CHAPTER II
HISTORICAL RESUME

In view of importance of reading and mathematical ability to scholastic achievement and their probable association, may be at the neural level, an abstract based study was conducted from National Informatics Centre, Delhi. This was supplemented by an exhaustive journal based literature search from the central library of M.D. University, Rohtak, Delhi University Library and library, N.C.E.R.T. The review indicated that initial research in the area focused on the relationship of ability with intelligence and achievement while recent researches focus more on identification of the role of specific components of the ability. In the present review also, initially the studies relating ability (reading and mathematical) with intelligence and academic achievement have been considered.

ABILITY (READING/MATHEMATICAL), INTELLIGENCE AND ACADEMIC ACHIEVEMENT

The relationship between intelligence and academic achievement has been considered infallible. This is evident from the fact that the criterion most frequently employed in validating intelligence tests is some index of academic achievement and intelligence tests have often been described as measures of scholastic aptitude. Review of researches relating to reading / mathematical ability also reveals a major interest of researchers in studying the relationship of ability with intelligence and academic achievement.
Triggs, Cartee, Binks, Foster and Adams (1954) examined 36 students (18 girls and 18 boys) in grade 7 to 12 and 40 students (23 girls and 17 boys) in grade 4 to 6. They administered the Diagnostic Reading Tests: Survey Section and Wechsler – Bellevue Intelligence Scales. Results indicated that reading skill measured in this study were more closely related to verbal than to non-verbal ability. Reading skill of children in grades four through six, though more closely related to verbal than to non-verbal ability were less closely related to verbal ability than the skills of the junior-senior high school students. Although the relationship of all reading skills to non-verbal ability was lower than to verbal ability, there was a positive correlation. Thus, persons endowed with markedly greater, non-verbal than verbal ability tend to have difficulty in learning to read, indicating that reading requires successful utilization of verbal as well as non-language factor of intelligence.

Bond and Wagner (1966) observed that correlation between mental age, and reading comprehension increased with progression of age, throughout schooling. They reported that the correlation between mental age, as measured by Stanford – Binet Test and reading comprehension at the end of the first-grade was approximately 0.35, at the end of fifth-grade it was approximately 0.60 while during the high school years it approached 0.80. These results are supported by DeHirsch and Jansky (1970) and Slobodzian (1970) who reported low correlations between reading achievement and intelligence test scores of kindergarten and primary level children. These findings, according to Dechant and Smith (1977), suggested that mental age is a basic determinant of reading
success when children have reached the stage at which they 'read to learn' than it is when they are ‘learning to read’.

Busch (1975) found a correlation of 0.59 between reading achievement as measured by Gates MacGnite Reading Test and I.Q. of 1052 children of first grade. He concluded that intelligence was a reliable predictor of reading achievement.

Krishna and Agrawal (1983) examined the role of reading ability and intelligence. They administered a battery of reading ability test, verbal and non-verbal tests of intelligence to 200 males and 200 females of XI standard to examine the relationship of intelligence and reading ability. They used reading ability test which was developed by Krishna (1967), Mohsin’s (Undated) General intelligence Test (GIT) and Nafde’s (1953) Non-Verbal Test of Intelligence (NVTI). Findings reveal that the main effects of sex, verbal and non-verbal measures of intelligence as well as their interaction were significant. Significant and positive correlations were found between reading ability and verbal as well as non-verbal measures of Intelligence.

Klicpera and Klicpera (2001) conducted an investigation involving 1800 second-to-fourth graders. The children were divided into three groups according to their reading and spelling achievement and the results of a non-verbal intelligence test: children with average achievement in oral reading and spelling, and those with poor achievement in both which were either discrepant or non-discrepant to their good-to-average scores on the intelligence test. Results for all three groups on a number of spelling tests were compiled to assess two components of spelling skills: phonological recoding and
application of orthographical knowledge. The results show that children with either specific or non-specific reading or spelling disabilities performed at the same level of phonological recoding, while both groups were worse than younger children of average ability at the same spelling level. Children with IQ-discrepant reading and spelling disabilities on the other hand had a certain advantage over children with the same number of difficulties in spelling, but a lower advantage, on tasks requiring a knowledge of orthography. Though particularly evident in the lower grades, this advantage declined with advancing grade level. Additional comparison of the three groups on tests of phonological awareness and other phonological skills revealed a similar pattern of great differences between the two groups of poor readers and spellers and the average children, but slight non-significant differences between children with IQ-discrepant and non-discrepant reading and spelling disabilities.

