CHAPTER IV
DESIGN AND METHODOLOGY

In order to study the structural, semantic and neuropsychological correlates of reading and mathematical ability, the following design and methodology was utilized.

DESIGN

An Expost facto study utilizing a correlational design was conducted. The study was conducted in three phases.

Phase I: In this phase Raven's Standard Progressive Matrices (SPM) was to be administered to a large population of middle school students (Class 6th, 7th and 8th) and on the basis of the scores on SPM students of average intelligence (PR=25-75) were to be selected. On the basis of their marks in Hindi and Mathematics, in the last annual examination (obtained from the school records), they were to be divided into two groups i.e. high achievers (60 +) and low achievers (below 40).

Phase II: In this Phase the reading and mathematical abilities of the students selected in Phase I was to be measured.

Phase III: In this Phase AIIMS Comprehensive Neuropsychological battery was to be administered to the students, with below average reading and/or mathematical ability.

SAMPLE

A sample of 600 students was selected by multistage purposive sampling. The student pool consisted of 6th, 7th and 8th
class students, (age range 10-15.6 yrs.), who were selected from schools of two cities of Haryana (Rohtak and Rewari). Both boys and girls were included in the sample. For the initial testing, 600 students were taken. The Phase-wise distribution of sample was as follows:

**Phase I:**

High and low achievers in Hindi /Mathematics were selected in this phase.

- Initial Student Pool (N = 600)
  - Administration of SPM
  - Students with Average IQ (N=396)
    - Marks in Hindi and Mathematics
  - High/ Low Achievers (N=318)

**Phase II:**

Students who were found to be low or / and high achievers in both Hindi and Mathematics were tested for both abilities. However, those students who were low / high on one ability, but average on the other were tested only on that ability. Distribution of the students was as follows:
Phase III:

In the phase, students between 14-15.6 years who were found to be below average (P_{25}) on reading / mathematical ability were selected. Left-handed subjects were not included in this sample. As the number of student between 14-15.6 years of age was very limited, therefore a few students who were between P_{25} and P_{28} were also included in the sample. The distribution of these students was as follows:

39 Students*

Below Average Reading Ability (N=19) Below Average Mathematical Ability (N=28)

*The groups were not exclusive as subjects who were below average on both abilities (n=8) were included in both the groups.
MATERIAL

The following tests were used for the present investigation.

1. Intelligence Test (Raven's Standard Progressive Matrices)

2. Neuropsychological Battery (AIIMS Comprehensive Neuropsychological Battery).

3. Ability Tests: Reading and Mathematical (Constructed by the Investigator).

1. **RAVEN'S STANDARD PROGRESSIVE MATRICES:** Raven's Standard Progressive Matrices (SPM) has been constructed by Raven, Court and Raven (1938). This is a non-verbal intelligence test which measures a person's capacity, at the time of the test, to comprehend the meaningless figures presented for observation, see the relations between them, conceive the nature of the figure, complete each system of relations presented and by doing so, develop a systematic method of reasoning. SPM was designed to cover the widest possible range of mental abilities and to be equally useful with persons of all ages, whatever their education, nationality or physical condition. The scale consists of 60 problems divided into five sets (A, B, C, D and E). In each set the first problem is, as nearly as possible, self evident. The problems which follow become progressively more difficult. The five sets provide five opportunities for grasping the method and five progressive assessment of a person's capacity for intellectual activity. The test can be used in individual as well as group situations.
Over forty studies dealing with reliability of SPM have been reported in the literature. They include a wide age-range, many cultural group and clinical as well as normal population. Examination of these studies reveals a general picture of good reliability, whether in terms of internal consistency or test-retest reliability. The majority of studies, where split half measures of reliability has been obtained, report the range between 0.60 to 0.98. Test-retest reliability of SPM has been reported between the range of 0.83 to 0.93 for different age group.

The criterion-oriented validity of SPM (concurrent and predictive) has been reported to vary with age, possibly sex and homogeneity of the sample, the method of assessment of the criterion to which the test is related and the reliabilities of test and criterion measures in the context considered. Correlation with concurrent intelligence measures vary from +0.3 to +0.95, while correlation with concurrent achievement measures vary between +0.2 to +0.9. For assessing predictive validity the external criterion commonly adopted by investigators is assessment of scholastic achievement assessed some time after the administration of SPM. Predictive validity has been found to vary from +0.33 to 0.70. The content validity of SPM, measured by the internal consistency of the test, varies markedly when different test items are considered. The range of content validity is +0.2 to +0.8. The range of factorial construct validity varies from +0.81 to +0.94.

