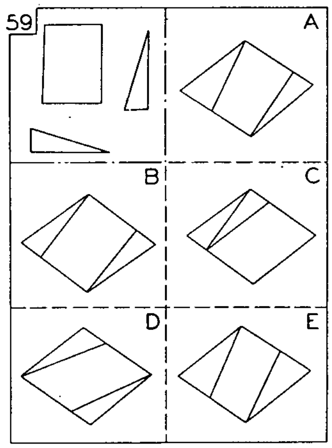

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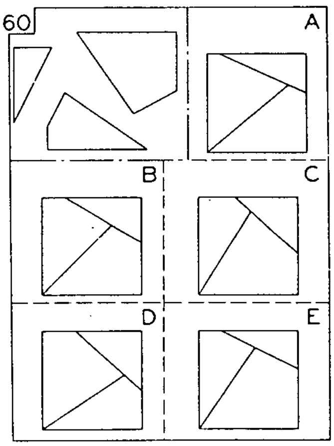

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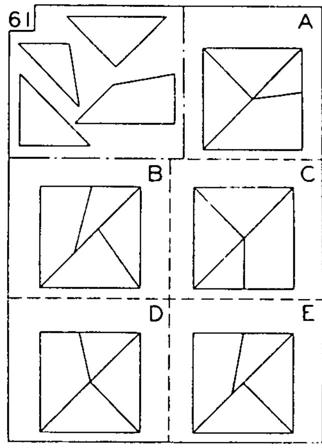

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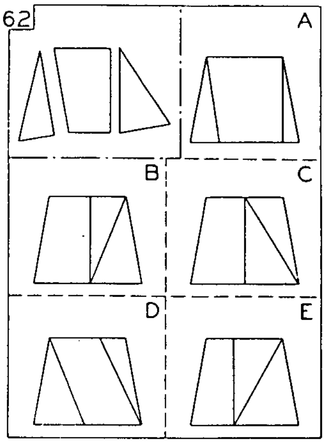

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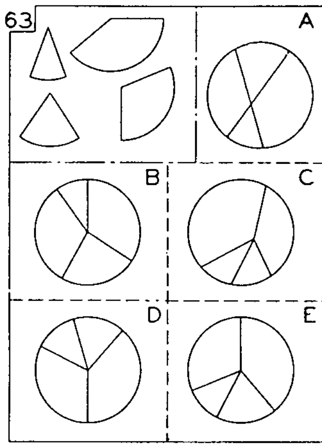

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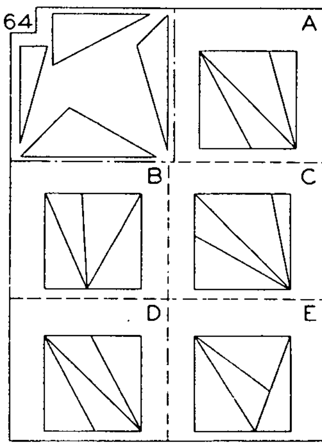


If you finish before you are told to stop, go back and make sure that every answer is right.

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB			Other Tests	
				Series	Mean	SD	Mean	SD
Measures of Intelligence, General Ability, and Reasoning								
Wechsler - Bellevue Intelligence Scale	High school students, aged 16.5-19.5 (Magsdick, 1950)	100		—	39[a]	12.1		
Full Scale			.61**				113[b]	15.3
Verbal Scale			.47**				53[b]	9.5
Performance Scale			.62**				60[b]	7.6
Stanford-Binet Intelligence Scale, Form L, 1937 Revision	74 boys and 87 girls, age 10, in the Brush Foundation Study of Child Growth and Development (Ebert & Simmons, 1943)	161	.54**	AA	—	—	—	—
Army Group Examination Alpha	Male prison inmates, aged 15+, modal age = 17 (R. T. Norlund, personal communication, from 1948 manual)	994	.47**	AA or BB	33.3	11.7	94.0	13.7
Army Group Examination Alpha, Form 5	Male prison inmates, aged 18-57 (Gurvitz, 1950)	1000	.68**	AA	30.3	14.1	—	—
Revised Beta Examination	Male prison inmates, aged 18-57 (Gurvitz, 1950)	1000	.71**	AA	30.3	14.1	65.0[c]	10.1
Otis Self-Administering Tests of Mental Ability: Higher Examination, Form A	Male applicants to a large eastern manufacturing company for positions as machine apprentices, aged 17-26, mean age = 20.3, mean grade completed = 12.0 (Personal communication, 1956)	53	.52**	AA	41.0	11.0	47.8[d]	11.9
Otis Self-Administering Tests of Mental Ability: Higher Examination, Form A (20-minute time limit)	Male supervisors (mostly assistant foremen) in an aircraft factory (Sartain, 1946)	40	.39*	—	—	—	—	—
	Male inspectors in an aircraft factory (Sartain, 1945)	46	.62**	—	34.5	10.5	28.6	9.5
The Henmon-Nelson Tests of Mental Ability, Form B (for College Students)	College freshmen, 150 male and 150 female (Alteneder, 1940)	300	.45**	AA	41.2	10.1	43.3	11.3

(*Table continued on next page*)

TABLE 7 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB			Other Tests	
				Series	Mean	SD	Mean	SD
Wonderlic Personnel Test, Form D	Male applicants for engineering positions at an electric utility (Personal communication, 1964)	201	.18**	MB	48.8	7.3	32.3	5.7
Arthur Stencil Design Test	High school students, aged 16.5-19.5 (Magsdick, 1950)	100	.52**	—	39[a]	12.1	14[a]	4.5
Cardall Test of Practical Judgment	Male inspectors in an aircraft factory (Sartain, 1945)	46	.43**	—	34.5	10.5	160.1	45.4
Minnesota Engineering Analogies Test, Form F	Male engineers and scientists at a large electrical company (Personal communication, 1960)	327	.25**	AA	50.3	7.9	32.1	7.1
Minnesota Engineering Analogies Test, Forms E and F	Male applicants for engineering positions at an electric utility (Personal communication, 1964)	201	.04	MB	48.8	7.3	30.7	5.6
Measures of Numerical Ability								
Personnel Tests for Industry—Numerical	Male applicants to an east coast chemical company (Personal communication, 1960-61)	216	.47**	MA	41.1	10.3	16.8	6.2
	Male employees in an east coast chemical company (Personal communication, 1960-61)	83	.55**	MA	38.9	9.8	16.9	4.5
	Male electrical maintenance workers at a large metropolitan public transportation company (Personal communication, 1964)	122	.53**	MA	39.0	9.9	19.2	6.3
	Male apprentices in mechanical and electrical positions at several plants of a large metals manufacturer (Personal communication, 1969)	178	.38**	AA or BB	44.8	7.8	22.3	4.9
	Male automotive personnel at a large metropolitan public transportation company (Personal communication, 1960)	53	.35**	MA	39.9	8.7	16.0	8.8

(*Table continued on next page*)

TABLE 7 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB Series	MPFB Mean	MPFB SD	Other Tests Mean	Other Tests SD
Short Employment Tests—Numerical, Form 2	Male applicants for engineering positions at an electric utility (Personal communication, 1964)	201	.20**	MB	48.8	7.3	47.9	13.7
Measures of Verbal Ability								
Personnel Tests for Industry—Verbal	Male electrical maintenance workers at a large metropolitan public transportation company (Personal communication, 1964)	122	.45**	MA	39.0	9.9	34.6	9.7
	Male apprentices in mechanical and electrical positions at several plants of a large metals manufacturer (Personal communication, 1969)	177	.34**	AA or BB	44.8	7.8	38.1	7.4
	Male automotive personnel at a large metropolitan public transportation company (Personal communication, 1960)	53	.39**	MA	39.9	8.7	30.9	6.6
Wide Range Vocabulary Test, Form B	Male applicants for engineering positions at an electric utility (Personal communication, 1964)	201	.10	MB	48.8	7.3	73.1	10.8
SRA Primary Mental Abilities: Word-Fluency	Male applicants for engineering positions at an electric utility (Personal communication, 1964)	201	.12	MB	48.8	7.3	44.6	11.3
Measures of Spatial Ability								
Revised Beta Examination, Test 4	Male prison inmates, aged 18-57 (Gurvitz, 1950)	1000	.62**	AA	30.3	14.1	10.1	2.6
Minnesota Spatial Relations Test	Male prison inmates with IQs of 90 and above (W. P. DeStephens, personal communication, 1950)							
	Literates (reading above Grade 4.4 level)	334	.61**	MB	38.2	—	—	—
	Illiterates (reading below Grade 4.4 level)	167	.38**	MB	27.8	—	—	—

(*Table continued on next page*)

TABLE 7 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB			Other Tests	
				Series	Mean	SD	Mean	SD
Wechsler-Bellevue Intelligence Scale, Block Design	High school students, aged 16.5-19.5 (Magsdick, 1950)	100	.61**	—	39[a]	12.1	13[e]	2.7
	Engineering school freshmen, aged 17.5-21, mean age = 18.2 (Estes, 1942)	103	.40**	AA	46.4	8.1	33.2	3.7
	War veterans in a general medical and surgical hospital (Schultz & Knapp, 1955)	28	.63**	—	—	—	—	—
Survey of Space Relations Ability	War veterans in a general medical and surgical hospital (Schultz & Knapp, 1955)	31	.67**	—	—	—	—	—
Differential Aptitude Tests: Space Relations	Male apprentices in mechanical and electrical positions at several plants of a large metals manufacturer (Personal communication, 1969)	63	.54**	AA or BB	42.1	7.7	54.2	21.1
Measures of Mechanical Ability								
Bennett Test of Mechanical Comprehension, Form AA	Male applicants to a fabricated metals factory (Personal communication, 1956)	111	.20*	AA	36.6	11.6	38.7	9.4
	Male applicants for positions as apprentice foremen at a western manufacturing company (Personal communication, 1955)	69	.35**	AA	40.4	9.4	44.8	9.5
	Male inspectors in an aircraft factory (Sartain, 1945)	46	.27	—	34.5	10.5	21.4	8.7
	Male apprentices in mechanical and electrical positions at several plants of a large metals manufacturer (Personal communication, 1969)	179	.31**	AA or BB	44.7	7.9	45.0	6.5
	Male supervisors (mostly assistant foremen) in an aircraft factory (Sartain, 1946)	40	.31*	—	—	—	—	—

(*Table continued on next page*)

TABLE 7 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB			Other Tests	
				Series	Mean	SD	Mean	SD
Bennett Test of Mechanical Comprehension, Form BB	Male automotive personnel at a large metropolitan public transportation company (Personal communication, 1960)	53	.39**	MA	39.9	8.7	26.5	11.0
	Male electrical maintenance workers at a large metropolitan public transportation company (Personal communication, 1964)	122	.47**	MA	39.0	9.9	25.5	9.6
	Male draftsmen in a large nationwide electrical manufacturing company (Personal communication, 1964)	64	.43**	AA	48.7	8.4	47.5	5.4
	Male applicants, aged 17-26, to a large eastern manufacturing company (Personal communication, 1956)	53	.46**	AA	41.0	11.0	22.5	10.1
Carl Hollow Square Scale	Engineering school freshmen, aged 17.5-21, mean age = 18.2 (Estes, 1942)	103	.44**	AA	46.4	8.1	117.2	10.7
O'Connor Wiggly Block	Engineering school freshmen, aged 17.5-21, mean age = 18.2 (Estes, 1942)	103	.31**	AA	46.4	8.1	3.8	2.1
MacQuarrie Test for Mechanical Ability	Male inspectors in an aircraft factory (Sartain, 1945)	46	.31*	—	34.5	10.5	58.6	11.0
O'Rourke Mechanical Aptitude Test, Form A	Male inspectors in an aircraft factory (Sartain, 1945)	46	.09	—	34.5	10.5	177.5	49.8
							Time in Seconds	
Bennett Hand-Tool Dexterity Test	Male adults (mostly veterans) at a vocational guidance center (Personal communication, 1946)	253	.33**[f]	AA	41.3	10.6	423″	84″
	Male electrical maintenance workers at a large metropolitan public transportation company (Personal communication, 1964)	122	.24**[f]	MA	39.0	9.9	393.4″	60.3″
	Male automotive personnel at a large metropolitan public transportation company (Personal communication, 1960)	53	.23[f]	MA	39.9	8.7	352.3″	70.9″

(*Table continued on next page*)

TABLE 7 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB			Other Tests	
				Series	Mean	SD	Mean	SD
Results of a Multi-Ability Study[g]								
SRA Primary Mental Abilities:	Grade 10, 255 boys and 310 girls (Mouly & Robinson, 1949)	565		AA	39.6	10.2		
Reasoning			.42**				17.4	5.8
Number			.16**				18.3	7.8
Word-Fluency			.19**				38.6	10.6
Verbal-Meaning			.26**				25.7	9.0
Space			.41**				22.2	12.5
	Grade 12, 239 boys and 287 girls (Mouly & Robinson, 1949)	526		AA	42.0	9.6		
Reasoning			.42**				19.2	5.8
Number			.21**				23.7	9.1
Word-Fluency			.16**				45.8	11.4
Verbal-Meaning			.36**				31.2	10.0
Space			.44**				26.0	12.8
General Aptitude Test Battery, B-1001:[h]	Grade 10, 255 boys and 310 girls (Mouly & Robinson, 1949)	565		AA	39.6	10.2		
Computation			.22**				—	—
Arithmetic Reason			.29**				—	—
Vocabulary			.24**				—	—
Tool Matching			.30**				—	—
Name Comparison			.26**				—	—
Form Matching			.49**				—	—
Two-Dimensional Space			.70**				—	—
Three-Dimensional Space			.52**				—	—
	Grade 12, 239 boys and 287 girls (Mouly & Robinson, 1949)	526		AA	42.0	9.6		
Computation			.26**				—	—
Arithmetic Reason			.34**				—	—
Vocabulary			.30**				—	—
Tool Matching			.28**				—	—
Name Comparison			.23**				—	—
Form Matching			.51**				—	—
Two-Dimensional Space			.70**				—	—
Three-Dimensional Space			.49**				—	—

(*Table continued on next page*)

TABLE 7 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Other Tests

Test	Group	N	r	MPFB Series	MPFB Mean	MPFB SD	Other Tests Mean	Other Tests SD
Minnesota Clerical Test	Grade 10, 255 boys and 310 girls	565		AA	39.6	10.2		
Number Comparison	(Mouly & Robinson, 1949)		.17**				104.7	22.9
Name Comparison			.26**				98.7	27.1
	Grade 12, 239 boys and 287 girls	526		AA	42.0	9.6		
Number Comparison	(Mouly & Robinson, 1949)		.21**				116.3	32.7
Name Comparison			.25**				111.6	28.0

*Significant at .05 level.
**Significant at .01 level.
[a] Mean raw score reported to the nearest whole number.
[b] These means correspond to weighted scores which were reported to the nearest whole number. Mean weighted scores of 113, 53, and 60 correspond to IQs of 112, 108, and 112, respectively, on the Full Scale, Verbal Scale, and Performance Scale.
[c] Mean weighted score.
[d] Mean raw score which is equivalent to a mean IQ of approximately 106.
[e] Mean weighted score reported to the nearest whole number.
[f] The sign of this correlation was changed from negative to positive so as to indicate the true relationship between the two tests. The score on the *Hand-Tool Dexterity Test* is the time required to complete the test. Thus, low scores are better than high scores, and negative correlations indicate positive relationships.
[g] In addition to the abilities listed in previous headings (e.g., numerical, verbal), the study included tests of clerical ability.
[h] Data presented for 8 subtests expected to be most closely related to *MPFB*; median correlation of *MPFB* with 7 omitted *GATB* motor tests = .16 for students in both grades.