These researches indicate that both verbal and non-verbal intelligence contribute to reading ability. The relation between verbal intelligence and reading ability becomes stronger with the progression of grade, indicating that non-verbal factors of intelligence could be contributing to the basic reading skills while the verbal factor is associated with the semantic, i.e. comprehension aspect.

The relationship appears to hold for both girls and boys, as no gender difference have been reported.
Coull (1956) made a survey of reading achievement in relation to intelligence, sex, bilingualism, and grade placement. Subjects consisted of 953 fourth-graders and 917 seventh graders randomly selected to represent urban and rural areas in Alberta (Canada). Correlation between total mental factor I.Q. on California Test of Mental Maturity and score on California Reading Test ranged from 0.67 to 0.81. Across gender comparison did not reveal any significant differences in intelligence or differences in reading achievement of seventh grade students. English speaking children scored higher both on intelligence and reading test as compared to bilingual children.

Downing (1975) studied the relationship of critical reading ability and intelligence in grades thirteen and fourteen. The sample included 244 males and 291 females. He found a significant relationship between intelligence as measured by Otis-Lennon Mental Ability Test and selected critical reading skills as measured by Advanced Critical Reading Test. No significant difference was found in critical reading between males and females.

Manning’s (1977) reported a significant relationship between the scores obtained by 50 students of tenth grade on the Gates MacGnile Reading Test and the Stanford-Binet Intelligence Scale. However, no significant differences were found between the scores of males and females on the Reading Test.

Shah (1981) undertook a comparative study of some personal and psychological variables and reading comprehension. The sample consisted to 412 students (226 boys and 186 girls) of class eight of
Bhavnagar schools. No sex differences were observed as far as mean reading comprehension of the two groups was concerned. A correlation of 0.67 was found between I.Q. and reading comprehension, indicating a high relationship between the two.

Reading plays an important role in the school curriculum as it is a tool of instruction for the various subjects. A number of investigators have studied the relationship between reading ability and school achievement.

Olson (1966) investigated the relationship between school achievement, reading ability and specific visual perception skills in the third grade. School achievement was measured with the help of California Achievement Test; and Developmental Reading Tests by Bond, Clymer and Hoyt was used to secure measures of reading ability. Analysis of the results for sixty-four boys and fifty-seven girls revealed a significant correlation (0.6) between reading ability and school achievement.

Srivastava (1969) conducted a study on 600 students who were divided into four groups on the basis of their achievement scores (under, over, high and low), comprising 150 boys in each group. Selection was on the basis of 3 ability tests on a random sample of 1837, X and XI class students. Three reading tests i.e. Hindi adaptation of Green's Michigan speed of reading test, Sharma's Hindi Vocabulary and Mohsin's Hindi spelling test were administered. Results indicated that high achievers scored the highest and the low achievers the poorest, while over achievers and underachievers scored moderately.
Srivastava (1989) conducted a study on 480 students (120 students from each school, i.e. two government, one private aided school and one public school) of grade VII before the commencement of the final examination. The percentage of the annual examination marks achieved in Hindi, mathematics, social studies and science were noted down. Results show that the correlation of intelligence with various measures of reading ability as well as with various measures of school achievement tended to be positive, significant and fair-sized. The correlations amongst various measures of reading ability as well as correlation between various measures of reading ability and school achievement tended to be positive, significant and consistently high in size as compared with the correlations of achievement with socio-cultural status (SCS) or intelligence. Of special significance were the correlations between various measures of reading comprehension and various measures of school achievement. These correlation tended to be positive, significant and higher as compared with the correlations of achievement with socio-cultural status, intelligence, word meaning and reading speed. Reading comprehension emerged as the most significant contributor to school achievement, while the next most significant contributor was word meaning.

Shivananda and Usha (1985) identified over and under achievers and compared their reading abilities. They took a sample of 229 students of standard VII. They used non-verbal test of intelligence which was developed by Premalatha (1961), Aruna's Achievement Test Battery (1981), Silent Reading Test in Kannada which was constructed and standardized by Gowda and Shivananda.
(1980). Results show no significant difference between reading ability of the over and under achievers as far as the word discrimination and reading comprehension aspects were concerned. However on vocabulary, opposites, sentence formation and the total score, the over achievers were found to be better than the under achievers.

Taken together these studies indicate that there is a positive relationship between reading ability and intelligence. Reading ability is correlated with verbal as well as non-verbal intelligence but the relationship is stronger with verbal intelligence especially among students of higher grades. No gender differences were observed. These studies implicate the multicomponential nature of reading ability as various components appear to contribute differentially to academic achievement.