**AIIMS COMPREHENSIVE NEUROPSYCHOLOGICAL BATTERY:**
AIIMS Comprehensive Neuropsychological Battery has been constructed by Gupta, Khandelwal, Tondon, Maheshwari, Mehta,
<table>
<thead>
<tr>
<th>Scale</th>
<th>Number</th>
<th>Item Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>(35 Items)</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,</td>
</tr>
<tr>
<td>Tactile</td>
<td>(19 Items)</td>
<td>36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54,</td>
</tr>
<tr>
<td>Visual</td>
<td>(18 Items)</td>
<td>55, 56, 57, 58, 59, 60, 61, 62,</td>
</tr>
<tr>
<td>Respective Speech</td>
<td>(19 Items)</td>
<td>63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81,</td>
</tr>
<tr>
<td>Expressive Speech</td>
<td>(17 Items)</td>
<td>82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,</td>
</tr>
<tr>
<td>Reading</td>
<td>(10 Items)</td>
<td>99, 100, 101, 102, 103, 104, 105, 106, 107,</td>
</tr>
<tr>
<td>Writing</td>
<td>(13 Items)</td>
<td>108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121,</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>(13 Items)</td>
<td>122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134,</td>
</tr>
<tr>
<td>Memory</td>
<td>(12 Items)</td>
<td>135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146,</td>
</tr>
<tr>
<td>Intellectual Processes</td>
<td>(14 Items)</td>
<td>147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160,</td>
</tr>
<tr>
<td>Left Hemisphere</td>
<td>(26 Items)</td>
<td>1, 3, 5, 7, 9, 11, 15, 17, 21, 37, 45, 47, 49, 51, 53, 96, 97, 127, 135, 139, 140, 148, 150, 154, 155, 158,</td>
</tr>
<tr>
<td>Pathognomonic</td>
<td>(7 Items)</td>
<td>17, 35, 38, 37, 41, 45, 160.</td>
</tr>
</tbody>
</table>
Sundaram, Mahapatra and Jain. It is an instrument, which allows statistical analysis of brain-behaviour relationships for both clinical use and theoretical purposes. It includes single test procedures, each involving number of areas within each unit of the brain, thereby providing a measure of cerebral competence both in terms of brain functions and localization. The battery comprises of AIIMS Comprehensive Neuropsychological Battery in Hindi, Theory and Practice, Manual for instructions and administration of items, Response Booklet, Booklet containing scoring sheets and items required for administration of battery [Match Box, Maze Test, marbles with container, five wooden cubes, blind goggles, single window counter (Manual Taper), stop watch, stimulus cards].

It includes 160 items, most of which are evaluated on a 5 point scale where zero credit is awarded for successful completion of the item and four credits for a complete failure on the item, while credits, 1, 2 or 3 are given to the intermediate performance depending upon its level. The items provide measures of specific behavioural functions. The primary behavioural areas covered are the motor, tactile, visual, receptive speech, expressive speech, reading, writing, arithmetic, memory and intellectual processes scale. These form the nine basic content scales. However, there are three other scales i.e. pathognomonic scale, left hemisphere scale and right hemisphere scale. The total score on the battery comprises of the total raw scores of these scales. Thus, the total number of items scored for computing total score is 200. The number of items and item numbers for each scale have been shown in Table 1.
<table>
<thead>
<tr>
<th>Lobe Scales</th>
<th>Items</th>
<th>Item Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left Frontal</strong></td>
<td>42</td>
<td>1, 3, 5, 7, 9, 11, 13, 15, 23, 24, 25, 26, 27, 28, 80, 81, 90, 91, 96, 118, 119, 121, 123, 127, 128, 129, 130, 132, 133, 134, 147, 148, 149, 150, 151, 152, 153, 154, 156, 157, 158, 159.</td>
</tr>
<tr>
<td><strong>Left Sensory Motor</strong></td>
<td>14</td>
<td>19, 21, 29, 43, 45, 46, 49, 63, 86, 87, 88, 89, 104, 105</td>
</tr>
<tr>
<td><strong>Left Temporal</strong></td>
<td>24</td>
<td>73, 74, 75, 76, 77, 78, 79, 98, 110, 111, 112, 113, 115, 117, 118, 119, 131, 135, 136, 139, 142, 143, 157, 158</td>
</tr>
<tr>
<td><strong>Right Frontal</strong></td>
<td>21</td>
<td>2, 4, 6, 8, 10, 12, 14, 16, 29, 30, 31, 32, 33, 34, 35, 60, 61, 62, 124, 125, 160</td>
</tr>
<tr>
<td><strong>Right Sensory Motor</strong></td>
<td>16</td>
<td>10, 20, 22, 31, 32, 33, 34, 35, 44, 46, 48, 50, 52, 54, 55, 160</td>
</tr>
<tr>
<td><strong>Right Parietal–Occipital</strong></td>
<td>12</td>
<td>18, 40, 52, 54, 56, 57, 58, 60, 61, 62, 121, 143</td>
</tr>
<tr>
<td><strong>Right Temporal</strong></td>
<td>15</td>
<td>42, 55, 56, 57, 62, 83, 84, 124, 125, 137, 138, 141, 144, 145, 146</td>
</tr>
</tbody>
</table>
The battery also provides an estimate of identification and lateralization of brain dysfunction. The items have been recategorized for measuring functions of eight brain areas i.e. left frontal (LF), left sensory motor (LSM), left parietal-occipital (LPO), left temporal (LT), right frontal (RF), right sensory motor (RSM), right-parietal occipital (RPO) and the right temporal (RT). The specific items which measure each lobe functions have been shown in Table 2.