TABLE 8

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Various Criteria

Group	N	r	Criterion: Description	Criterion: Mean	Criterion: SD	MPFB: Series	MPFB: Mean	MPFB: SD
			School Success					
Students at an industrial institute (Bradley, 1958)			Course grades:[a]					
	46	.21	Air Conditioning, Refrigeration	3.0	0.6	MA	42.6	8.1
	99	.37**	Auto Mechanics, General	3.2	0.7	MA	42.5	9.8
	66	.29*	Baking	2.8	0.7	MA	37.9	9.5
	51	.35*	Building Construction, Drafting, and Estimating	3.1	0.7	MA	50.2	6.2
	42	.37*	Building Construction, Carpentry	3.0	0.8	MA	43.9	7.3
	74	.52**	Electrical, General	3.1	0.8	MA	47.1	8.7
	76	.23*	Machine Shop, General	2.7	0.6	MA	46.7	7.0
	53	.31*	Mechanical Drafting, General	3.3	0.7	MA	48.7	8.7
	43	.40**	Printing, General	2.8	0.6	MA	44.4	9.2
	79	.33**	Radio-TV Electronics	3.0	0.9	MA	46.1	8.0
Students in a basic instruction course for aviation mechanics (T. Harrell, personal communication, from 1948 manual)	84		Course grades:					
		.41**	Mechanical Drafting and Blueprint Reading	—	—	—	—	—
		.35**	Elements of Metalwork	—	—	—	—	—
College students in a wartime defense training plan, mean age = 22 (Crawford, 1942)	80		Course grade:					
		.50**	Machine Design and Detail Drafting	—	—	—	—	—
Evening college students in a wartime engineering defense training program (Moore, 1941)			Course grades:					
	85	.49**	Pre-Mathematics, Mechanics, and Strength of Materials	—	—	—	—	—
	167	.34**	Engineering Drafting	—	—	—	—	—
Full-time day college students in a wartime engineering defense program (Moore, 1941)	282		Course grades:					
		.35**	Engineering Drafting	—	—	—	—	—
		.17**	Mathematics	—	—	—	—	—
		.14*	Mechanics	—	—	—	—	—
		.13*	Chemistry	—	—	—	—	—
		.17**	Physics (Cooperative Physics Test)	—	—	—	—	—
Enrollees in engineering, science, management, defense training (ESMDT) courses at North Carolina State College during wartime (McGehee & Moffie, 1942)			Course grades:					
	22	.14	Architectural Engineering	—	—	—	—	—
	63	.35**	Engineering Drawing	—	—	—	—	—
	19	.26	Instrument Men	—	—	—	—	—
Trainees in an aircraft company (Grimsley, 1944)	165	.48**	Grades in a Detail Draftsmen Training Program	—	—	—	—	—

(*Table continued on next page*)

TABLE 8 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Various Criteria

Group	N	r	Criterion: Description	Criterion: Mean	Criterion: SD	MPFB: Series	MPFB: Mean	MPFB: SD
Engineering school freshmen (Estes, 1942)	76	.31**	Instructors' ratings in Descriptive Geometry, disregarding Drawing Technique	5.2	1.9	AA	45.0	9.7
Entering West Point cadets (French, 1955)	361		Course grades:			MA	45.6[b]	9.0[b]
		.06[b]	Foreign Language	63.0	5.8			
		.20**[b]	English	62.1	4.1			
		.53**[b]	Military Topography and Graphics	63.5	5.0			
		.31**[b]	Mathematics	65.4	5.9			
Junior and senior high school students (Hunter, 1945)	75	.45**	Pupil efficiency: Work samples graded on the basis of accuracy, quality of finish, and speed	—	—	—	—	—
Freshmen dentistry students (Thompson, 1942)	35					AA	39.3	8.8
		.04	Grade point average for one year of dentistry courses	2.4	0.8			
		.24	Combination of grade point average in dentistry courses and ratings of mechanical technique made by two laboratory instructors	—	—			
Senior dentistry students (Thompson, 1942)	40					AA	42.4	13.9
		.31*	Grade point average for four years of dentistry courses	2.3	0.4			
		.61	Combination of grade point average in dentistry courses and ratings of mechanical technique made by two technical instructors	—	—			
Art school freshmen, architecture majors, all male (Bryan, 1942)	75		Course grades:			AA or BB	44.8	7.8
		.33**	Average of all art courses	78.2	5.7			
		.25*	Design	78.6	9.0			
		.17	Structural Representation	78.1	6.5			
Art school freshmen, art education majors, 61 male and 157 female (Bryan, 1942)	218		Course grades:			AA or BB	46.7	17.7
		.17**	Average of all art courses	82.8	4.8			
		.21**	Design	82.0	7.0			
		.15*	Structural Representation	82.8	6.4			
Art school freshmen, design majors, 374 male and 341 female (Bryan, 1942)	715		Course grades:			AA or BB	43.8	8.1
		.20**	Average of all art courses	81.4	5.3			
		.20**	Design	81.0	8.1			
		.09**	Structural Representation	81.2	7.9			

(*Table continued on next page*)

TABLE 8 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Various Criteria

			Criterion			MPFB		
Group	N	r	Description	Mean	SD	Series	Mean	SD
Fine arts students (Thompson, 1942)	50	.18	Grade point average for all courses	2.9	0.5	AA	40.8	10.2
College freshmen, 150 male and 150 female (Alteneder, 1940)	300	.30**	Average grades for the first semester of college	—	—	AA	41.2	10.1
Male electrical and mechanical workers (mostly aged 25-35 with high school education) for a large metals manufacturer (Personal communication, 1969)	154	.11	Grade point average[c] in an in-company training program	3.5	0.3	AA or BB	44.9	7.9
			Job Success					
Male inspectors in an aircraft factory (Sartain, 1945)	46	.47**	Job efficiency: The sum of two independent ratings by two instructors in a refresher course for inspectors	5.9	1.4	—	34.5	10.5
Male draftsmen in a large nationwide electrical manufacturing company (Personal communication, 1964)	64	.22	Performance ratings: The sum of six 5-point ratings on the following qualities: Productivity, quality of work, knowledge of work, sense of responsibility, relations with others, self-control	22.0	3.4	AA	48.7	8.4
Male electrical maintenance workers at a large metropolitan public transportation company (Personal communication, 1964)	122					MA	39.0	9.9
		.24**	Supervisory ratings composed of the following scales: 6 personality traits, behavior in 11 areas, performance in 4 areas	213.8	30.2			
		.48**	Age-level index:[d] Overall achievement level of each man	17.7	9.1			
Male automotive personnel at a large metropolitan public transportation company (Personal communication, 1960)	53					MA	39.9	8.7
		.21	Supervisors' ratings of job performance	105.2	10.2			
		.21	Age-level index: Overall achievement level of each man	13.8	8.3			
Male employees in an east coast chemical company (Personal communication, 1960-61)	83	.35**	Performance ratings by supervisors[e]	33.7	—	MA	38.9	9.8
Female inspector-packers in a pharmaceutical supply house (Ghiselli, 1942)	26	.57**	Ratings of job proficiency by supervisors	—	—	—	—	—

(*Table continued on next page*)

TABLE 8 *(continued)*

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Various Criteria

Group	N	r	Criterion: Description	Criterion: Mean	Criterion: SD	MPFB: Series	MPFB: Mean	MPFB: SD
Male and female inspectors in aircraft plants (Shuman, 1945a)	49	.50**[f]	Ratings of job success[g]	—	—	AA	—	—
Male engine testers in aircraft plants (Shuman, 1945a)	45	.16[f]	Ratings of job success[g]	—	—	AA	—	—
Male and female machine operators in aircraft plants (Shuman, 1945a)	81	.38**[f]	Ratings of job success[g]	—	—	AA	—	—
Male foremen in aircraft plants (Shuman, 1945a)	99	.47**[f]	Ratings of job success[g]	—	—	AA	—	—
Male job setters in aircraft plants (Shuman, 1945a)	25	.59**[f]	Ratings of job success[g]	—	—	AA	—	—
Male toolroom learners in aircraft plants (Shuman, 1945a)	64	.42**[f]	Ratings of job success[g]	—	—	AA	—	—
Male electrical and mechanical workers (mostly aged 25-35 with high school education) for a large metals manufacturer (Personal communication, 1969)	178	.14	Supervisors' ratings of overall job performance[h]	3.2	0.8	AA or BB	44.7	7.9
Male supervisors (mostly assistant foremen) in an aircraft factory (Sartain, 1946)	40	.10	Job efficiency: The sum of the standard scores of four ratings (Two different rating forms were filled out by two superiors of the supervisors studied)	—	—	—	—	—
Male supervisors in aircraft plants (Shuman, 1945b)	208	.39**[i]	Ratings of job success given by superiors of the supervisors studied, on the following characteristics: Production, handling workers, condition and maintenance of department, general overall ability	—	—	AA	—	—
Front-line supervisors eligible for promotion to foremen at a manufacturing company (Dicken & Black, 1965)	31	.23 .27	Final salary Job level increase	— —	— —	— —	— —	— —
Male bricklayers, World War II veterans, enrolled in a commercial institute (Ferson, 1951)	150	.38**	Weighted combination of instructor's performance ratings[j] and oral trades questions test scores	—	—	BB	—	—

(Table continued on next page)

TABLE 8 (*continued*)

Coefficients of Correlation between the Revised Minnesota Paper Form Board Test and Various Criteria

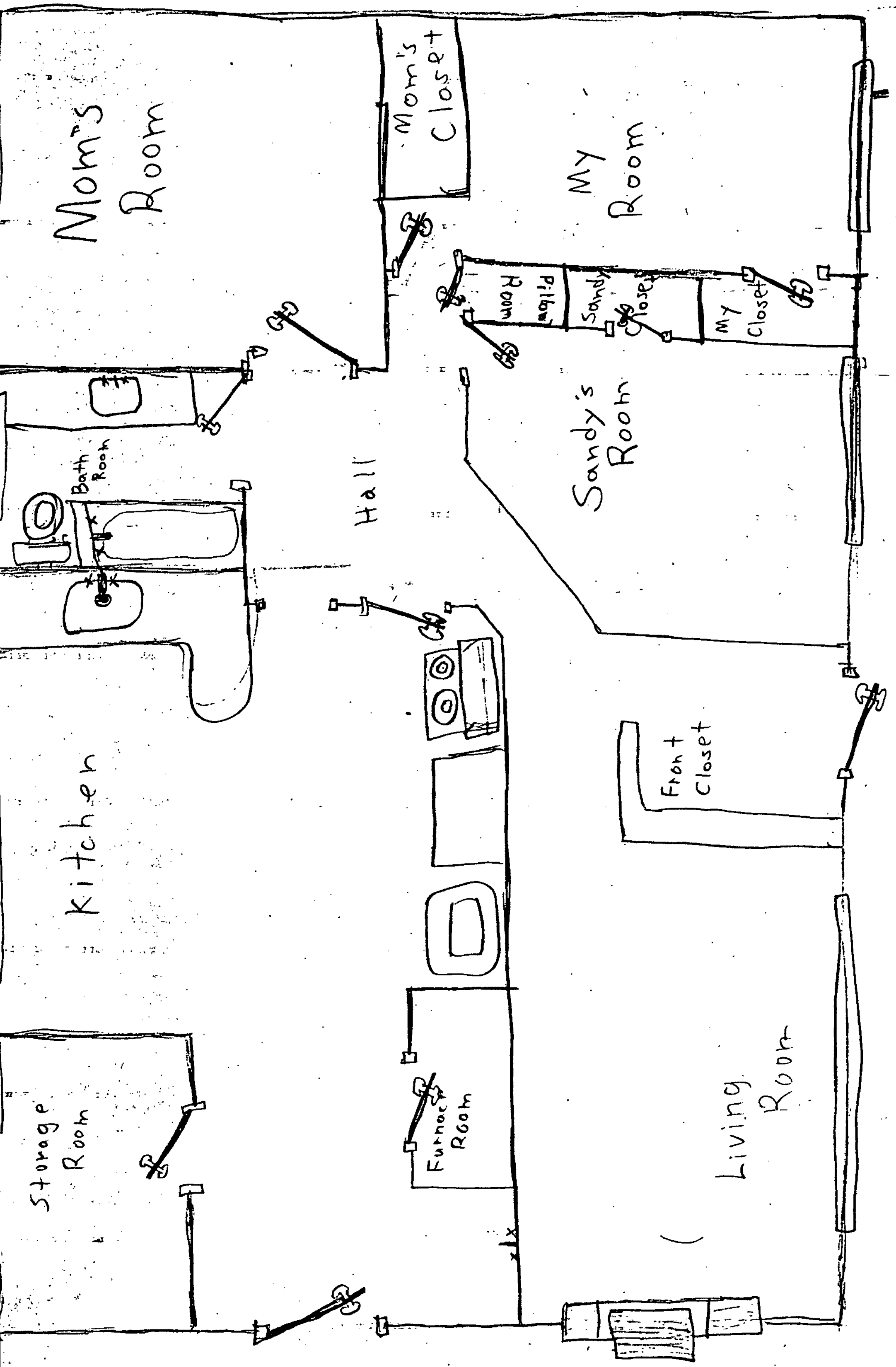
Group	N	r	Criterion: Description	Criterion: Mean	Criterion: SD	MPFB: Series	MPFB: Mean	MPFB: SD
Male auto mechanics, World War II veterans, enrolled in a commercial institute (Ferson, 1951)	87	.48**	Weighted combination of instructor's performance ratings[j] and oral trades questions test scores	—	—	BB	—	—
Male plumbers, World War II veterans, enrolled in a commercial institute (Ferson, 1951)	173	.36**	Weighted combination of instructor's performance ratings[j] and oral trades questions test scores	—	—	BB	—	—
Male linotype operator trainees (Beamer, Edmondson, & Strother, 1948)	27	.29	Objective measure of production (lines per hour minus twice the errors made)	—	—	—	38.7	8.9
Female power sewing machine operators (Otis, 1938)	52	.32*	Quality of work as indicated by performance on a series of work samples	—	—	AA or BB	—	—
Male engineers and scientists in development classifications at a large electrical company (Personal communication, 1960)	148	.19*	Salary (with the influence of age removed statistically)[k]	−351.2	1726.7	AA	50.2	8.0
Male engineers and scientists in research classifications at a large electrical company (Personal communication, 1960)	116	.24**	Salary (with the influence of age removed statistically)[k]	448.0	2062.0	AA	50.3	8.1

*Significant at .05 level.
**Significant at .01 level.
[a] Grades were converted to the following scale: A = 1; B = 2; C = 3; D = 4; F = 5. Since low scores are better than high scores, positive relationships would be indicated by negative correlations. To show the true relationships between the *MPFB* and the criteria, the signs of the correlations were changed from negative to positive.
[b] Mean and standard deviation based on original total group of 410 cadets; coefficients of correlation based on 361 of original group of cadets.
[c] Grade point averages were converted to the following scale: A = 4; B = 3; C = 2.
[d] This index relates chronological age and level of achievement. Age-level index $= \frac{100L - (A-Y)}{A + (Y-L)}$ where L = weighted level according to position (level 10 down to level 3); A = age; Y = years in level.
[e] Ratings on each of four job characteristics: quality, quantity, dependability, attitude. Sum of ratings could range from 10 (poor) to 50 (excellent).
[f] Biserial r.
[g] Ratings made by trained workers who interviewed one or more supervisors familiar with work of those being rated.
[h] Ratings ranged from 1 (low) to 5 (high).
[i] Mean biserial r for groups tested.
[j] Performance ratings based on quality, quantity, and job knowledge.
[k] Criterion value for an individual is the deviation of his income from the expected salary for his age.

APPENDIX 6

RAMSON - 11YRS.