With regard to mathematical ability also, a number of researches have investigated the relationship with intelligence, gender and achievement in mathematics.

Deo (1976) studied, 1,300 boys and girls in the sixth, seventh and eighth grades. The Algebraic Concepts Test (which was developed by the investigator in the absence of such tool) and Jaiota’s (1960) group test of Mental Ability was administered to the sample. The results indicated that boys tend to understand algebraic concepts better than the girls, provided all other extraneous variables are held constant. It was also found that students in higher grades are exposed to wider syllabi than the pupils in the lower grades and obviously get greater amount of guidance and training which helps in having better understanding and development of algebraic concepts.
The results also show that superior intelligence seems to account for better understanding of the algebraic concepts.

Pandey and Singh (1978) studied the relation between school examination marks, intelligence and achievement scores. The study was conducted on 120 male students of VIII grade. Mohsin's Verbal Intelligence Test and general science test were administered to measure intelligence and achievement respectively. The results showed a positive correlation between verbal intelligence test score and school examination marks in elementary mathematics and social studies. Although no significant positive correlation was observed between achievement scores and school examination marks in elementary mathematics and social studies but there was a tendency towards positive correlation.

Park, Bauer and Sullivan (1998) investigated the role of gender in Mathematics performance of high achieving (top 5%) elementary school students. A sample of 2,421 female and 2,240 male fourth grades and 1,268 female and 1,273 male sixth graders was drawn based on California Achievement Test scores of students in the state of Louisiana. Mathematics performance was measured using 2 dimensions: Mathematics computation and mathematics concepts and applications. A significant gender difference was found in both 4th and 6th graders. It was found that 4th and 6th grade females performed better in mathematics computation than males but sixth grade males outperformed females in terms of mathematic concepts and applications. Males showed a greater ability to apply mathematics and understanding mathematical concepts.
Furthermore as the students got older, the differences between genders become greater.

These studies indicate that like reading ability, intelligence level of student also influences his/her mathematical ability. A positive correlation was reported between verbal intelligence test score and school examination marks in elementary mathematics, but no positive correlation was found between mathematics achievement scores and school examination marks indicating that this ability permeates other subjects less as compared to reading ability. However, gender differences were observed where females were found to be better at the computational and males at the conceptual and application aspect, implicating the multicomponenential nature of this ability also.

**NATURE OF ABILITY**

Researches have been conducted to study the nature of reading/mathematical ability. Both the abilities appear to be multicomponential, where the structural ability constitutes of basic skills and the higher level semantic component is related to the inference and abstraction level.

**Reading Ability**

Researches over the past two decades have focused on the role of specific components of reading ability in the reading process. At the basic structural level, phonological awareness appears to be an important contributor to reading success.
Schlagal, (1989) conducted a study to trace patterns of constancy and change in spelling errors as children’s word knowledge advances across the elementary years. Errors were elicited from 242 children in grades 1-6, using spelling inventories constructed from graded word pools. Words were chosen based on their likelihood to provide representative difficulties to learning of various subjects at each grade level. Findings support an orderly stage like progression of word knowledge at the lower grades. Analysis of errors across the grades revealed clear patterns of coherent change and underscored the persistent difficulty of certain features (such as consonant doubling) of English orthography.

Feng, Miller, Shu and Zhang (2001) examined how readers of Chinese and English take advantage of orthographic and phonological features in reading, the authors investigated the effects of spelling errors on reading text in Chinese and English using the error disruption paradigm of Daneman and Reingold (1993). Skilled readers in China and the United States read passages in their native language that contained occasional spelling errors. Results showed that under some circumstances very early phonological activation can be identified in English, but no evidence for early phonology was found in Chinese. In both languages, homophone errors showed a benefit in measures of later processing, suggesting that phonology helps readers recover from the disruptive effects of errors. These results suggest that skilled readers take advantage of the special features of particular orthographies but that these orthographic effects may be most pronounced in the early stages of lexical access.
Siok and Fletcher (2001) examined the role of phonological awareness and visual-orthographic skills in Chinese reading acquisition. The subjects were 154, 1 to V graders in Beijing who had learned an alphabetic script known as Hanyu Pinyin to help read Chinese characters. Children's performance on tests of various cognitive skills, reading ability, and Pinyin knowledge were examined. Results of hierarchical regression analyses showed that (a) visual skills predicted reading success at lower grades; (b) Pinyin knowledge and the ability to discriminate homophonic characters predicted reading success in Grades 2, 3 and 5; and (c) onset-rime awareness, but not phonemic awareness, predicted Chinese reading. This suggests that learning to read Chinese progresses from a logographic phase to an orthographic-phonological phase and that the nature of phonological awareness predicting reading success is contingent on the characteristics of the writing system.