For analysis of the neuropsychological performance of an individual the obtained raw scores are computed for the 12 basic and 8 lobe scales which can be converted into T-scores. The Expected T score for each of the basic score can be computed in terms of age and number of educational years for the purpose of comparison. With the help of the lobe scores, a lobe profile can be obtained, for the purpose of clinical diagnosis and estimations of lobe functions.

For obtaining estimates of reliability of the test, three types of reliability (i.e. test-retest; inter-rater and internal consistency) had been computed during the process of standardization of the battery.

For the Test-Retest reliability, 32 brain damaged subjects with intermediate scores on the items of the 10 basic scales (160) were employed. Co-efficient for the above 10 basic scale ranged from 0.792 to 0.984 with an average value of 0.896. To find out the "examiner variance", Inter-Rater Reliability was established which provided confidence in the findings of the battery even when administered by two different individuals. Reliability coefficients ranging from 0.981 to 1.00 have been reported which suggest almost
negligible examiner variance in relation to the scoring of the items of the battery. For internal consistency reliability, the values of the coefficient Alpha measure for the clinical scales range from 0.791 to 0.986.

For the purpose of validation of the battery three groups (normal control: 175, Schizophrenics: 70, brain damaged: 160) were employed. Findings indicate that the battery had sufficient measures to make the psychological discriminations necessary for making the anatomical and physiological discriminations. The findings of the study revealed overall hit rates ranging from 66.67% to 89.62% on all the 14 variables in the three groups. On an individual basis, the “total” score scale classified correctly 98.88% of the normal control subjects; 78.57% in the schizophrenic group and 80% in the brain damaged group. The percentage of correctly classified subjects in the normal control group ranged from 91.43% to 100% on all the 14 variables. The significance of these findings was that the skills measured by the items of the battery are so simple that the items can be passed by a vast majority of normal subjects. The battery fulfills the requirements of having included test items which measure simple skills.

Thus, this battery provides a comprehensive estimation of specific brain functions, lateralization and neuropsychological localization and has wide utility for research and clinical purposes.

ABILITY TESTS (PREPARED BY THE INVESTIGATOR): In the present investigation, reading and mathematical ability were to be assessed as multicomponential abilities, where distinct measures of
the basic structural and higher order semantic level were to be obtained. Initially, catalogues of various psychological publication houses were scanned. Perusal of the available tests of reading ability revealed that a number of reading ability tests gave measures on reading speed, word meaning, vocabulary and comprehension [Reading Ability Test (Measures the level of Comprehension and Vocabulary) by Prabhjot; A Scale of Reading-Writing Skills for Preprimary School Children (R-W-S Test) by Singh; Reading Comprehension Test (RCT) English by Ahuja & Ahuja and Hindi Vocabulary and Comprehension Tests by Gaur]. However, separate measures of the structural and semantic level were not available.

Similarly, the available mathematical ability tests gave measures on numerical and problem solving ability and separate measures of basic and higher order mathematical skills were not available. In view of the non-availability of the specific tools, the following two tools were constructed by the present investigator.

**Reading Ability Test:**

Review of literature indicated that the structural component could be tapped by obtaining measures of orthographic, phonological and syntactic abilities, whereas for the semantic component, measures of word recognition and comprehension were required. As the target population for the present investigation comprised of students whose primary language was Hindi, it was decided that the reading ability test would be constructed in Hindi.

Hindi is a simple and scientific language, which is to be written as it is spoken. It has a vast vocabulary. Words from various
Table 3  Number of items in initial and final format of reading ability test.

<table>
<thead>
<tr>
<th>Name of Subtest</th>
<th>Initial Question Pool</th>
<th>First Format</th>
<th>Final Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>शब्द मण्डल</td>
<td>–</td>
<td>–</td>
<td>15</td>
</tr>
<tr>
<td>उपसर्ग / प्रत्यय</td>
<td>90</td>
<td>60</td>
<td>25</td>
</tr>
<tr>
<td>संधि</td>
<td>120</td>
<td>90</td>
<td>23</td>
</tr>
<tr>
<td>शुद्ध शब्द</td>
<td>50</td>
<td>30</td>
<td>14</td>
</tr>
<tr>
<td>शुद्ध वाक्य</td>
<td>60</td>
<td>45</td>
<td>13</td>
</tr>
<tr>
<td>वाक्यांश के लिए सही शब्द बताना</td>
<td>55</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>अनुपसंक्ति शब्द</td>
<td>54</td>
<td>42</td>
<td>18</td>
</tr>
<tr>
<td>शब्दों का उच्चारण</td>
<td>60</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>पढने की गति</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>समझ – बूझ</td>
<td>–</td>
<td>–</td>
<td>15</td>
</tr>
</tbody>
</table>
languages such as Sanskrit, English, Urdu, Arabic, French etc. have been incorporated in it. Nearly all the languages of the world can be written in the Hindi script.