Additional Detail



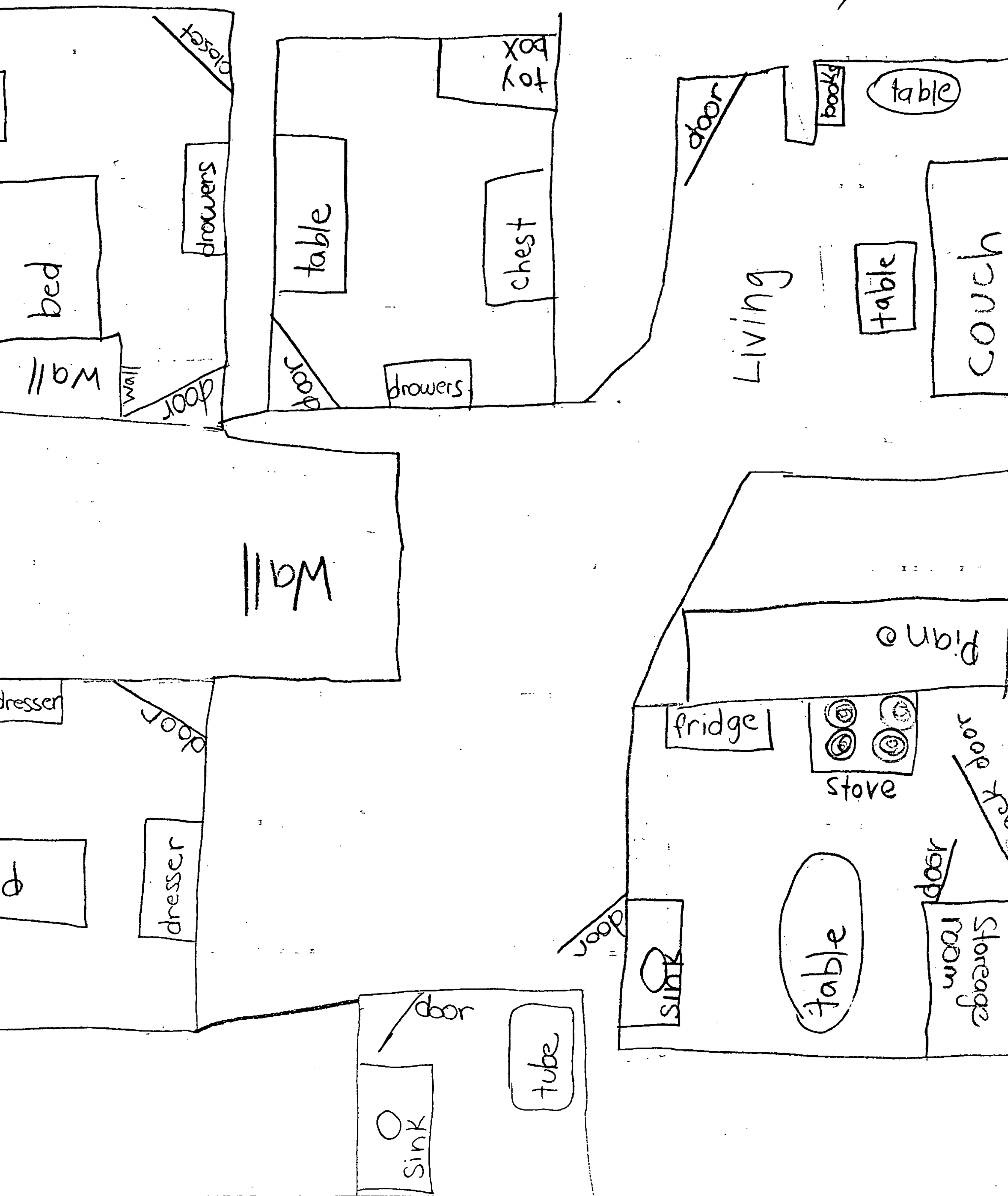
Danny
11 yrs.
3065

4127

Additional Detail

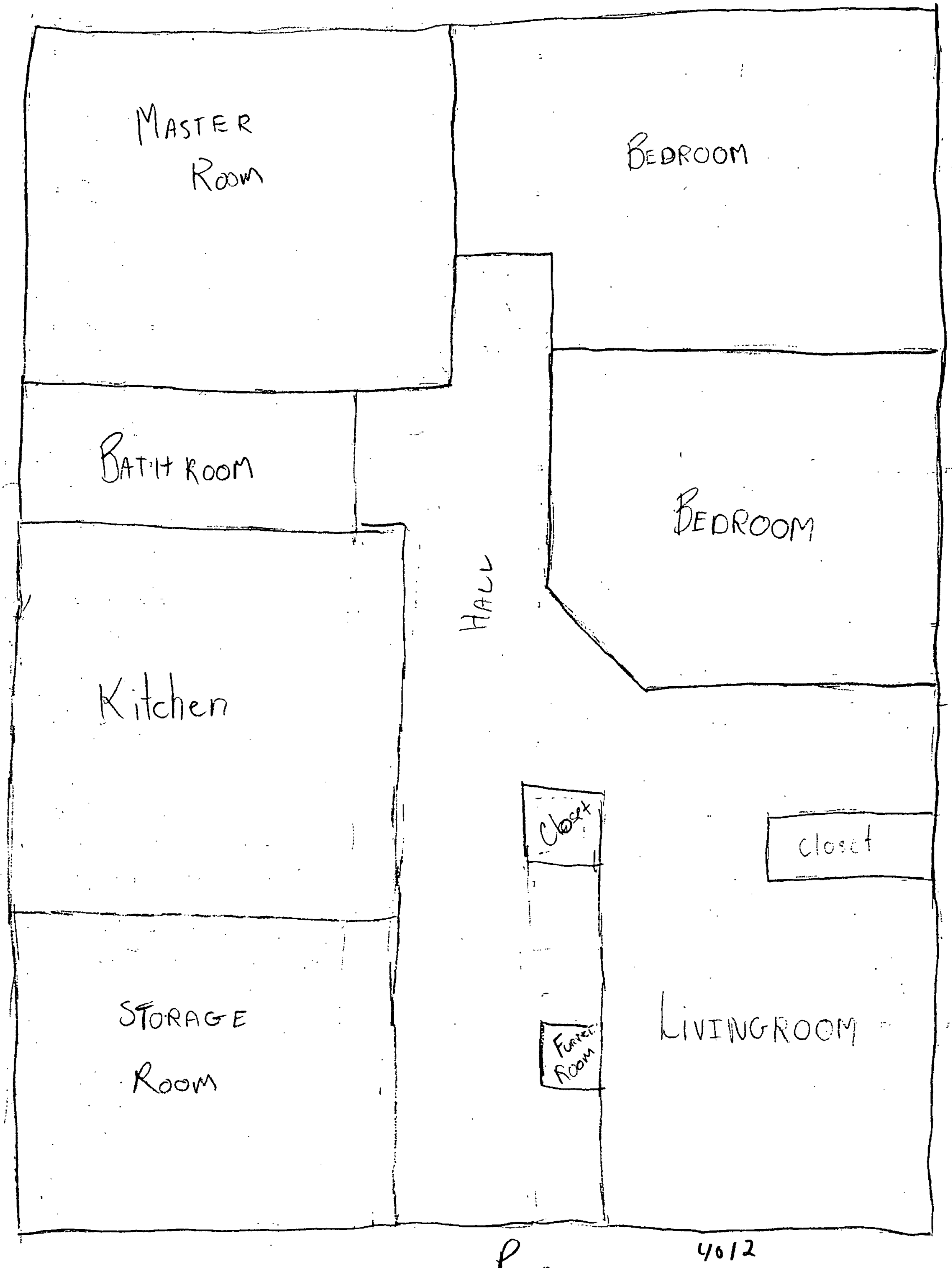
Martha Armstrong

10 YRS



Kitchie
10yrs
4010

Sketching Technique



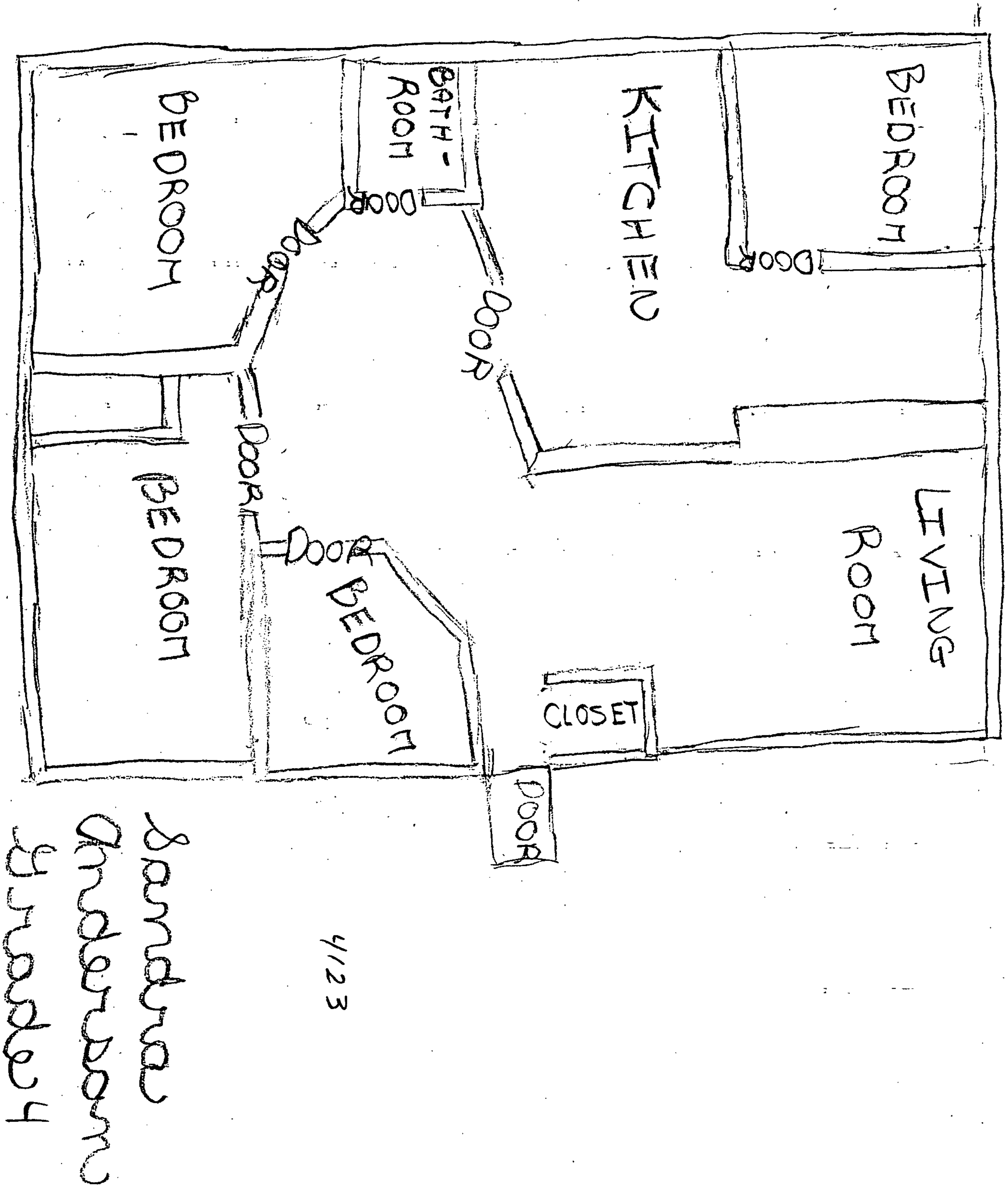
Pam

4012

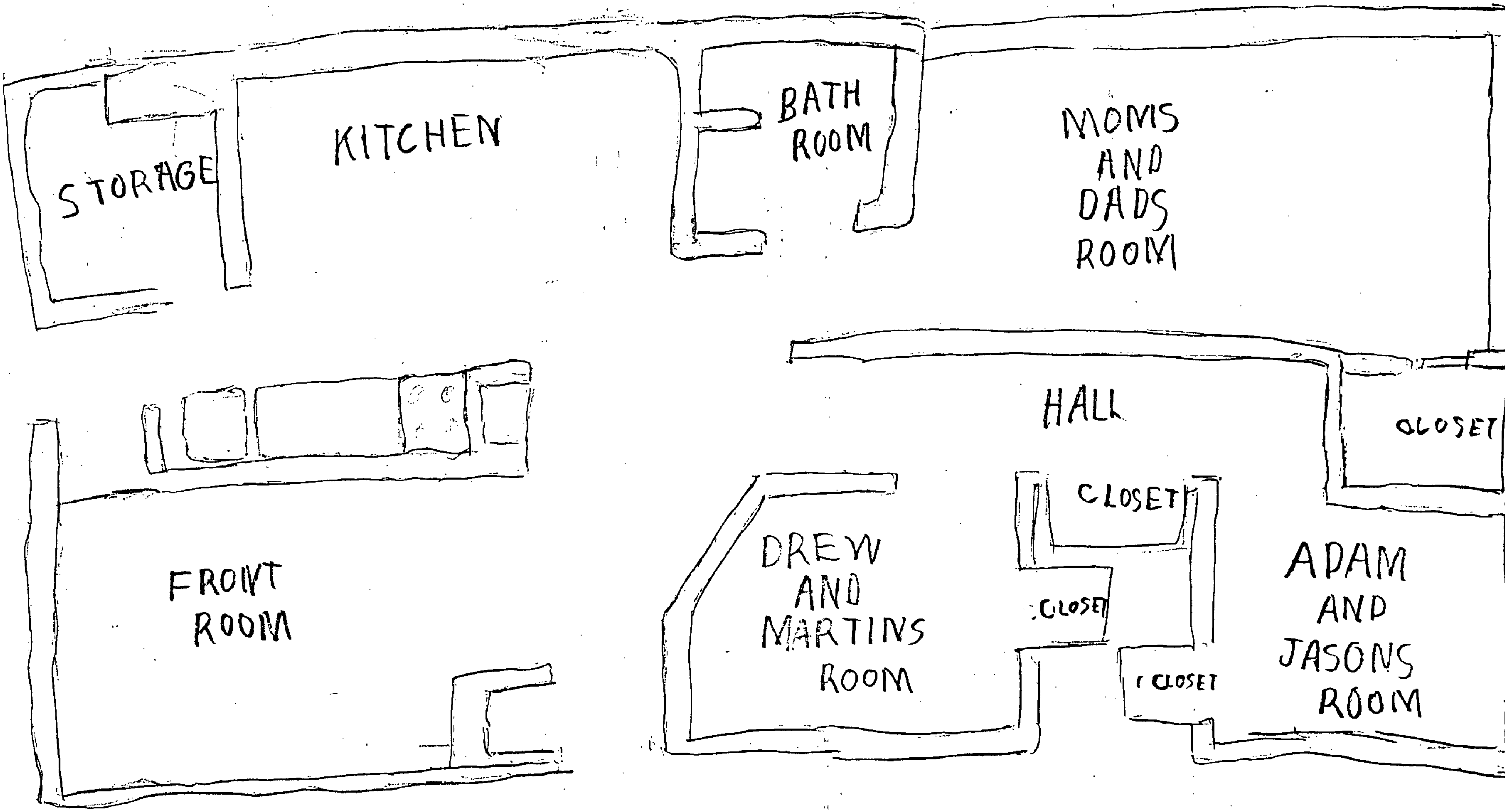
Thick Walls

ANDERSON

9 YRS . 171.



Thick Walls



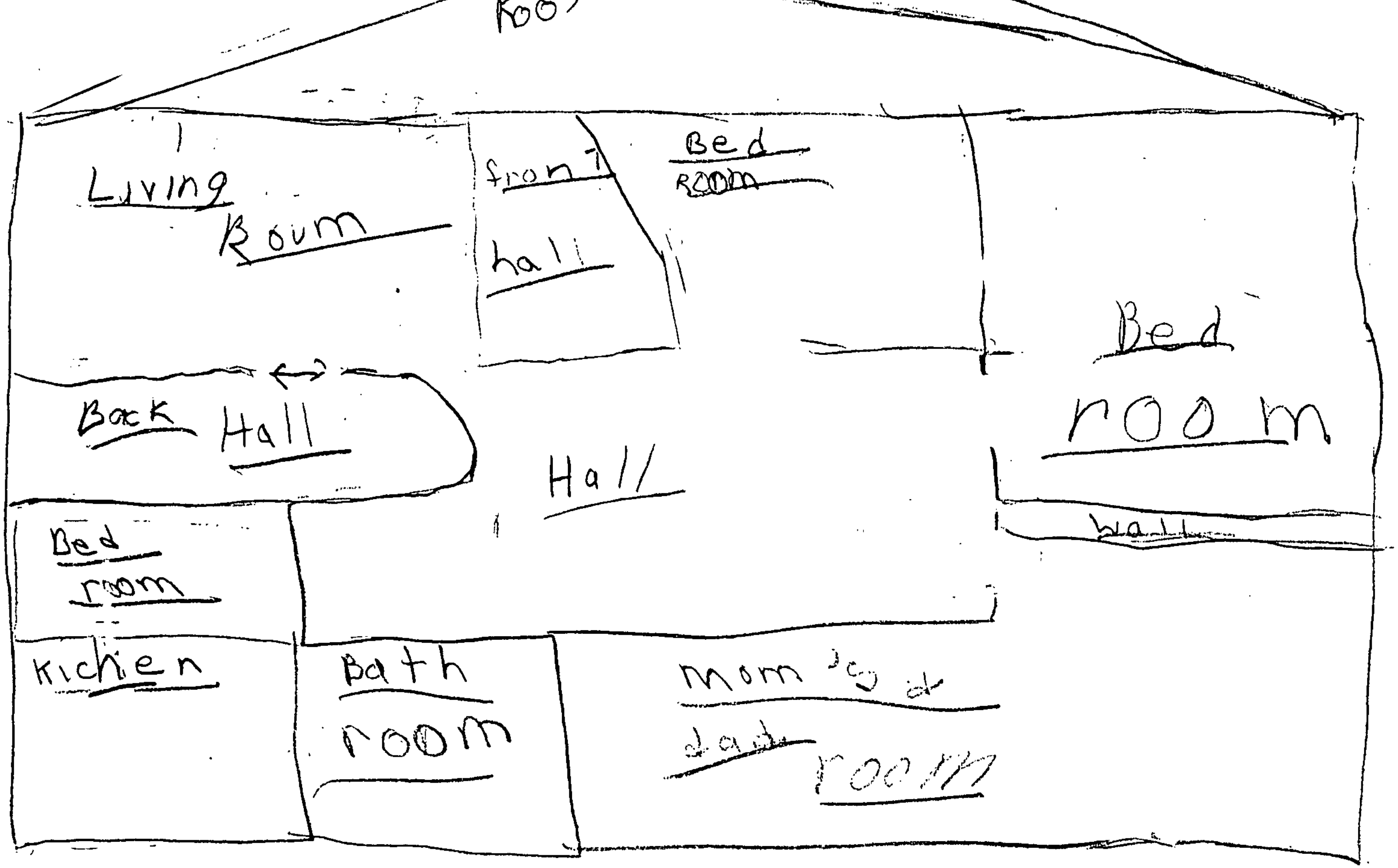
3056

172.