Sprenger-Charolles, Siegel, Bechennec and Semielaes (2003) studied the development of phonological and orthographic processing from the middle of grade 1— to the end of Grade 4 (age: 6-10 years) using the effects of regularity and of lexicality in reading aloud and in spelling tasks, and using the effect of pseudo homophony in a silent reading task. In all the tasks, signs of reliance on phonological processing were found even when indicators of reliance on orthographic processing appeared. Multiple regression analyses were conducted to determine which early skills predict later reading achievement. Pseudoword and irregular word scores were used as measures for phonological and orthographic skills, respectively. Only middle of Grade 1 phonological reading skills
accounted for independent variance in end of grade 4 orthographic skills. Conversely, from the middle to the end of grade 1, and from the end of grade 1 to the end of grade 4, both orthographic and phonological skills accounted for independent variance in later reading skills. In the prediction of phonological skills, only the unique contribution of earlier phonological skills was significant. Thus, phonological and orthographic processing appear to be reciprocally related, rather than independent components of written word recognition. However, very early reliance on the phonological procedure seems to be the bootstrapping mechanism for reading acquisition.

Miellet and Sparrow (2004) employed the boundary paradigm during sentence reading to explore the nature of early phonological coding in reading. Fixation durations were shorter when the parafoveal preview was the correct word that when it was a spelling control pseudoword. In contrast, there was no significant difference between correct word and pseudohomophone previews. These results suggest that the phonological codes are assembled before word fixation and are used for lexical access. Moreover, there was evidence that orthographic codes influence the activation of word meaning. Fixation durations were shorter for orthographically similar parafoveal previews and this orthographic priming effect was limited to pseudohomophones. Thus, it seems that both the orthographic and the phonological similarities of the parafoveal preview to the target play a part in the facilitative effects of the preview.

Considered together, these studies indicate the orthographic processing contributes to reading skills where written characters are
complex (Chinese script). However, a reciprocal relationship with phonological skills is clearly evident.

Stuart (1995) compared the power of two screening batteries (that of Clay, 1979, and that of a set of tests of phonological awareness and sound to letters correspondence knowledge) to identify, in the first term at school, children at risk of failing to learn to read successfully. A single test from one of the batteries was shown to provide an adequate screening procedure. Reading processes of the screened children were investigated at the end of their first year in school, and again seven months later. Almost all the best readers could use some phonological recoding processes by the end of their first year at school. Seven months later, this was true of all the best readers with children who had now learned to use phonological recoding process showing greater gains in reading age than those who had not.

Dash, Kantha and Dash (1999) made an attempt to understand the cognitive and speech related processing differences between good and poor readers coming from high as well as low I.Q. groups. One hundred class VII students categorized into four groups (high I.Q. good readers, high I.Q. poor readers, Low I.Q. good readers and low I.Q. poor readers) through a double-median split procedure on variables of intelligence and reading comprehension, were assessed on the PASS (planning – attention – simultaneous-successive) and speech related processing (phonological coding and articulation) measures. The findings revealed significant influence of reading status on all the speech related measures. Among the good as well as poor readers, variation in I.Q. was reflected in some PASS
processes, but not in measures of phonological coding and articulation. The results provide cross-cultural data from the Oriya language in support of the hypothesis that phonological coding and articulation rate lie at the core of deficits experienced by the poor readers, irrespective of I.Q.

Metsala, Stanovich and Brown (1998) present a meta-analysis of spelling to sound regularity effects in individuals with reading disabilities and reading level comparison groups. The phonological deficit model of reading disabilities, coupled with the classic dual route model of word recognition, has led to two predictions: (a) a specific deficit in the pseudoword reading of those with reading disabilities and (b) an absent or reduced regularity effect for those with reading disabilities relative to reading-level controls. Previous reviews confirm the first prediction. The present meta-analysis tested the second prediction. There was a clear effect of word regularity for individuals with reading disabilities, the magnitude of which did not differ from the word regularity effect for reading level controls.