After perusal of various reading ability tests and consultation of experts in Hindi language, it was decided that for obtaining a measure of the structural component of reading, measures of orthographic (identification of correct spelling) phonological (pronunciation and reading rate) and syntactic processing (synthesis of morphemes into words and correct sentence) would be taken. The semantic component would include measures of word recognition (prefix / suffix, inappropriate word, vocabulary, conversion of proposition into word) and comprehension. Since a standardized reading test by Bayti and Sodi (1995) provided measures on reading rate, comprehension and vocabulary, these subtests were taken from the standardized test. For obtaining an initial pool of items for the remaining subtests, CBSE books of Hindi for middle school (6th, 7th and 8th) students were consulted.

A question pool was constructed for the remaining 7 subtests. This question pool were evaluated by six experts (Faculty Members of Department of Hindi, Education and Psychology, M.D. University, Rohtak), in terms of how far they measured the particular aspects of structural /semantic components and difficulty level (i.e. for middle school students). On the basis of suggestions of the experts, some items were modified / dropped and the initial format of the test was prepared. The number of questions in the initial question pool and the first draft are shown in Table 3.
This test was administered to 45 students of 6th, 7th and 8th class. For scoring, each right answer was assigned one mark and each wrong answer was given zero. For reading rate subtest, the average number of words read per minute by the student were computed on the basis of amount of text read in four minutes.

For obtaining a measure of item difficulty, frequency of correct answers per item was computed. The items which had been answered by the mid 50% of the students (frequency between 11-29) were retained.

After removing the very easy and very difficult item, the final draft of the test was prepared. The number of items in each subtest in this draft are shown in Table 3. The final draft of the test was administered to 50 students. Scoring was done by assigning one mark to right answer and zero for wrong answer. The time taken by each student for each sub test was also noted down.

For determining the reliability (test-retest) and validity (construct) of the test, it was readministered to the 50 students after a gap of 2 months and the scores of the students in Hindi in the preceding terminal examination were obtained from the school records. The reliability of the test was found to be 0.957 (p < 0.01) and validity was 0.343 (p< 0.05).

DESCRIPTION OF THE READING ABILITY TEST

The Reading Ability Test provided a measure of reading ability (Hindi) of middle school children. It consisted of ten subtests which provided separate measures on structural and semantic aspects of
reading ability. The sequence of subtests was randomized in order to balance out the effects of fatigue. A copy of the test has been appended in Appendix A-I. The details of the subtests are as follows:

STRUCTURAL COMPONENT: Reading is a complex process where interaction between the lower order perceptual and higher order comprehension processing occurs in both bottom-up as well as top-down. Thus, an attempt was made to select items requiring minimum processing at the semantic level for measuring the structural component. The following subtests provided measures on orthographic, phonological and syntactic abilities. The total score on these five components provided a global measure of structural ability.

1. Orthographic Ability

   a) Identification of Correct Word (शब्द शब्द): During reading, a reader identifies the letters and combines them to form a word. Experienced readers generally follow the visual mediation process of reading rather than phonetic mediation as with experience the correspondence between abstract lexical spelling of word and the written symbol rather than the simple grapheme – phoneme correspondence is utilized (Chomsky, 1980). This subtest required the respondent to choose the correct spelling from four alternatives whose pronunciation was nearly the same. Since high frequency words were used, it was assumed that identification would be on the basis of the lexical spelling and would tap the orthographic – visual lexicon relation. This subtest comprised of 14 items. The time limit for this subtest was 8 minutes.

   e.g. अ) दुर्घटना आ) दूर्घटना इ) दुर्घटना आ) दुघटना
2. Phonological Ability:

a). Pronunciation (शब्दों का उच्चारण): The role of phonetic mediation in reading is well established as reading is strongly linked with linguistic ability. Although phonetic mediation is not an absolute necessity for reading, readers generally find the spoken form of a word more easy to process. This subtest provided a measure of the accuracy of phonetic processing. In each item, readers were presented with two words which were orthographically similar, but the auditory production was different. In the Hindi script, the same syllable when represented in a different orthographic manner is pronounced differently in terms of voicing, palletization etc. It was assumed that readers who had been taught to identity graphemes with the corresponding phoneme would perform better on this task in comparison to readers utilizing visual-semantic mediation. This subtest comprised of 22 items.

    e.g. गृह ग्रह

b) Reading Rate (पढने की गति): This subtest also provide a measure of phonological processing, i.e. the speed of grapheme – phoneme conversion. Skilled readers have been found to pronounce words faster than less skilled readers (Perfetti, 1985). However, this measure is not a pure measure of structural ability as reading rate has also been found to be a predictor of comprehension. It reflects the extend to which reading has become automatic, thereby leading to rapid comprehension. Reading rate is also influenced by the nature of material and motivation of the reader. In the present subtest the material was not very familiar as there were a number of English
words written in Hindi script and a description of an adventure journey to the south pole was given. The average time require to read the entire text by middle school children was 8-10 minutes.