11 YRS

BURNS

ANDERSON 8 YRS 173.



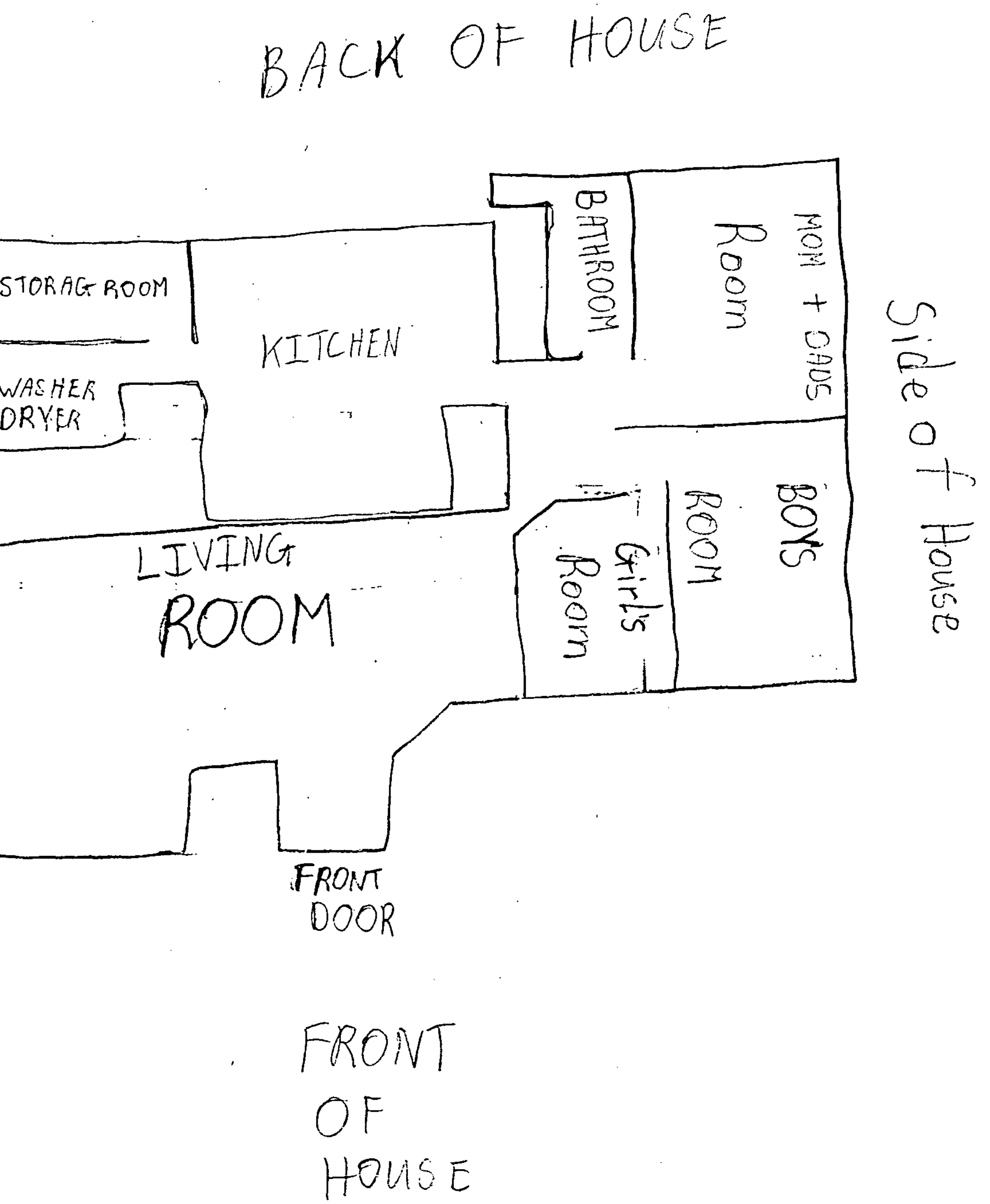
Roof (also large hall)

4124

Brenda A.
Grade 3.

FAINSTEIN
12 YRS.
174.

Non-Square Style

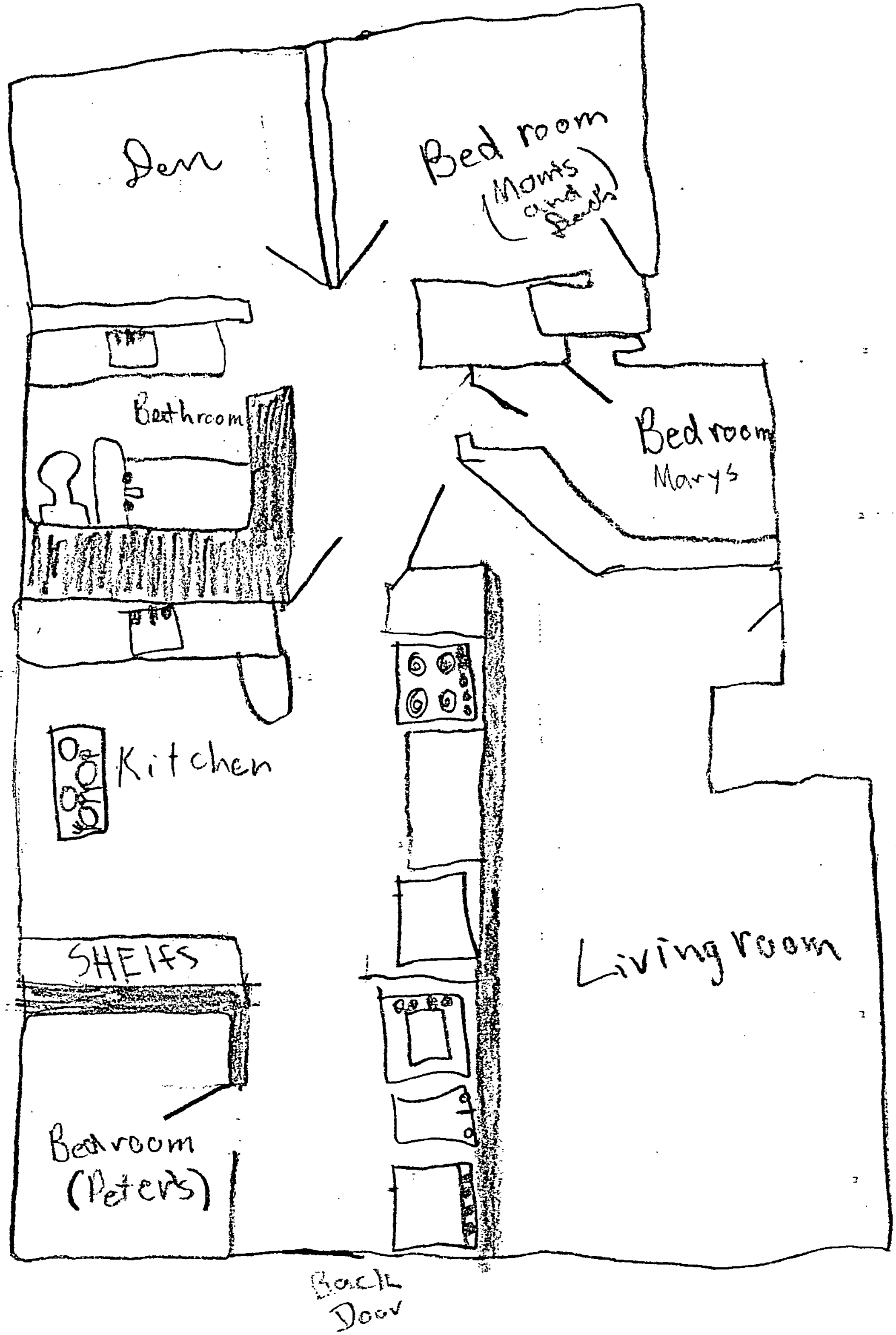


3038

ADAMS 3139

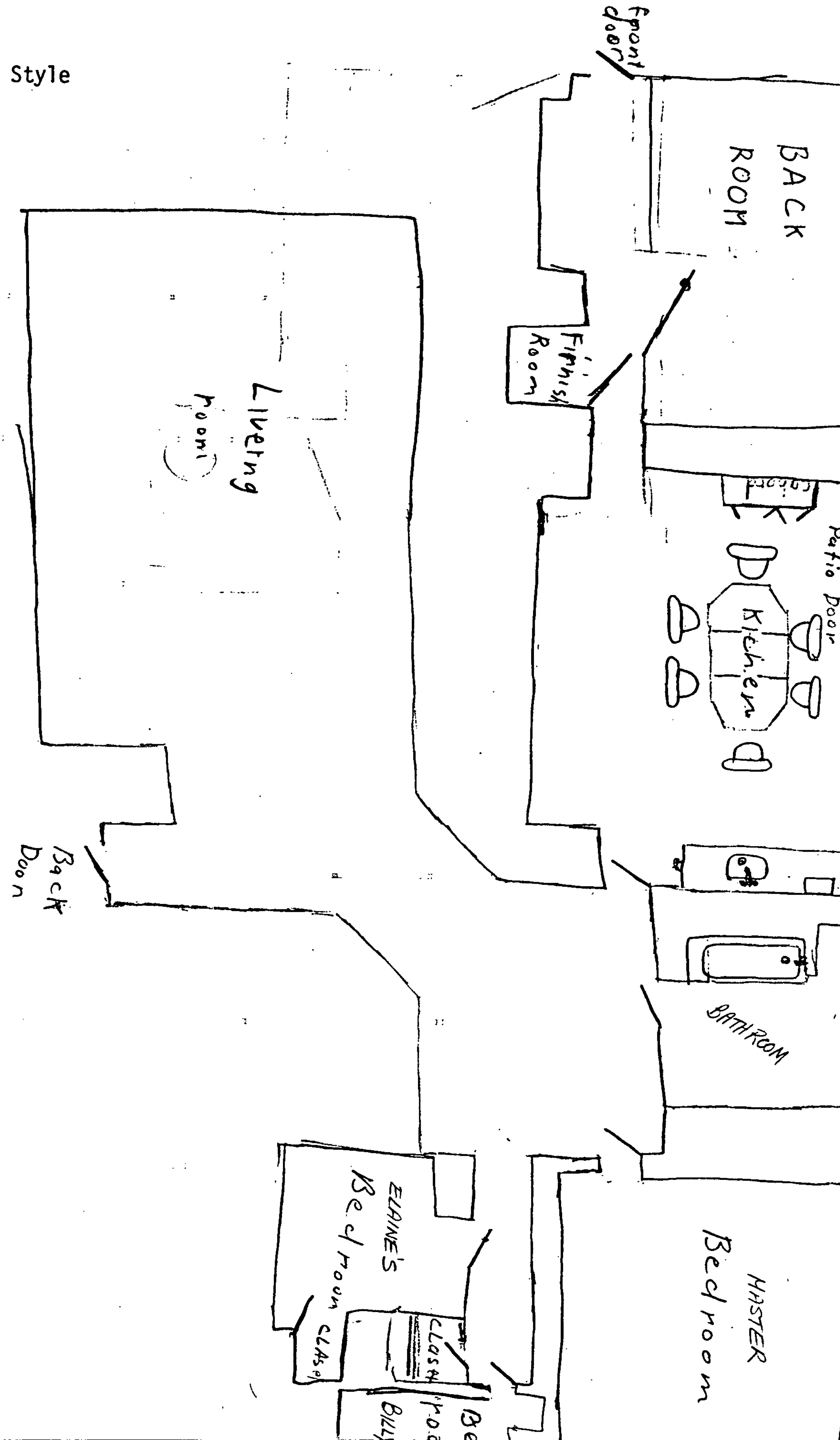
Peter - 12YRS 175.