Porpodas (1999) examined the patterns of reading and spelling performance of Greek first graders (mean age 7.1 yrs) facing difficulties in literacy acquisition. The relationship between obtained literacy development levels and the subjects phonological awareness and ability to retain phonological information, in short-term memory was also studied. Subjects were tested in the reading of single letters, letter clusters, words, non-words and word and non-word spelling. Phonological processing knowledge was assessed by a battery of phonological awareness tasks and short-term memory phonetic representation tasks. Results indicate that accurate
decoding of Greek was achieved by almost every subject. The time the subjects needed to process a written item was the crucial index of their difficulty in literacy acquisition. Sound spelling correspondence knowledge was the basis of spelling. Low achievers achieved a satisfactory performance in phonological processing, but it was significantly lower than that of the normal achiever. Phonemic awareness and speech rate tasks were found to be the best predictors of learning to read and spell Greek words.

Catts, Fey, Zhang, and Tomblin (1999) examined the contributions of phonological processing and oral language abilities to reading and reading disabilities in young children. Six hundred and four participants (mean age 7.9 years) were divided into good and poor readers on the basis of reading performance in second grade. Reading groups were then compared in terms of kindergarten phonological processing and other language abilities. Multiple regression was employed to investigate the relative contributions of phonological processing and oral language abilities in predicting second grade reading achievement across reading groups. Results indicated that 70% of poor readers had a history of language deficits in kindergarten. Most of these children had problems in both phonological processing and oral language. Regression analysis further indicated that oral language and phonological processing abilities accounted for the unique variance in reading achievement.

Lopez and Gonzalez (1999) compared 87 Spanish reading disabled students (aged 9-10 years) with 45 normal readers in order to determine whether reading disabled would have particular difficulties in naming words under conditions that require extensive
phonological computation. The frequency and form of naming errors produced by the reading disabled and normal reading groups when naming real words and non-words were analysed. Disabled readers made more errors in non-words, low frequency words and long non-words, thereby indicating that poor phonological skills are a characteristics of reading disabled children.

Swanson, Mink and Bocian (1999) compared children with comorbid symptoms (RD+ADHD) and slow learners (SL) on measures of phonological and executive processing. No significant differences in performance emerged between the ability groups in phonological processing. The SL+hyperactivity disorder and slow learner performed better than reading disability group (RD alone and RD + ADHD) on the visuo-spatial working memory (WM) factors score and the RD alone groups was inferior to RD + ADHD, SL+ADHD and SL-alone groups on the verbal WM factors score. The results support the notion that poor readers, whether suffering from RD or ADHD symptoms, share a common phonological core deficit.

Demont and Gombert (1996) investigated the relations between two metalinguistic abilities (phonological awareness and syntactic awareness) and two components of reading (recoding abilities and comprehension). A four year follow-up study comprising 23 children was conducted. Children were tested repetitively during their first years of learning to read. Data was analysed with fixed order regression in which the dependent variables was either recoding abilities or comprehension performance. Results indicated that children's phonological awareness predicted later recoding
abilities, while syntactic awareness predicted later reading comprehension after the effects of extraneous variables (intelligence and vocabulary) had been ruled out.

Metsala (1999) examined phonemic awareness ability in a traditional as well as pseudo word reading level match design. Thirty five reading disabled (RD) subjects (aged 6.5 – 14.6 yrs) were compared to 48 normally achieving children matched for word reading ability. The results show that RD children with typical pseudo word reading and phonemic awareness deficits in the traditional reading level match design nonetheless have phonemic awareness skills commensurate with their level of pseudoword reading ability.

Chan and Siegel (2001) studied ninety four children in grades one to six (7 to 12 years old) in Hong Kong who were individually administered a Chinese Reading Test consisting of 80 characters that varied in frequency (high or low) and orthographic structure (simple or complex), phonological processing tasks, including short-term memory, pseudo-character recognition, and tone discrimination tasks. During reading, younger normal and poor readers made more semantic and visual errors, whereas older and normally achieving children made more phonologically related errors. Normally achieving readers also performed at a higher level than poor readers on short-term memory, pseudo character recognition and tone discrimination tasks. Phonological processing apparently plays a significant part in the development of reading skills in Chinese.