3. Syntactic Ability:

   a) Synthesis of morpheme to form word (संधि): Every language has its own set of rules, which govern the combination of letters into words. Hindi script is more complex than the English script and the vowels are represented in different orthographic shape when combined with different consonants. Further, complex letters are also used which are combinations of consonants. The succeeding and preceding letters also, at time, changes the nature of vowel. Synthesis of morphemes into a word in Hindi are governed by specific rules. This subtest was included to assess the knowledge of the basic rules of synthesizing morpheme into words. This subtest comprised of 23 items. The time limit for this subtest was 10 minutes.

   e.g. सत्यार्थ

       अ) सत्य. अर्थ।

       आ) सत्या. अर्थ।

       इ) सतय. अर्थ।

       ई) सतया. अर्थ।

   b) Identification of Correct Sentence (शुद्ध वाक्य): Syntactic knowledge is acquired unconsciously while learning the spoken language. However, it plays an important role in reading as it allows prediction of the forthcoming syntactic categories, grammatical relations or hierarchy of importance of the word. However, a major difference is observed in the spoken and written nature of Hindi
language as spoken language is influenced by regional differences while the written script still maintains the basic nature. Children generally tend to write as they speak thereby leading to grammatical inconsistencies. This subtest provided a measure of grammatical knowledge of the subject. In each item, two alternative sentences, which conveyed the same meaning were given and the subject had to choose the grammatically correct sentence. This subtest comprised of 13 items. The time limit for this subtest was 6 minutes.

e.g. अ) आपने हँस दिया।
आ) आप हँस दिए।

SEMANTIC COMPONENT: Semantic processing relates to assigning meaning to the visually presented signs. Here processing occurs at two levels i.e. a local word meaning level and a supraordinate text level. Two major measures of semantic processing i.e. word recognition and comprehension were selected for this component.

1. Word Recognition:

(a) Vocabulary (शब्द भण्डार): Vocabulary plays an important role in reading as with practice. The major input unit, whether visual or auditory, becomes a word. Initially a child attaches a single meaning to a word symbol as the word is experienced in a particular context. Varied exposure to the same word leads to the extension of meaning and further experience leads to understanding the conceptual aspects of the word. This subtest provided a measure of the vocabulary of the reader. Simple words with four alternatives were presented where one of the alternatives reflected the correct
meaning. This test comprised of 15 items. The time limit of this subtest was 5 minutes.

(b) Choosing the Inappropriate Word (अनुपयुक्त शब्द बताना): Different words of the same languages can be used to express the same or nearly the same meaning especially in terms of the cognitive meaning. As reading becomes more varied, the vocabulary of an individual becomes larger and different combinations of letters (synonym) lead to the activation of the same meaning. Thus, synonyms can be considered an index of the extensiveness of vocabulary. In this subtest a word with four alternatives was provided in each item where three were synonyms and one was a distracter. Here, the distractor had to be identified. This subtest comprised of 18 items. The time limit of this subtest was five minutes.

(c) Prefix/suffix (उपसर्ग/प्रत्यय)

Prefix and suffix permit a variety in language as a word can be modified in terms of meaning by adding a morpheme. As in English language, Hindi language also has a set of specific prefix and suffix which modify the word in a particular manner making its comprehension easy for the reader.

However, the same prefix and suffix cannot be attached universally to every word. In this subtest a word followed by four alternatives, were the word was changed by adding a prefix/suffix, was given in each item. However, only one of the prefix/suffix
modified the word to form a meaning word. The meaningful word had to be identified. This subtest comprised of 25 items (Prefix: 10, suffix: 15). The time limit of this subtest was 15 minutes.

e.g. उपसर्ग : दाग अ) हमदाग आ) सहदाग इ) सुदाग ई) बेदाग
प्रत्यय : सरल : अ) सरलत्व आ) सरलपन इ) सरलिमा ई) सरलता

d) Conversion of Proposition into word (बाक्यांश के लिए सही शब्द):
The meaning of a word can be accessed through different routes i.e. visual, auditory, attributional, conceptual etc. In this subtest the opposite process i.e. accessing a word from its description was done. In this subtest each item consists of a sentence followed by two words one of which represented the same meaning as the proposition. This subtest comprised of 10 items. The time limit of this subtest was 4 minutes.

e.g. जो जरूरी हो।
अ) अनिवार्य आ) आवश्यक

2. Comprehension (समझ-बूझ):

Comprehension is the ultimate goal of reading. This involves determining the meaning of words in the context in which they are presented and linking the meaning into a larger language pattern and fusing them into a chain of related idea. Lanier and Davis (1972) while summarizing comprehension skills, categorized them as literal skills – recall and recognition of facts, interpretative skills (inferring, drawing conclusions, generalizing, deriving meaning form figurative language, predicting, anticipating, and summarizing), critical skills (judging, detecting, analyzing, checking validity, checking the
author’s biases and purposes) and creative skills (applying information, and responding emotionally). As comprehension is a very complex process involving different levels i.e. literal, interpretative or inferential and variation in past knowledge of the reader plays an important role, a global test of comprehension was not used. This subtest provided a measure of the basic level of comprehension i.e. literal meaning of the text. This subtest comprised of 15 items. The time limit of this subtest was 5 minutes.