Non-Square Style



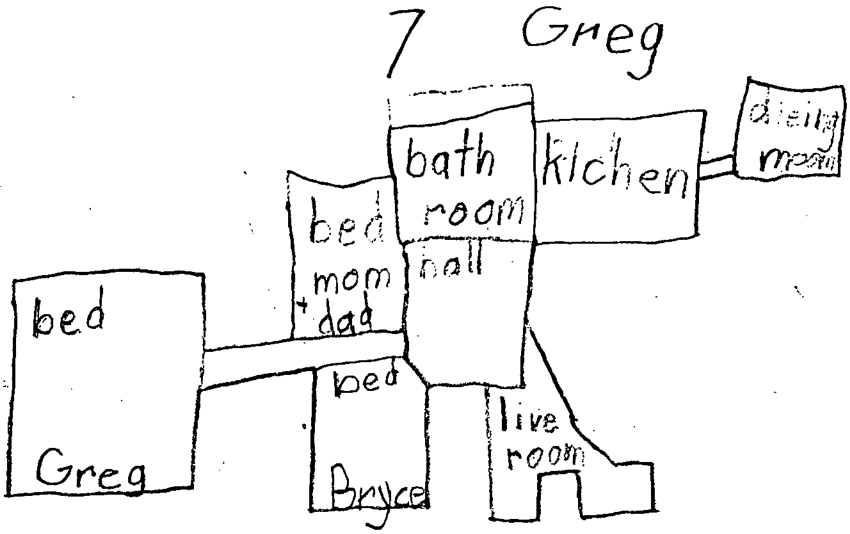
GEDDES 3113
12YRS

Appended Room Style



JENSEN 7YRS

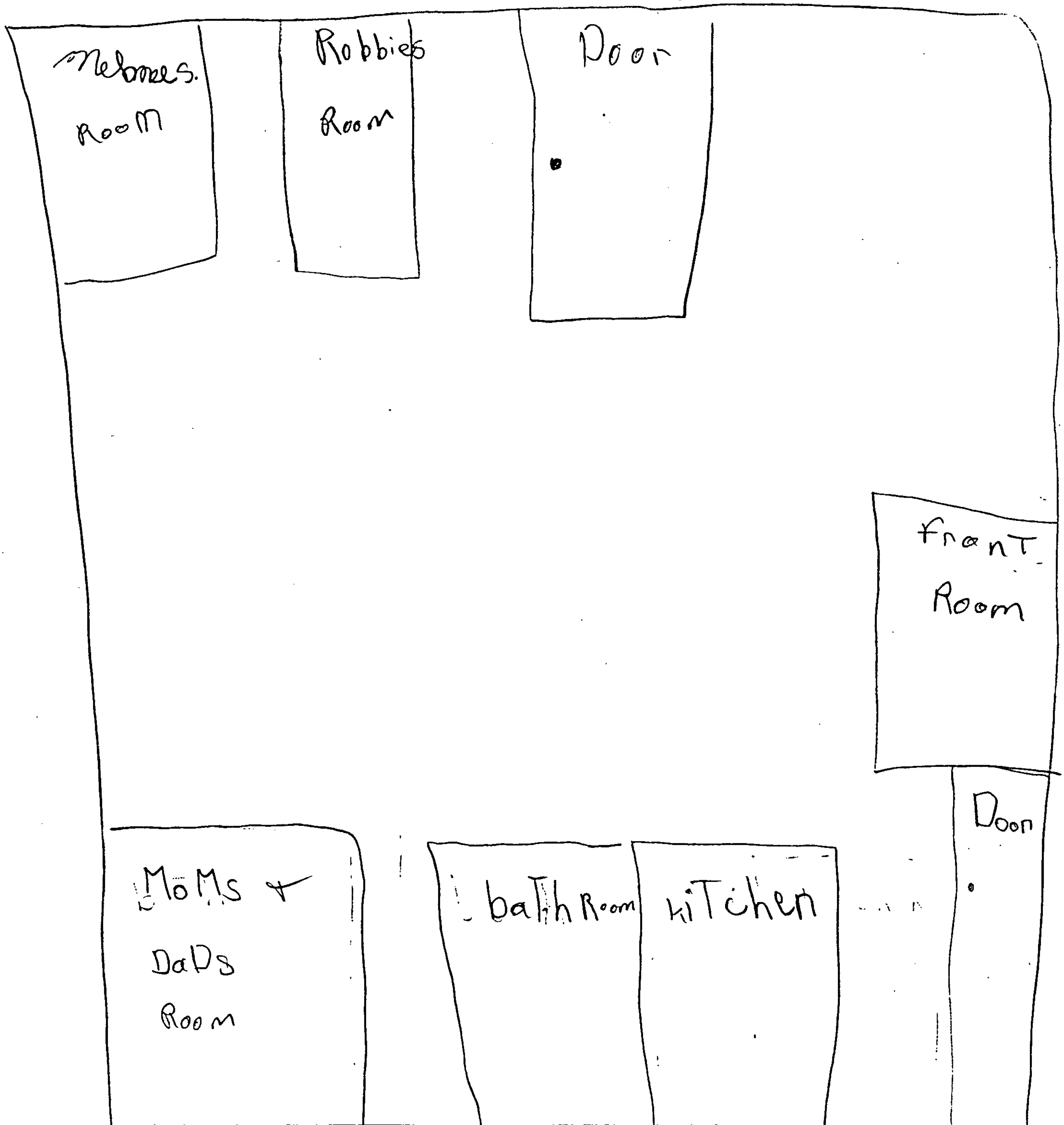
3149



Appended Room Style

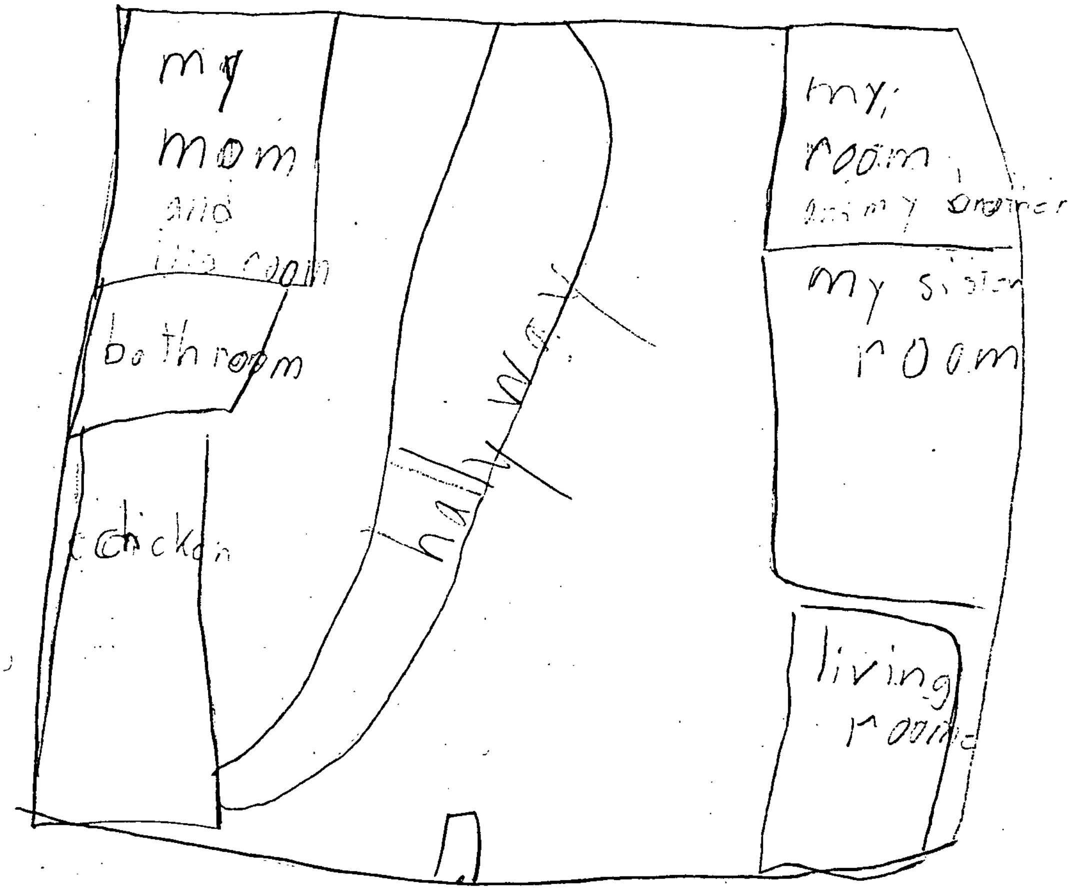
Box Style

Melonie watson - AgE7



KALTENEGGER 8 YRS

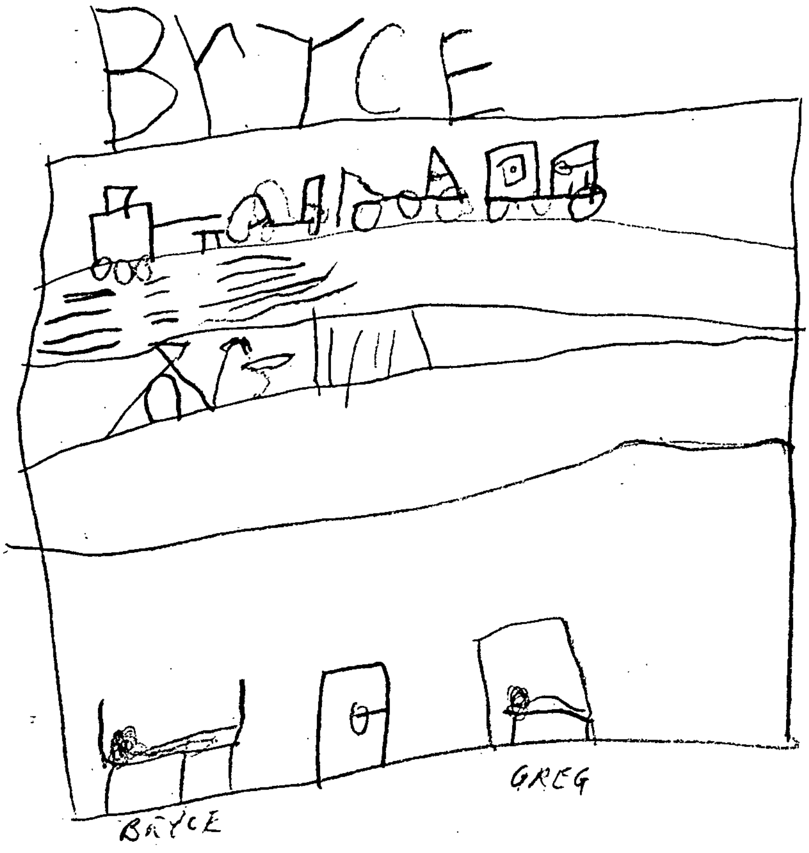
Box Style



Hans
3084

Side View

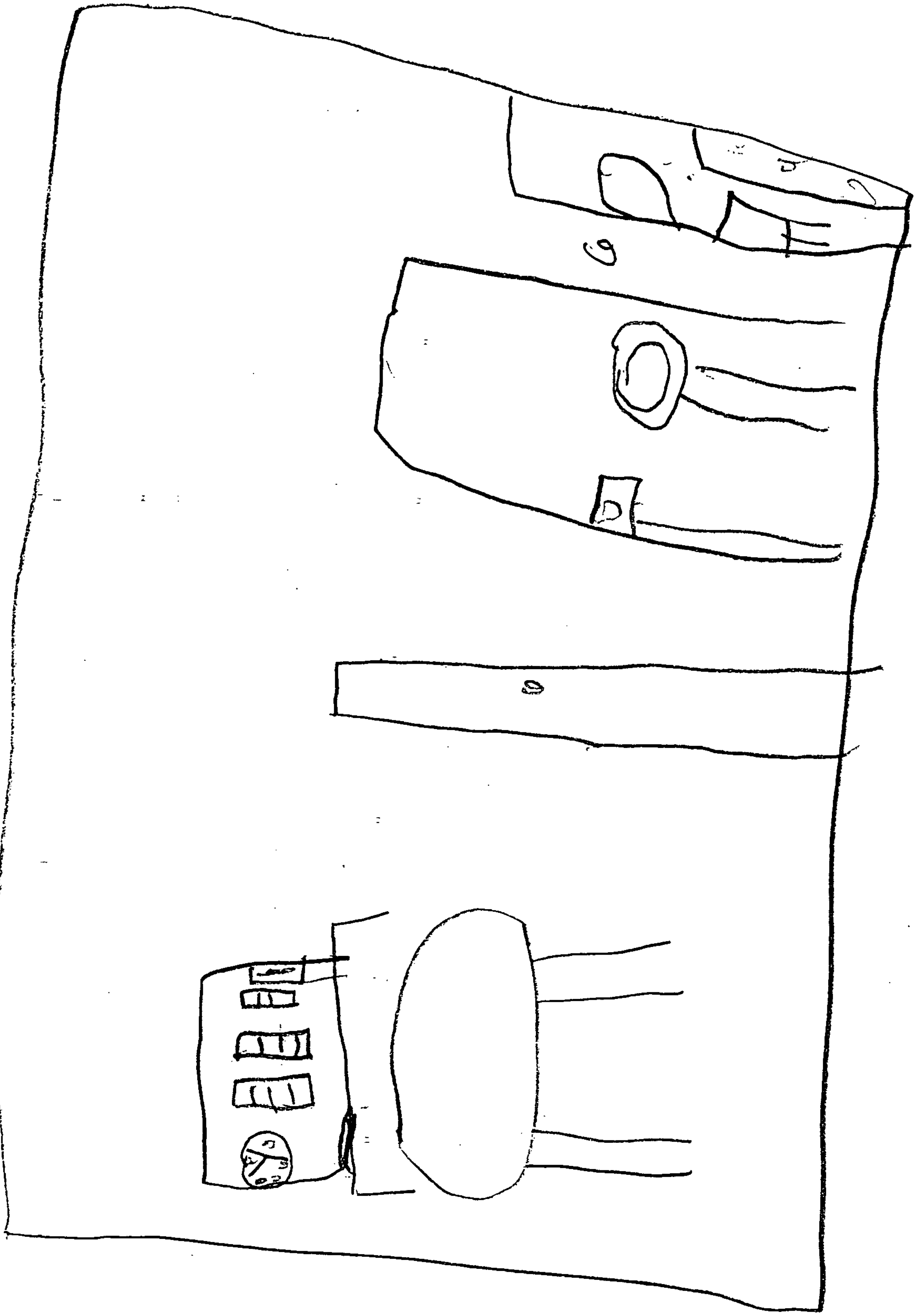
JENSEN 5YRS



3150

LORNE 5YRS.