Cardoso-Martins and Pennington (2001) studied the relationship of rapid serial naming (RSN) to phonetic awareness and
reading and spelling ability in a sample consisting of North American Children and adolescents aged 7-18 years among which 71 subjects had reading difficulties. The Peabody Individual Achievement Test, the Wide Range Achievement Test – Revised, the Gray oral Reading Test, part of the Woodcock – Johnson Psycho-Educational Battery, IQ tests from the Raven Progressive. Matrices and the Wechsler Intelligence Scale for Children – Revised (WISC-R), and the tasks of phonemic awareness and Rapid Serial Naming (RSN) were administered. The results indicate that RSN is particularly important for the development of the ability to read texts rapidly and accurately, whereas phonemic awareness is particularly important for the development of the ability to read by phonological recoding.

Plaza and Cohen (2003) examined the performance of 267 first-grade children on tasks assessing phonological processing, syntactic awareness, and naming speed. The children were also given several measures of word and pseudoword reading, reading comprehension, and pseudoword and dictation spelling. A series of hierarchical analyses indicated that three variables (phonological awareness, syntactic awareness and naming speed) were still predictors of reading and spelling performance after variance in the others had been controlled for. The results, which confirm that syntactic awareness can account for variance in written language after phonological ability had been controlled for, support the hypothesis concerning the relationships between naming-speed processes and written language, and challenge the unitary phonological theory of reading difficulty.
Sprugevica and Hoien (2003) investigated the power of early measures of phonological skills (phonemic awareness, rapid naming, short-term memory) in predicting later reading skills at various points of time. About 70 children were followed from the end of kindergarten to the middle of grade 2. Correlation analyses were performed as well as a linear growth curve analyses. In the traditional regression analysis, phonemic awareness in kindergarten explained about 27% of the variance in word reading six months later and about 9.5% of the variance at the end of grade 1. Even when prior level of reading skill was included in the predictive equation, a significant amount of variance was still explained by phonemic awareness. The other predictor variables did not explain any variance in word reading, and phonemic awareness did not predict any variance in reading skills in grade 2. When using sentence reading as the dependent variable, phonemic awareness explained about 16% of unique variance after six months, and about 13% of the variance in the middle of grade 2. Similarly, when employing growth curve analysis, phonemic awareness was the only phonological factor which accounted for significant variance in slope of word reading, explaining about 25% of its variance, whereas naming and short-term memory did not explain any unique variance. The lack of predictive power of phonemic awareness on the sentence b-slope is assumed to be caused by unreliable sentence scores in kindergarten.

Francis (1984) studied 48 children who read material from their school reading scheme, arranged both in sentences and in word lists. The samples were collected in the early months of learning to read, before phonic instructions were introduced. In the second study,
samples were collected from time to time from 8 children during their first three year in school, during which time they received phonic instructions. The findings implicate the visual and phonological paths to word recognition and indicate that the development of direct lexical access entails considerable unconscious, automatic and interactive processing, and the first letters recognition is an important cue for initial readers, both for direct access and in the establishment of a phonological route.

Courcy, Beland and Pitchford (2000) studied the performance of a group of pre-literate French-speaking children identified at risk (n=26) for reading disabilities was compared to that of normally developing age-matched controls (n=22) on a range of standardized and experimental tests. Results showed that risk children have a selective impairment in expressive relative to receptive language, whereas controls performed at equivalent levels on both measures. Although the children at risk performed at a significantly lower level than controls on all but one of the metaphonological tests, their pattern of performance was similar to that of controls, suggesting a developmental delay. Interestingly, both groups showed a superiority of awareness for syllables over phonemes, reflecting the phonological structure of the French language.

Buchanan, Kiss and Burgess (2000) studied brain-injured, previously literate adults who were diagnosed as deep dyslexics. Their reading errors included semantic paralexias (e.g., reading HEART as BLOOD) and impaired reading non-words (e.g., FRIP). The diversity of these symptoms indicate that there are multiple sources of impairment in this syndrome and that one of the most critical is a
failure to process phonological information at a sublexical level. The patient (SD) reported in this study fits the deep dyslexia profile to the extent that she made several semantically related reading errors. She also showed the classic frequency and image ability effects of the syndrome. However, she could read some nonwords correctly and she showed a strong advantage for naming when phonemic cues are presented. Thus the performance of SD could be attributed to these preliminary tasks, in terms of a phonological selection impairment.

Carroll and Snowling (2004) studied the links between reading difficulties and speech difficulties. Seventeen children with speech difficulties between the ages of four and six were compared to children with a family history of dyslexia and normally developing controls on phonological processing, phonological learning, phonological awareness and literacy tasks. The two groups of children at risk of reading difficulties showed very similar patterns of impairment, with average vocabulary but poor input and output speech processing, phonological learning, phonological awareness and reading development. It was concluded that the antecedents of reading difficulty were similar in these two groups of children, with both groups showing deficits in the development of phonological representations.