Thus, the total number of subtests was 10, among, which 5 provided a measure of structural and 5 of the semantic component.

SCORING: Every right response was given one mark and zero was awarded for the wrong response. For the pronunciation subtest, the student was awarded 0.5 score for pronouncing one word correctly. For reading speed subtest, number of words read per minute by student was calculated. The scores of the respective subcomponents were computed and for computing the structural and semantic ability scores, the scores on the subcomponents were added and finally the total reading ability score was obtained by adding the scores on the structural and semantic components.

Mathematical Ability Test:

Review of literature related to mathematical ability in Chapter-2 indicated that research regarding its multicomponential nature is
Table 4  
Number of items in initial and final format of mathematical ability test.

<table>
<thead>
<tr>
<th>Name of Subtest</th>
<th>Initial Pool</th>
<th>Question</th>
<th>First Format</th>
<th>Final Format</th>
</tr>
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<tr>
<td>Computational</td>
<td>160</td>
<td>102</td>
<td>43</td>
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<tr>
<td>Conceptual</td>
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rather sparse. Here again, like reading ability various components like numeral knowledge, calculation, mathematical vocabulary and problem solving have been identified. As the target population for the present investigation was middle school children, the syllabi of 6th, 7th and 8th class (C.B.S.E.) was scanned. The major areas covered by the syllabus were number theory (fundamental operations of mathematics, H.C.F. and L.C.M.), exponents, algebra (BODMAS, polynomials), time and distance, rational number, percentage (commercial mathematics), mensuration, basics of geometry, complex problems based upon four fundamental operations of mathematics and statistics.

The emphasis at this level is more on the computational aspects and concepts are introduced only at the basic levels. Thus, it was decided that the mathematical ability test would cover computational and basic conceptual aspects and higher problem solving strategy would not be tapped. An initial question pool of 100 items each was constructed for the computational and conceptual subtests. Simple computational and conceptual items requiring simple calculations/concepts application were framed. Here multiple choice items were not used, as the first subtest i.e. the computational component was constructed to tap the computational ability of the students and use of multiple choice items would facilitate fact retrieval rather than the computational aspects. Therefore, in order to maintain uniformity both the subtests were constructed in such a manner that the computational subtest require minimal conceptual application and vice-versa. These items were evaluated by experts and modified on the basis of the suggestions, pretested and finally
<table>
<thead>
<tr>
<th>S.No.</th>
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<tr>
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<tr>
<td>1.</td>
<td>Number theory (Fundamental Operations of Mathematics)</td>
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<td>Number theory (H.C.F. and L.C.M.)</td>
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<td>Exponents</td>
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<td>4.</td>
<td>Algebra (BODMAS)</td>
<td>13-15</td>
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<tr>
<td>5.</td>
<td>Time and Distance</td>
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<td>6.</td>
<td>Relational Number</td>
<td>16-19</td>
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<td>7.</td>
<td>Algebra (Polynomials)</td>
<td>20</td>
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<td>8.</td>
<td>Percentage (Commercial Mathematics)</td>
<td>21-27</td>
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<tr>
<td>9.</td>
<td>Mensuration</td>
<td>28, 29</td>
</tr>
<tr>
<td>10.</td>
<td>Basics of geometry</td>
<td>30-33</td>
</tr>
<tr>
<td>11.</td>
<td>Mix problems based upon four fundamental operations of mathematics</td>
<td>34-43</td>
</tr>
<tr>
<td>12.</td>
<td>Statistics</td>
<td></td>
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</tbody>
</table>
modified in terms of item difficulty as in case of reading ability test. The number of items in each subtest for each draft has been shown in Table 4. The reliability (test-retest) and validity (construct): were determined by administration and readministration (after two months) of the test to 51 students. The reliability of the test was found to be $0.951 (p<0.01)$ and validity was $0.756 (p<0.01)$.

**Description of the Test:**

The mathematical ability test provided separate measures on computational and conceptual aspects of mathematical ability of $6^{th}$, $7^{th}$, $8^{th}$ class students. A copy of the test has been appended in Appendix A-II. The details of the subtests are as follows.

1. **COMPUTATIONAL COMPONENT:** This subtest consisted of 43 questions covering the various areas. The numbers of items in each area have been given in Table 5. The items included in this subtest were framed in order to measure the computational skills of the student. In order to remove the necessity of conceptual retrieval or application, the specific conceptual rules, if any, to be applied were given along with each item. The sequence of items was in terms of difficulty, where initially the areas were placed in an ascending order of difficulty and within each area the items were sequenced in terms of difficulty on the basis of analysis of item difficulty. The time limit for completing the subtest was 65 minutes.