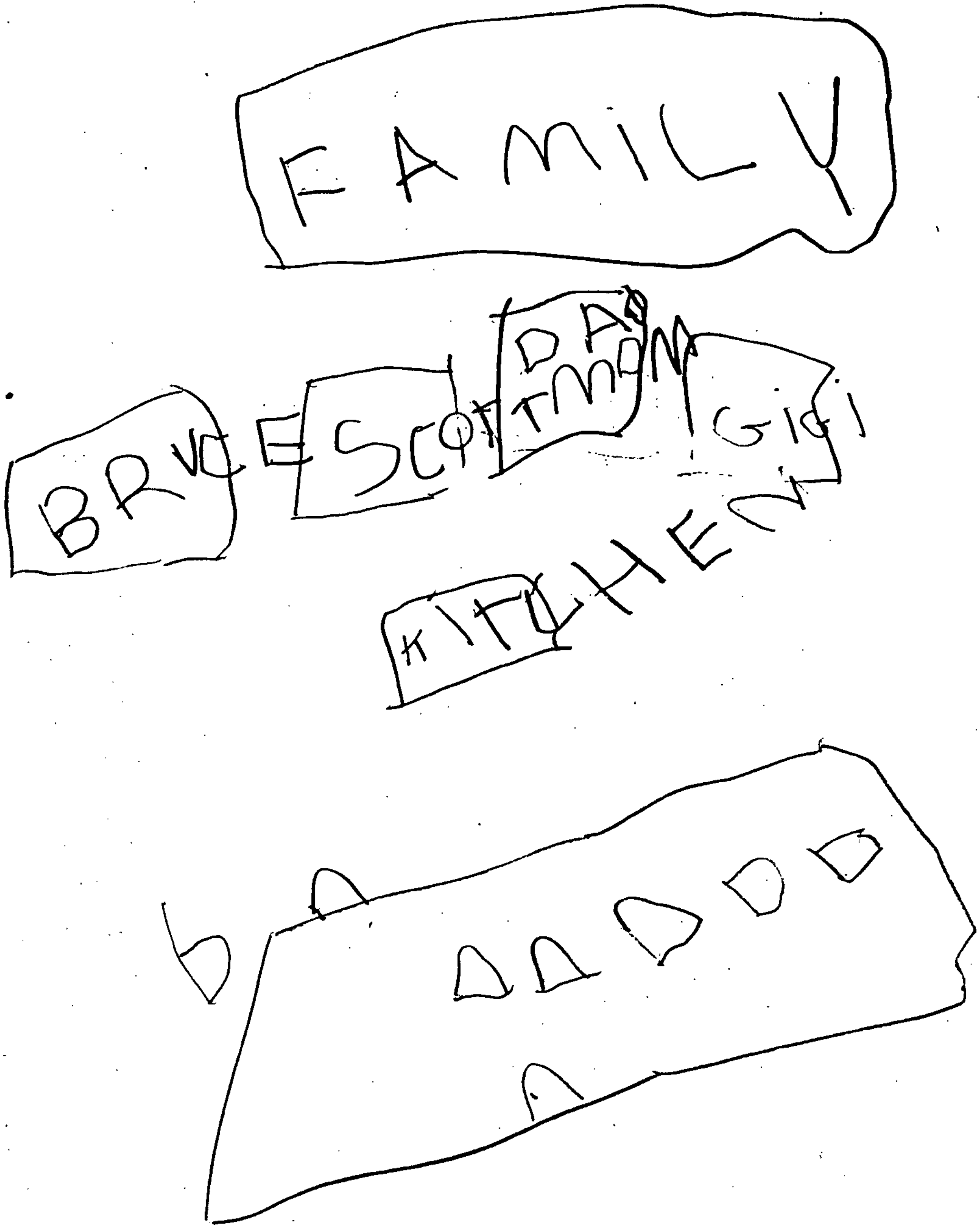
Side View



ATHESTON

4 YRS.

Four Years Old - Disjointed Style

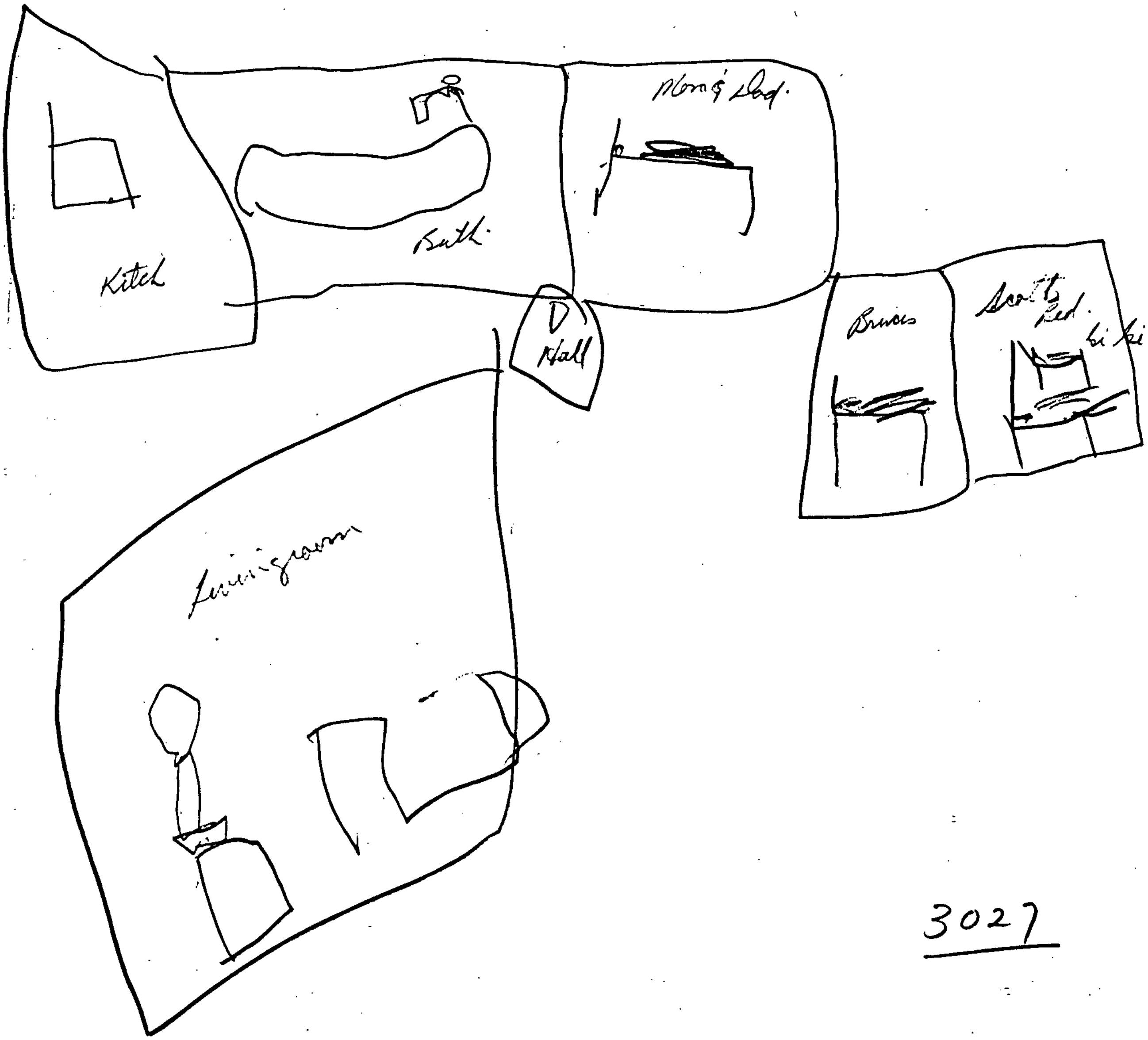


4028

ATHESTON

4YRS.

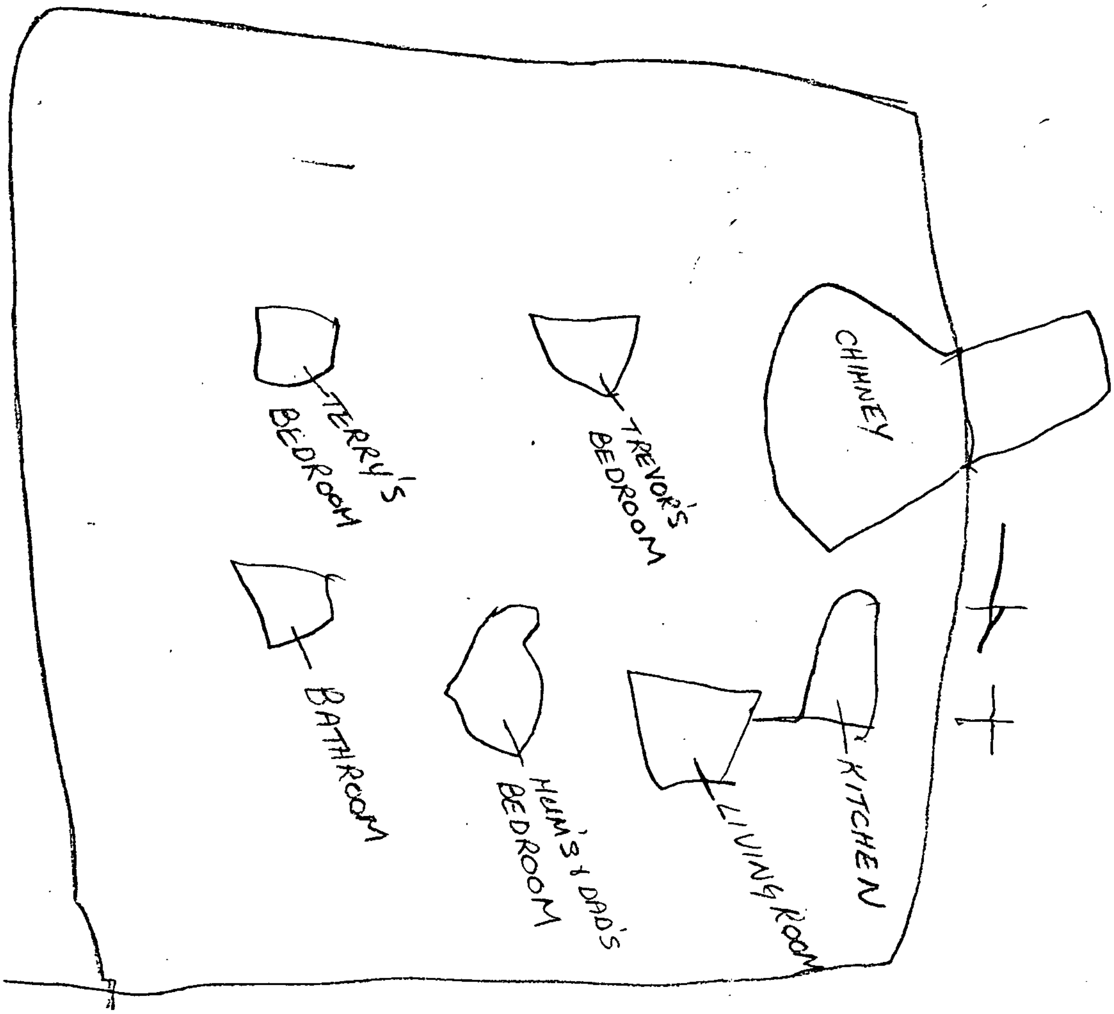
Four Years Old - Appended Style



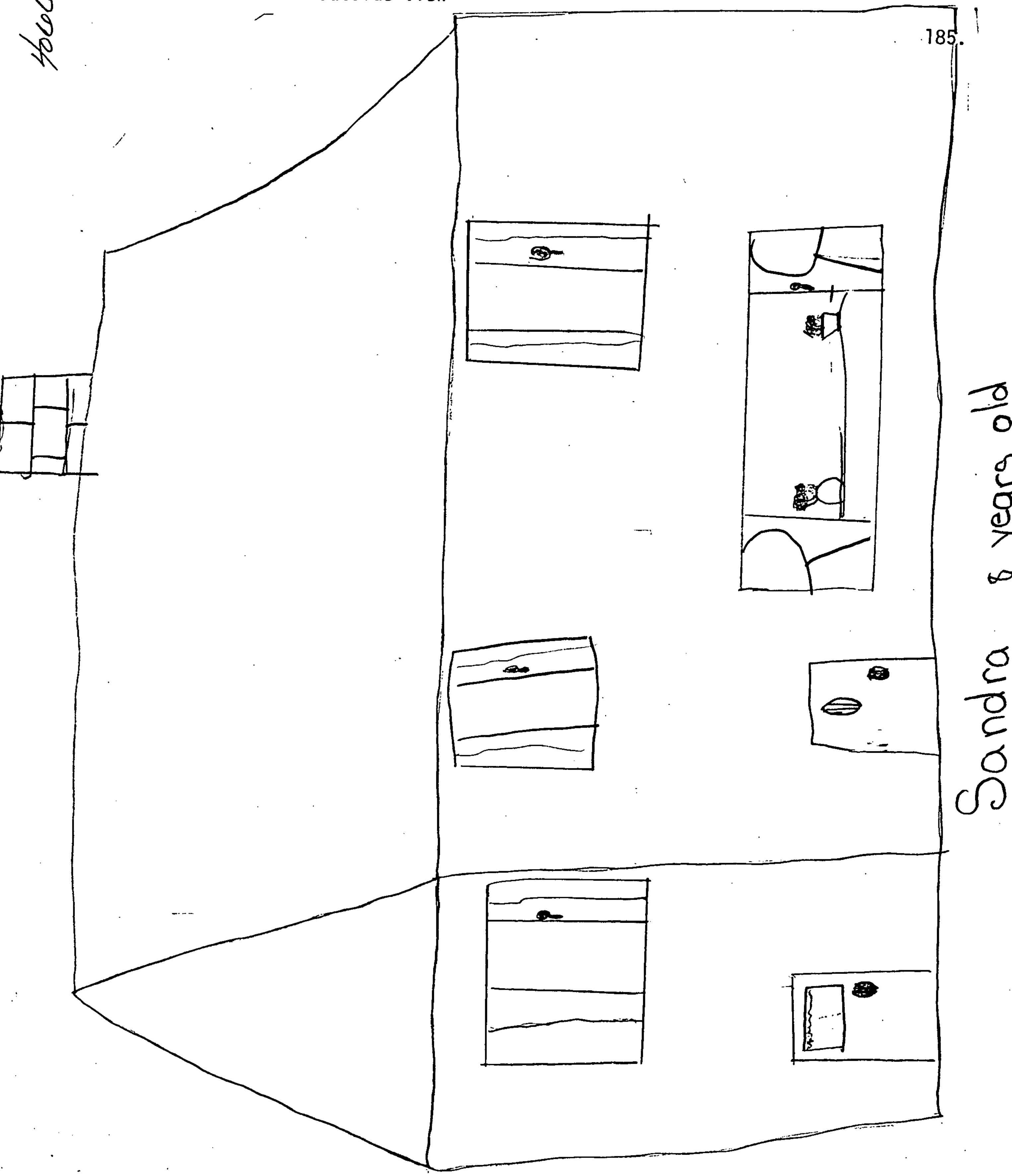
3027

31606
STONE
3YRS

Three Years Old - Box Style

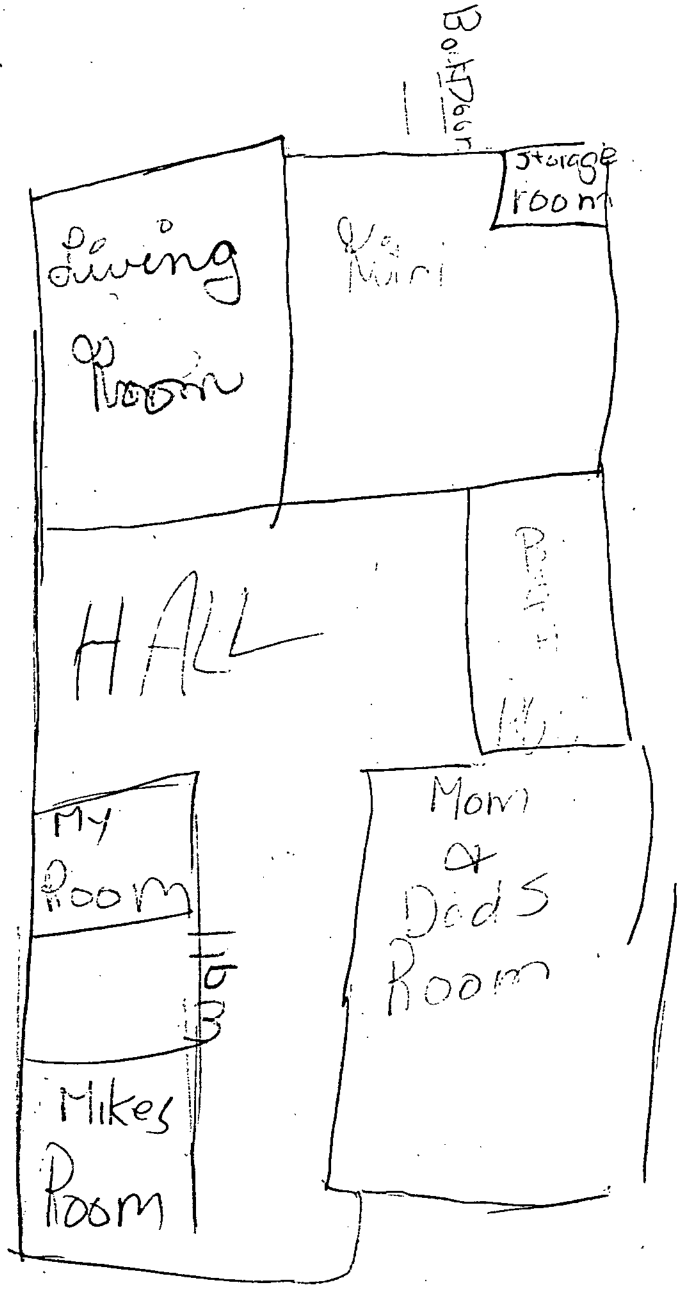


Non-Codable - Outside View



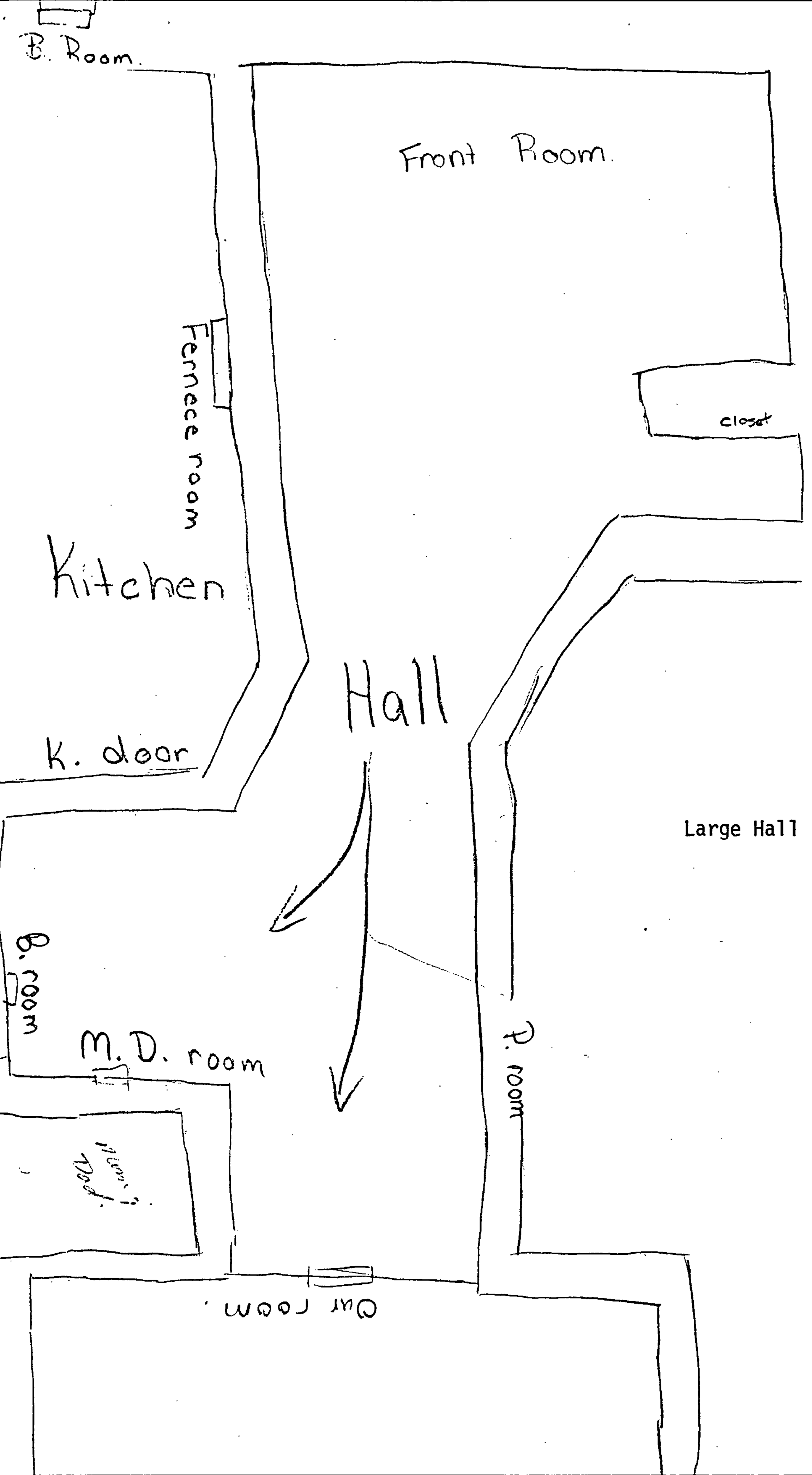
Clarke
13yrs.