Inhoff, Connie, Eiter, Radach and Heller (2004) studied the temporal dynamics of a visual target word's phonological representation by presentation of an irrelevant spoken companion word when the participant's eyes reached the target's location during sentence reading. The spoken word was identical, similar, or
dissimilar to the phonological specification of the visual target. All spoken words increased the time spent viewing the target, with larger effects in the similar and dissimilar spoken word conditions than in the identical condition. The reading of post-target text was disrupted when the spoken word was similar but not when it was identical or dissimilar to the target. Phonological interference indicates that a word’s phonological representation remains active after it has been identified during sentence reading.

Considered together these studies indicate that phonological ability is a major contributor to reading ability. Good readers have command on this component because they use phonological recoding processes at their early school years. They show greater gains in reading as compared to those who do not use phonological recoding processes. Children who have language problems in early age, suffer from both phonological processing and oral language. Poor readers, who have comorbid symptoms (RD + ADHD), also have phonological deficit. It is found that rapid serial naming is particularly important for the development of the ability to read texts rapidly and accurately, whereas phonemic awareness is particularly important for the development of the ability to read by phonological recoding. Phonological interference indicates that a word’s phonological representation remains active after it has been identified during sentence reading. Studies indicate that phonological awareness can be considered as the best predictor of reading ability.

Another major area of interest among researchers has been the higher order level (semantic) of reading where focus has been on
identification of syntactic or semantic components of reading ability which affect comprehension.

Pace and Golinkoff (1976) assessed the relationship between word difficulty and semantic access by using easy and difficult words. A sample of 32 third graders and 32 fifth graders (16 above and 16 below median on paragraph meaning section of the Stanford Achievement Test) from each grade were selected from a semi-rural elementary school. Each subject was tested during the last two months of the school year where decoding and interference tasks were administered. Results indicate that access of meaning of single words may depend on the ease with which these words can be decoded. Retrieval of the meaning of difficult words was least apparent for the less skilled third graders, the group that had the most difficulty in decoding these words. Thus, it appears that decoding ease and extraction of word meanings are related and also suggest that decoding ability must be considered a factor in reading comprehension.

Parikh (1979) examined the effect of content and vocabulary on reading speed and comprehension of primary school children. The sample consisted of 35 primary school pupils (age: 11+ years). Vocabulary test (modified form of Vakil, 1955), Reading Comprehension Test (developed by investigator) and Reading Speed Measure were used. It was found that content of reading material does not have a significant effect on reading speed or comprehension. There was a no correlation between reading speed and comprehension and vocabulary also did not have a significant effect on reading speed. However, vocabulary had a significant
effect on comprehension. These results reflect the independence of structural (reading speed) and semantic components (comprehension) of reading and implicate the role of vocabulary in both the components.

Isakson and Miller (1976) examined the cognitive processing strategies used in comprehending written language. A sample of forty-eight 4th grade students equivalent on word recognition skills but differing in comprehension ability was selected. The students read sentences manipulated at the verb position to determine whether sensitivity to syntactic and semantic cues differed between good and poor comprehenders. Data in the form of oral reading errors at the verb position support the hypothesis that poor comprehenders are not affected by the disruptive effect of syntactic and semantic violations, while good comprehenders exhibit an increasing number of errors across semantic and syntactic/semantic violations. Thus, it appears that poor comprehenders ignore semantic and syntactic cues and treat words as individual entities.

Kirby and Gordon (1988) explored the syntactic analysis or text segmenting stage, in order to investigate the effects of assisting subjects with syntactic analysis and to explore the information processing abilities which may underlie the text segmenting process. A sample of 352 primary school children from grades 3, 4, 5 and 6 of a middle class school were administered tests to measure reading vocabulary, reading comprehension, simultaneous and successive processing and performance under altered text conditions. Results indicate that poor comprehenders regardless of word-level skills, do benefit from text segmenting and simultaneous processing is
involved in forming of syntactic units. In conditions in which the text is already segmented, both successive and simultaneous processing was observed. The results suggest that syntactic analysis is a potential bottleneck in reading, and that training studies should be designed, employing simultaneous and successive processing, to improve syntactic analysis skills and facilitate reading comprehension.