2. **CONCEPTUAL COMPONENT:** This subtest consisted of 52 items. This subtest provided a measure of the understanding of basic mathematical concepts. The items in this subtest required minimal computation. These items were to be solved either by fact retrieval or
applications of conceptual knowledge. Time for completing the subtest was 55 minutes.

SCORING: Each right answer was given one mark and zero for wrong answer. The number of items attempted correctly was the score for each component. The total mathematical ability score was obtained by adding the scores on the two components.

METHODOLOGY

Initially the Principals of various schools in two cities of Haryana (Rohtak and Rewari) were contacted with the request for permission for conducting the study. After obtaining permission the students of classes 6th, 7th and 8th, both girls and boys, were contacted during school hours. Intelligence and ability tests were administered to the students in groups of 4-8, while neuropsychological assessment was conducted individually. The tests of reading and mathematical abilities were administered from April to December i.e. after the annual examination and neuropsychological assessment was done in January and February (follow-up to the ability testing).

Phase I: In order to obtain a sample of average I.Q., high and low achievers in Hindi and Mathematics, 600 middle school students were contacted and their intelligence was assessed by administration of Standard Progressive Matrices (SPM). For administration of Raven’s Standard Progressive Matrices, students were taken in groups of 8-10. The students were seated comfortably and rapport was establishment with them. They were provided pen/pencil and response sheet of SPM. First of all, they were asked to fill their name
and other necessary information in the response sheet. Then the following instructions were given.

"प्रथम पृष्ठ पर बने चित्र में कुछ रिक्त स्थान दिया गया है। नीचे दिए दुकड़े का काम करना है जो उस रिक्त स्थान को पूरा कर सकें। सही दुकड़ा मिल जाने पर, उसकी संख्या अपनी उत्तर पत्रक पर चित्र की संख्या के सामने लिखनी है। कृपया उत्तर पुस्तिका पर कुछ नहीं लिखिए। शुरू की समस्याएं आसान हैं लेकिन बाद में कठिनाई स्तर बढ़ता जाएगा। यदि आप सरल समस्याओं के समाधान पर ध्यान देने के लिए बाद बाली समस्याएं कम कठिन लगेंगी। आप जितना चाहें उतना समय ले सकते हैं।"

After completing the test, the test booklet and response sheet were taken back. Scoring was done by assigning one mark to each right response and zero mark to each wrong response and total score of the five subtests was computed. With the help of the obtained raw score, percentile of each student was computed by using the given standardized norms. On the basis of the percentile score, the students of average I.Q., i.e. between $P_{25}$ to $P_{75}$ were selected. Those students whose marks in Hindi and/or Mathematics in the preceding annual examination were above 60 or below 40 were selected. These students were divided into two categories i.e. high achievers (above 60) and low achievers (below 40). In this way, finally 318 students were selected.

Phase II: In this phase measures of reading and mathematical abilities of high and low achievers in Hindi/Mathematics were obtained. For measurement of reading ability the students were divided into group of 3-5 each. They were seated in a separate room and rapport was established with them. Each subject was handed a
booklet containing the ten subtests and response sheet. The following instructions were given to the students.

यह परीक्षण आपकी वाचन योग्यता को जानने के लिये किया जा रहा है। इस परीक्षण में 10 उपपरीक्षण हैं। सभी उपपरीक्षणों से पहले उनके निर्देश तथा समय-सीमा दिए गए हैं। आरम्भ के 7 उपपरीक्षण आपको एक-2 करके करने हैं तथा शेष 3 उपपरीक्षण के लिए परीक्षक आपको बुलाएगा। शुरू के 7 उपपरीक्षणों के सही उत्तर को उत्तर पत्रक में अंकित करना है। ’शुरू’ कहने पर आप परीक्षण करता शुरू कर दे तथा ’रुको’ कहने पर आप जाहं है वही कार्य को रोक दे। उपपरीक्षण को एक-2 करके करना है। ध्यानपूर्वक सभी प्रश्नों को पढ़ते हुए आपको उत्तर देने हैं।

यदि आपके कोई संदेह हो तो पूछ लें।

After completing the seven subtests except reading rate, pronunciation and comprehension, students were called one by one for pronunciation and reading rate subtest. For pronunciation subtests, the student was asked to turnover to subtest eight and pronounce each word, written in the booklet. The words which was pronounced correctly, was noted by the investigator. After completing this subtest, the subject was asked to turnover the subtest nine and read the given passage. After 4 minutes he/she was asked to put a mark at the last word read and proceed further. After reading the entire passage, the student was asked to turnover to the comprehension subtest (subtest 10) and give the answers on the basis of the earlier read paragraph.

Students who were high and/or below in both Hindi and Mathematics were given both the ability tests. The mathematical ability test was administered to these students after a gap of 5-15 days.
After completing the reading test, student was instructed for mathematical ability test as follows:

When the students completed the first subtest, they were provided 15 minutes for rest. Then, they were given subtest No. 2. When the students completed both the subtests, the response sheet and booklet were taken back.

The scoring of the tests was done as specified in the description of the test and scores on each component and the total ability scores were computed.