Large Hall - Large Bathroom



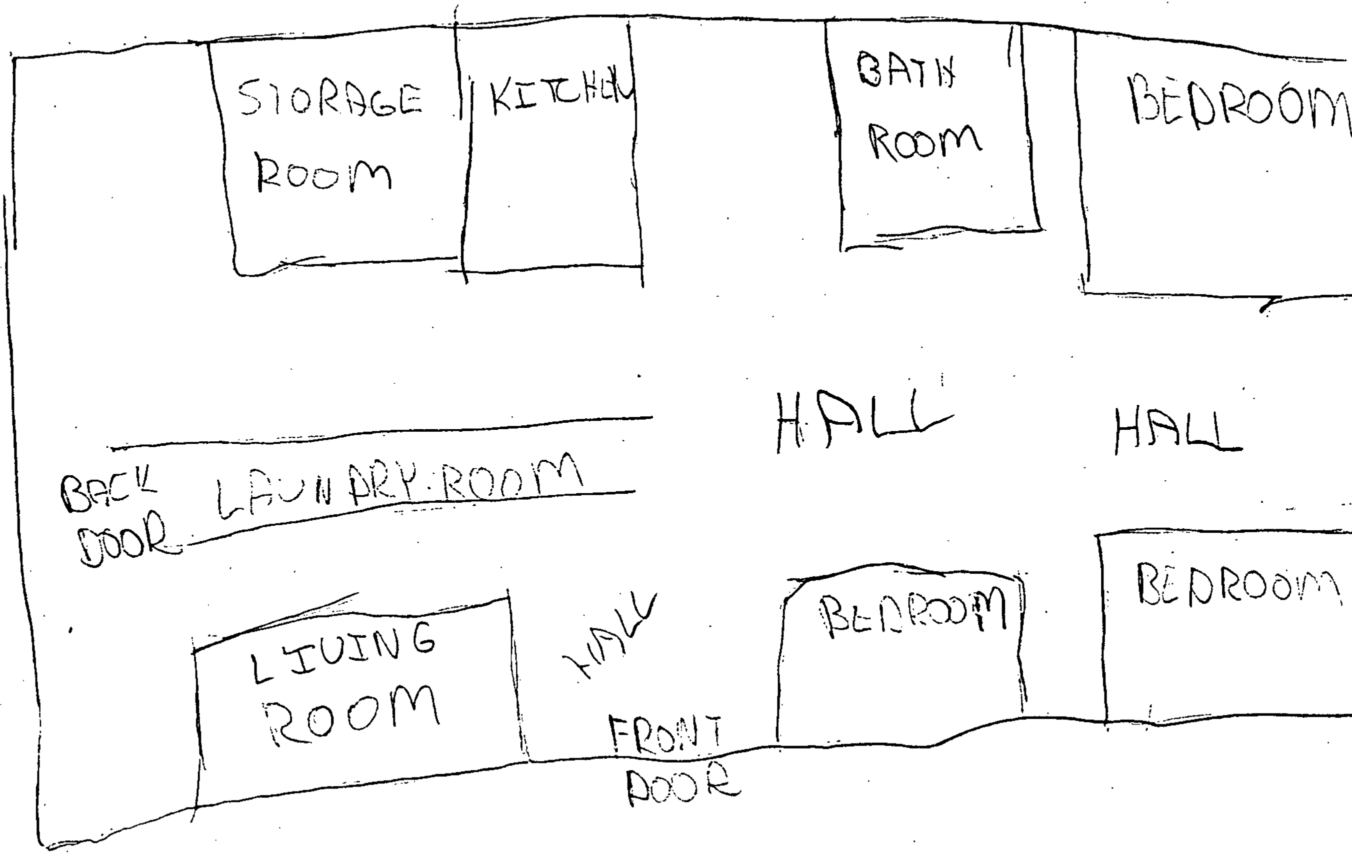
Leanna
Krug
9 yrs
187.

4015



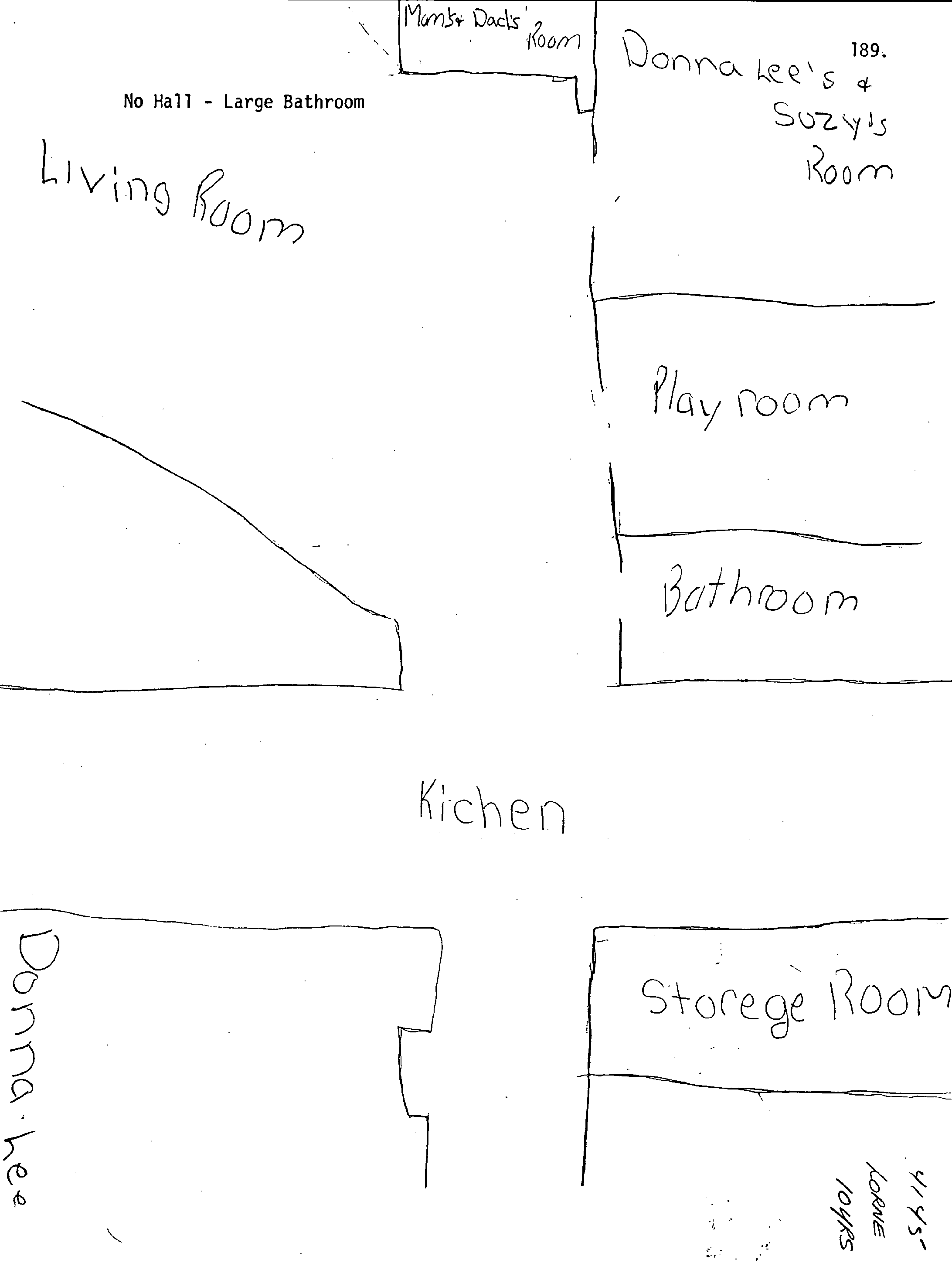
KEMP 12 YRS.

Large Hall - Large Bathroom



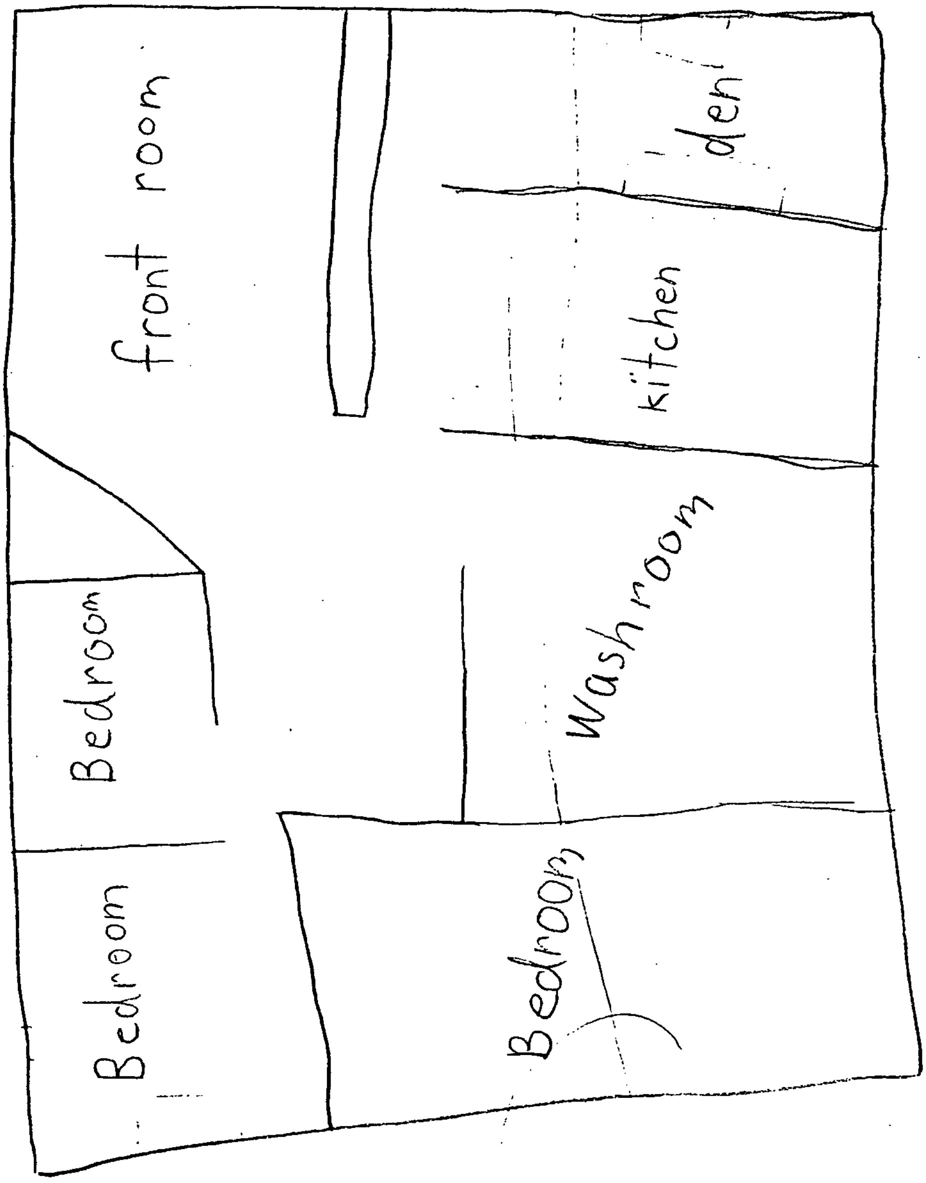
4047

No Hall - Large Bathroom



DAVE Reilly
8 yrs
#3021

Large Bathroom



PREVIOUSLY COPYRIGHTED MATERIAL
IN APPENDIX 7 NOT MICROFILMED.

Leaves 192-197.

APPENDIX 7

Goodenough-Harris Drawing Test

By Florence L. Goodenough and Dale B. Harris

Name ______________________ Boy ________ Girl ________

School ______________________ Date of Drawing ________

Grade ____________ Age ________ Birth Date ________

Father's Occupation ______________________

Examiner's Notes

Summary

	Raw Score	Standard Score	Percentile Rank
Point Scale			
Man	________	________	________
Woman	________	________	________
Average		________	
Self	________	________	________
Quality Scale			
Man	________	________	________
Woman	________	________	________
Average		________	

Make Your First Drawing Here

Draw a picture of a man. Make the very best picture you can. Be sure to make the whole man, not just his head and shoulders.

1.____	41.____
2.____	42.____
3.____	43.____
4.____	44.____
5.____	45.____
6.____	46.____
7.____	47.____
8.____	48.____
9.____	49.____
10.____	50.____
11.____	51.____
12.____	52.____
13.____	53.____
14.____	54.____
15.____	55.____
16.____	56.____
17.____	57.____
18.____	58.____
19.____	59.____
20.____	60.____
21.____	61.____
22.____	62.____
23.____	63.____
24.____	64.____
25.____	65.____
26.____	66.____
27.____	67.____
28.____	68.____
29.____	69.____
30.____	70.____
31.____	71.____
32.____	72.____
33.____	73.____
34.____	
35.____	
36.____	
37.____	
38.____	
39.____	
40.____	

Raw Score ______

TABLE 7 | *Summary of Correlations Between Goodenough Scores and Scores on Other Psychological Tests*

PRIMARY MENTAL ABILITIES

		CORRELATIONS
Ansbacher (1952)	100 ten-year-olds	(PMA quotients) .40 Reasoning .38 Space .37 Perception .26 Verbal Meaning .24 Number .41 Total test
Harris (unpublished)	164 kindergarten children	(Raw scores) .29 Verbal Meaning .17 Perceptual Speed .43 Quantitative .43 Motor .46 Space .46 Total score

STANFORD-BINET

		CORRELATIONS
Yepson (1929)	37 institutionalized mentally retarded boys, aged nine to eighteen years	.60 (IQ values)
McElwee (1932)	45 fourteen- and fifteen-year-olds, ungraded class	.72 (MA values)
Williams (1935)	100 children, aged three to fifteen, subnormal to gifted	.80 (MA values) .65 (IQ values)
Havighurst and Janke (1944)	70 ten-year-olds	.50 (IQ values)
McHugh (1945)	90 kindergarten children	.45 (MA values) .41 (IQ values)
Pechoux, *et al.* (1947)	100 abnormal and delinquent children aged five to eighteen	.38 boys (MA values) .26 girls (MA values)
Rottersman (1950)	50 six-year-olds	.36 (IQ values)
Johnson, *et al.* (1950)	all mentally subnormal, epileptic, and brain-damaged children in a state hospital	.48 (IQ values)

			AGE	N	
Ellis (1953)	116 children in outpatient psychiatric clinic, aged four to nine years	.75	4	17	(MA values)
		.78	5	19	
		.69	6	20	
		.79	7	26	
		.92	8	20	
		.60	9	14	

TABLE 7 (*continued*)

WECHSLER INTELLIGENCE SCALE FOR CHILDREN

		CORRELATIONS
Rottersman (1950)	50 six-year-olds	V .38 (IQ values) P .43 FS .47
Hanvik (1953)	25 psychiatric patients, aged five to twelve years	FS .18 (rho, IQ values)
Ellis (1953)	psychiatric outpatients, aged eight to thirteen	(IQ values)

V	P	FS	AGE	N
.77	.67	.70	8	16
.63	.59	.67	9	34
.17	.26	.24	10	20
.45	.46	.50	11	17
.50	.68	.62	12	19
.05	.15	.13	13	17

WECHSLER ADULT INTELLIGENCE SCALE

		CORRELATIONS
Berdie (1945)	56 older, retarded adolescents	.62 (Raw scores)
Gunzburg (1955)	adult mental defectives	V .43 (IQ values) P .73 FS .63

MISCELLANEOUS TESTS

		CORRELATIONS
Havighurst and Janke (1944)	70 ten-year-olds	(IQ values) .63 Cornell-Coxe .48 Minnesota Paper Form-board
Pechoux, *et al.* (1947)	100 abnormal and delinquent children, aged five to eighteen years	(MA values) .25 boys Porteus Mazes .27 girls Porteus Mazes
Ansbacher (1952)	100 ten-year-olds	(Raw scores) .34 Tracing McQuarrie Test .23 Tapping of Mechanical .16 Dotting Ability
Harris (1959)	98 kindergarten children	.22 (Raw scores) Raven Progressive Matrices (1947)
Spoerl (1940)	30 mentally retarded children, tested during three successive years	Examination, presumably individual, not named (IQ values) .56 first year .67 second year .78 third year

Short Scoring Guide *

MAN POINT SCALE

1. Head present
2. Neck present
3. Neck, two dimensions
4. Eyes present
5. Eye detail: brow or lashes
6. Eye detail: pupil
7. Eye detail: proportion
8. Eye detail: glance
9. Nose present
10. Nose, two dimensions
11. Mouth present
12. Lips, two dimensions
13. Both nose and lips in two dimensions
14. Both chin and forehead shown
15. Projection of chin shown; chin clearly differentiated from lower lip
16. Line of jaw indicated
17. Bridge of nose
18. Hair I
19. Hair II
20. Hair III
21. Hair IV
22. Ears present
23. Ears present: proportion and position
24. Fingers present
25. Correct number of fingers shown
26. Detail of fingers correct
27. Opposition of thumb shown
28. Hands present
29. Wrist or ankle shown
30. Arms present
31. Shoulders I
32. Shoulders II
33. Arms at side or engaged in activity
34. Elbow joint shown
35. Legs present
36. Hip I (crotch)
37. Hip II
38. Knee joint shown
39. Feet I: any indication
40. Feet II: proportion
41. Feet III: heel
42. Feet IV: perspective
43. Feet V: detail
44. Attachment of arms and legs I
45. Attachment of arms and legs II
46. Trunk present
47. Trunk in proportion, two dimensions
48. Proportion: head I
49. Proportion: head II
50. Proportion: face
51. Proportion: arms I
52. Proportion: arms II
53. Proportion: legs
54. Proportion: limbs in two dimensions
55. Clothing I
56. Clothing II
57. Clothing III
58. Clothing IV
59. Clothing V
60. Profile I
61. Profile II
62. Full face
63. Motor coordination: lines
64. Motor coordination: junctures
65. Superior motor coordination
66. Directed lines and form: head outline
67. Directed lines and form: trunk outline
68. Directed lines and form: arms and legs
69. Directed lines and form: facial features
70. "Sketching" technique
71. "Modeling" technique
72. Arm movement
73. Leg movement

* For use only after the scoring requirements have been mastered.

TABLE 32 | *Table for Converting Raw Scores to Standard Scores*

Drawing of a Man, by Boys

RAW SCORE	CHRONOLOGICAL AGE IN YEARS													RAW SCORE
	3*	4*	5	6	7	8	9	10	11	12	13	14	15	
0	68	55	53	52	51	50	49							0
1	73	61	56	54	53	52	50							1
2	77	66	59	57	55	54	52	50	51					2
3	82	70	62	60	57	56	54	52	52					3
4	86	74	65	62	59	58	55	54	54	51				4
5	91	78	68	65	62	60	57	55	55	52				5
6	95	83	71	68	64	62	59	57	56	53				6
7	100	87	74	70	66	63	60	58	58	55	50			7
8	104	91	77	73	68	65	62	60	59	56	51			8
9	109	96	80	75	70	67	63	61	60	57	53			9
10	113	100	83	78	72	60	65	63	62	59	54	50	50	10
11	118	104	86	81	75	71	67	64	63	60	56	52	52	11
12	122	109	89	83	77	73	69	66	65	61	57	53	53	12
13	127	113	92	86	79	75	70	67	66	63	58	55	55	13
14	131	117	95	89	81	77	72	69	68	64	60	56	56	14
15	136	122	98	91	84	79	74	70	69	66	61	58	57	15
16	140	126	101	94	86	81	75	72	70	67	63	59	59	16
17	145	130	104	96	88	83	77	73	72	68	64	60	60	17
18	149	134	107	99	90	85	79	75	73	70	65	62	62	18
19	154	139	110	102	92	87	80	76	74	71	67	63	63	19
20	158	143	113	104	94	89	82	78	76	72	68	65	64	20
21	163	147	116	107	97	90	84	79	77	73	70	66	66	21
22	168	152	119	110	99	92	85	81	78	75	71	68	67	22
23	172	156	122	112	101	94	87	82	80	76	73	69	69	23
24		160	125	115	103	96	89	84	81	78	74	70	70	24
25		164	128	117	105	98	90	86	83	80	75	72	72	25
26		169	131	120	108	100	92	87	84	81	77	73	73	26
27		173	134	123	110	102	94	89	85	82	78	75	74	27
28		177	137	125	112	104	95	90	87	83	80	76	76	28
29			140	128	114	106	97	92	88	85	81	78	77	29
30			143	131	116	108	99	93	90	86	82	79	79	30
31			146	133	119	110	100	95	91	87	84	80	80	31
32			149	136	121	112	102	96	92	89	85	82	81	32
33			152	138	123	114	104	98	94	90	87	83	83	33
34				141	125	116	105	99	95	92	88	85	84	34
35				144	127	118	107	101	97	93	89	86	86	35

* These values have been calculated from samples which are not as representative as the age samples from 5 through 15 years. They are likely to be a little high for unselected or more adequately representative samples. They are offered as tentative guides for use with pre-

TABLE 32 *(continued)*

RAW SCORE	CHRONOLOGICAL AGE IN YEARS													RAW SCORE
	3	4	5	6	7	8	9	10	11	12	13	14	15	
36				146	130	119	109	102	98	94	91	88	87	36
37				149	132	121	110	104	99	96	92	89	88	37
38					134	123	112	105	101	97	94	90	90	38
39					136	125	114	107	102	98	95	92	91	39
40					138	127	116	108	103	100	96	93	93	40
41					141	129	117	110	105	101	98	95	94	41
42					143	131	119	111	106	102	99	96	96	42
43					145	133	121	113	108	104	101	98	97	43
44					147	135	122	115	109	105	102	99	98	44
45					149	137	124	116	110	106	103	100	100	45
46						139	126	118	112	108	105	102	101	46
47						141	127	119	113	109	106	103	103	47
48						143	129	121	114	111	108	105	104	48
49						145	131	122	116	112	109	106	105	49
50						146	133	124	117	113	110	108	107	50
51						148	134	125	119	115	112	109	108	51
52						150	136	127	120	116	113	110	110	52
53							137	128	121	117	115	112	111	53
54							139	130	123	119	116	113	113	54
55							141	131	124	120	118	115	114	55
56							142	133	125	121	119	116	115	56
57							144	134	127	123	120	118	117	57
58							146	136	128	124	122	119	118	58
59							147	137	130	126	123	120	120	59
60							140	139	131	127	125	122	121	60
61								140	132	128	126	123	122	61
62								142	134	130	127	125	124	62
63								143	135	131	129	126	125	63
64								145	137	132	130	128	127	64
65								146	138	134	132	129	128	65
66								148	139	135	133	130	130	66
67								150	141	136	134	132	131	67
68									142	138	136	133	132	68
69									143	139	137	135	134	69
70									145	140	139	136	135	70
71									146	142	140	138	137	71
72									148	143	141	139	138	72
73									149	145	143	140	139	73

TABLE 33 | *Table for Converting Raw Scores to Standard Scores*

Drawing of a Man, by Girls

RAW SCORE	CHRONOLOGICAL AGE IN YEARS: 3*	4*	5	6	7	8	9	10	11	12	13	14	15	RAW SCORE
0	66	58	50	50	49									0
1	70	62	53	52	51	50								1
2	74	66	56	55	53	51								2
3	78	70	59	57	55	53	50							3
4	83	74	62	60	58	55	52							4
5	87	78	65	62	60	57	54	50						5
6	91	81	68	65	62	59	55	51						6
7	96	85	70	67	64	61	57	53	49					7
8	100	89	73	70	66	63	59	55	51	49				8
9	104	92	76	72	69	65	61	56	52	51				9
10	108	96	79	75	71	67	62	58	54	52				10
11	113	100	82	77	73	69	64	60	55	54	50			11
12	117	104	85	80	75	70	66	61	57	55	51			12
13	121	107	87	82	77	72	67	63	58	56	53	50		13
14	126	111	90	85	79	74	69	64	60	58	54	51		14
15	130	115	93	87	82	76	71	66	61	59	56	53	50	15
16	134	119	96	90	84	78	73	67	63	61	57	54	51	16
17	139	122	99	93	86	80	74	69	64	62	59	56	53	17
18	143	126	102	95	88	82	76	71	66	64	60	57	55	18
19	147	130	105	98	90	83	78	72	68	65	62	59	56	19
20	152	134	107	100	92	86	80	74	69	66	63	61	58	20
21	156	137	110	103	95	88	81	75	71	68	65	62	60	21
22	160	141	113	105	97	89	83	77	72	70	66	64	61	22
23	165	149	116	108	99	91	85	79	74	71	68	65	63	23
24	169	152	119	110	101	93	86	80	75	72	69	67	65	24
25	173	156	122	113	103	95	88	82	77	74	71	68	66	25
26	177	160	124	115	105	97	90	83	78	75	72	70	68	26
27		164	127	118	108	99	92	85	80	77	74	72	70	27
28		168	130	120	110	101	93	87	81	78	75	73	71	28
29		171	133	123	112	103	95	88	83	80	77	75	73	29
30		175	136	125	114	105	97	90	84	81	78	76	75	30
31			139	128	116	106	98	91	86	83	80	78	76	31
32			142	130	118	108	100	93	87	84	81	79	78	32
33			144	133	121	110	102	95	89	86	83	81	80	33
34			147	135	123	112	104	96	91	87	84	83	81	34
35			150	138	125	114	105	98	92	88	86	84	83	35

* These values have been calculated from samples which are not as representative as the age samples from 5 through 15 years. They are likely to be a little high for unselected or more adequately representative samples. They are offered as tentative guides for use with pre-

TABLE 33 *(continued)*

RAW SCORE	CHRONOLOGICAL AGE IN YEARS: 3	4	5	6	7	8	9	10	11	12	13	14	15	RAW SCORE
36				140	127	116	107	100	94	90	87	86	85	36
37				143	129	118	109	101	95	91	89	87	86	37
38				146	131	120	111	103	97	93	91	89	88	38
39				148	134	122	112	104	98	94	92	90	90	39
40				151	136	124	114	106	100	96	94	92	91	40
41					138	125	116	108	101	97	95	94	93	41
42					140	127	118	109	103	99	97	95	95	42
43					142	129	119	111	104	100	98	97	96	43
44					144	131	121	112	106	102	100	98	98	44
45					147	133	123	114	107	103	101	100	100	45
46					149	135	124	116	109	104	103	101	101	46
47					151	137	126	117	110	106	104	103	103	47
48						139	128	119	112	107	106	104	105	48
49						141	130	120	114	109	107	106	106	49
50						142	131	122	115	110	109	108	108	50
51						144	133	124	117	112	110	109	110	51
52						146	135	125	118	113	112	111	111	52
53						148	137	127	120	115	113	112	113	53
54						150	138	128	121	116	115	114	115	54
55							140	130	123	118	116	115	116	55
56							142	132	124	119	118	117	118	56
57							143	133	126	120	119	119	120	57
58							145	135	127	122	121	120	121	58
59							147	136	129	123	122	122	123	59
60							149	138	130	125	124	123	125	60
61							150	140	132	126	125	125	126	61
62								141	133	128	127	126	128	62
63								143	135	129	128	128	130	63
64								144	137	131	130	130	131	64
65								146	138	132	131	131	133	65
66								148	140	134	133	133	135	66
67								149	141	135	134	134	136	67
68								151	143	136	136	136	138	68
69									144	138	138	137	140	69
70									146	139	139	139	141	70
71									147	141	141	141	143	71
72									149	142	142	142	145	72
73									150	144	144	144	146	73

APPENDIX 8

APPENDIX 8

The following example illustrates the calculation for TRE and MRE.

The subject's ratio for each wall of the manual map is subtracted from the real ratio and from the mean ratio. The absolute differences are then summed to produce a total error score. Individual room scores can also be calculated.

Wall	Subject's Ratio	Real Ratio	True Ratio Error (TRE)	Subject's Ratio	Mean Ratio	Mean Ratio Error (MRE)
AE	4.58	4.14	.44	4.58	4.30	.28
AS	2.60	2.55	.05	2.60	2.52	.08
..	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..
OM	1.00	.93	.07	1.00	1.25	.25
MF	.60	.57	.03	.60	.76	.16
Total Error			8.54			8.94

APPENDIX 8

LIST OF DISTANCE RATIOS

	Real	Average	Male Head	Female Head	Others
1. AE	4.14	4.30	4.26	4.47	4.04
2. AS	2.55	2.52	2.49	2.60	2.48
3. SV	2.43	1.88	2.30	2.45	2.38
4. VW	.18	.27	.26	.40	.23
5. XW	1.71	1.93	1.94	2.02	1.68
6. XE	2.73	2.64	2.62	2.70	2.55
7. AB	1.25	1.33	1.29	1.38	1.32
8. AJ	1.09	1.15	1.10	1.21	1.10
9. JL	1.25	1.33	1.27	1.33	1.39
10. LB	1.09	1.15	1.10	1.20	1.10
11. BC	.64	.71	.75	.71	.62
12. BF	.77	.84	.83	.85	.82
13. FG	.64	.68	.67	.71	.62
14. GC	.77	.86	.88	.87	.83
15. CD	1.23	1.36	1.33	1.47	1.25
16. CO	1.18	1.37	1.39	1.38	1.37
17. OP	1.14	1.17	1.13	1.28	1.05
18. PD	1.32	1.35	1.34	1.39	1.33
19. DE	1.02	.97	1.01	1.00	.84
20. DH	.68	.78	.80	.80	.75
21. HI	1.02	.78	.80	.80	.75
22. IE	.68	.76	.77	.78	.75
23. HP	.64	.60	.62	.60	.58
24. PQ	1.02	1.00	1.02	1.01	.87
25. QI	.64	.58	.58	.59	.59
26. JK	1.00	.92	.90	.96	.93
27. JS	1.46	1.38	1.39	1.42	1.37
28. ST	1.00	.95	.91	.99	.98
29. TK	1.46	1.39	1.39	1.43	1.38
30. TM	1.16	1.13	1.17	1.14	1.10

	Real	Average	Male Head	Female Head	Others
31. MN	.55	.75	.71	.81	.74
32. NR	.48	.44	.44	.43	.46
33. RV	.82	.90	.86	.85	.73
34. UT	1.00	1.02	1.01	1.01	1.03
35. UV	.43	.51	.51	.48	.38
36. XQ	1.41	1.30	1.29	1.36	1.22
37. QO	2.16	2.15	2.16	2.24	1.92
38. OV	1.23	1.27	1.26	1.32	1.18
39. OG	.61	.56	.56	.55	.56
40. OM	.93	1.25	1.21	1.32	1.18
41. MF	.57	.76	.73	.84	.69

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