Phase III:

In this phase, students, age ranging from 14-15.6 yrs, who were below average on mathematical/reading ability were selected for neuropsychological assessment. For neuropsychological analysis AllIMS Comprehensive Neuropsychological Battery was used. The test was administered individually. The general instructions were given as follows:
After giving general instructions, the instructions for each item was read from manual one by one. The subject performed the tasks and answered the simple questions. Sample items (one each) from the various scales have been presented here.

1. **Motor Function Scale:**

   एक डिब्बे में रखी गोलियाँ और एक खाली कप प्रयोज्य के सामने रखते हुए परीक्षक ने कहा - “अब आपको दायें हाथ से ये गोलियाँ एक-एक करके (परीक्षक ने कप की ओर इशारा किया) इस कप में डालनी है। मेरे तेयारों बोलने पर आप कार्य के लिए तैयार हो जायें। जब मैं "शुरू" बोलूं आप कार्य जलदी-जलदी करना शुरू कर दें और "बस" बोलने पर कार्य बन्द कर दें।

   समय-सीमा - 10 सेकंड

2. **Tactile Functions Scale**

   परीक्षक ने प्रयोज्य को अन्धक चश्मा पहनाकर कहा - “अपने दोनों हाथों को मेरे सामने रखें। परीक्षक ने माहिस की तीली का मसाले बाल रिश्ता प्रयोग करते हुए धीरे या जोर से दायें हाथ के ऊपर बाले भाग को दबाया और प्रयोज्य से पूछा कि दबाव ज्यादा है या कम। प्रयोज्य के गलत उत्तर की परवाह न करते हुए परीक्षक ने आगे कहा - मैं कई बार यह तीली जोर से दबाऊँगा/दबाऊँगी और कई बार धीरे से। आपको बतलाना है कि कब मैंने तीली जोर से दबायी और कब धीरे से? (स्पष्ट स्थान बीच की अंगुली से लगभग 4-5 से. मी. ऊपर होना चाहिये)। माहिस की तीली का स्पष्ट इस क्रम से कराया: धीरे से, जोर से, जोर से, धीरे से।

3. **Visual Functions Scale**

   परीक्षक ने प्रयोज्य से कहा - मैं एक कार्ड (वी आइ एस-1) पर बने कुछ वस्तुओं के चित्र दिखाएँगा/दिखाऊँगी। चित्रों को देखकर आप बतायें कि ये क्या है? (कार्ड 10 सेकंड तक दिखाये)। वस्तुओं के चित्र: कद्धा, किताब, पलंग, जूता।
4  Receptive Speech Scale:

परीक्षक ने प्रश्न रखा - मैं आपको एक-एक करके कुछ निर्देशक शब्द सुनाएँगा/सुनाएँगी। सुनने के बाद आप उन्हें ज्ञात करेंगे कि शब्द कि पहला अक्षर कौन सा है (परीक्षक को भाषा रखना है कि प्रश्न के द्वारा हर एक निर्देशक शब्द का अक्षर तीसरे बोलने आवश्यक है। चाहे बाद के अन्दर के अक्षर ढील बोले गये हों या नहीं।) शब्द : मीक, जीक, नीक, खीक।

5  Expressive Speech Scale:

परीक्षक ने प्रश्न रखा - अब मैं आपको जो कार्ड (ई एक्स पी-1) दिखाएँगा/दिखाएँगी। उस पर कुछ वस्तुएँ लिखी हैं। आप पहचानने के लिए उनके नाम बताएँ। (यदि प्रश्न में दर्शायी वस्तु का नाम है तो उसके उपयोग के विषय में बताते हैं तो उत्तर गलत माना जाएगा।) वस्तुओं के नाम के नाम : कैमी, ट्रिक्युल, ऐनक, छाल।

6  Writing Scale:

परीक्षक ने प्रश्न रखा - अब मैं एक-एक करके कुछ शब्द बोलूँगा/बोलूँगी। आप हर एक शब्द का दूसरा अक्षर मुझे बताएँ। समय-सीमा: 10 सेकंड प्रति शब्द। शब्दों को बोलने का क्रम: कमल, सहमत, खबर, गदगद।

7. Arithmetic Scale:

परीक्षक ने प्रश्न रखा - इस बार भी आप दायी तरफ से गिनतियाँ पढ़ें। जो सिस्टम (ए आर आई-4) पर लिखे 346 को 643 पढ़ कर जाएगा। इसी प्रकार दिये गये कार्ड (ए आर आई-5) पर लिखी गिनतियाँ उत्तरी तरफ से पढ़कर सुनाएँ। समय-सीमा: 10 सेकंड प्रति प्रश्न।
8 Memory Scale:

The raw score of the subject on the neuropsychological functions (12) and lobe scale (8) were obtained by scoring each item as per the scoring procedure given in the manual and adding the scores for each function/lobe scale. Later these were converted into T scores. The scores of each subject on the various tests have been tabulated in Appendices C-I to C-II. The statistical analysis and interpretation of the obtained data have been discussed in the next chapter.