Haberlandt, Graesser and Schneider (1989) conducted three subjects paced experiments to evaluate reading patterns at the word, line and sentence level for fast and slow readers. A sample of 316 undergraduate students was selected. A moving - window method was used to collect word reading times for natural texts. At the word level, reading times of word N were influenced by features of word N-1 for fast readers but not for slow readers. The lag effect exhibited by fast readers indicated certain commonalities as well as specific differences in the reading time patterns of fast and slow readers. At the word level, there was a lag effect in fast readers. Their reading times were influenced by attributes of the previous word, which was not the case in slow readers. At the levels of intermediate text structures (e.g. sentences and lines), fast readers paused longer at physically defined locations such as the beginning of a line, whereas slow readers paused longer at linguistically defined locations such as sentence boundaries. However, fast and slow readers did not use different strategies of extracting new arguments from the text. Fast readers in all three experiments used the many - argument strategy rather than a single argument strategy, as did the slow readers. These results indicate that at least two "shortcuts" i.e., chunking of
words and line oriented reading strategy taught in speed reading courses have their basis in reading strategies adopted spontaneously by readers when they choose to read fast or when they are instructed to do so. A consequence of the first strategy is the lag effect at the word level. Although both reader groups adopted a many-argument strategy, fast readers exhibited greater new-argument effects relative to lines, whereas slow readers exhibited greater new-argument effects relative to sentences. Specifically, slow readers integrated the new arguments primarily at the end of the sentence, whereas fast readers did so at line boundaries. These results provide support for a buffer and integrate model of reading comprehension.

Swanson and Trahan (1996) investigated (a) whether learning disabled readers' working memory deficits that underlie poor reading comprehension are related to a general system, and (b) whether metacognition contributes to comprehension beyond what is predicted by working memory and word knowledge. To this end, performance between learning disabled (N=60) and average readers (N=60) was compared on reading comprehension, reading rate, and vocabulary subtests of the Nelson Skills Reading Test, Sentence Span Test composed of high and low imagery words, and a metacognitive questionnaire. Overall, the results suggest that the relationship between learning disabled readers' generalized working memory deficits and poor reading comprehension may be mediated by metacognition.

Nation and Snowling (1997) studied the relationship between different tests of reading accuracy, reading comprehension and linguistic comprehension. Eleven thousand eight hundred and forty
seven, 10 years old children completed a listening comprehension test, three tests of reading accuracy (reading of non-words, single words and text) and two tests of reading comprehension (text comprehension and sentence completion). While sentence completion was well accounted for by individual differences in word recognition, text comprehension was more heavily dependent on listening comprehension. Study 2 compared the performance of children with poor comprehension skills with controls matched for age, non verbal ability and decoding skill. The poor comprehenders had greatest difficulty with tests most heavily dependent on linguistic comprehension and least difficulty on purer measures of decoding.

Zhou and Marslen-Wilson (2000) investigated the relative time course of semantic and phonological activation in the context of whether phonology mediates access to lexical representations in reading Chinese. Compound words (Experiment 1) and single-character words (Experiments 2 and 3) were preceded by semantic and phonological primes. Strong semantic priming effects were found at both short (57 ms) and long (200 ms) stimulus onset asynchrony (SOA), but phonological effects were either absent in lexical decision (Experiment 1), were present only at the longer SOA in character decision (Experiment 2) or were equally strong as inhibitory effects, depending on SOA, in phonological judgments to character pairs that were not phonologically but semantically related. It was concluded that, in reading Chinese, semantic information in the lexicon is activated at least as early and just as strongly as phonological information.
Considered together these results implicate the role of syntactic and semantic cues in reading comprehension. Comprehension of text requires extraction of meaning both at the word as well as sentence level. However, metacognitive factors also play an importance role. Further use of an appropriate strategy for comprehending the text is necessary in order to process the input in an efficient manner.

From the review of studies related to reading ability it can be seen that researchers have focused on the structural level, there also, mainly on the phonological aspect. During reading, comprehension is facilitated by faster processing of information, and the phonological route appears to be more appropriate for faster access to the semantic lexicon. Further focus on word recognition, which requires an integration of structural (letter and sentence level) and semantic (word and context level) processing, could further the understanding of reading ability.

Mathematical Ability:

Mathematical ability has also been found to be multicomponential, with simple mathematical skills at the structural and technical vocabulary and higher order cognitive abilities (comprehension of problem, determination of appropriate operations etc.) at the semantic end. However, the differentiation between these two levels does not surface as clearly as for reading ability.

Miura and Okamoto (1989) examined the arguments that differences in mathematical performance between students from the United States and Japan may be due, at least in part, to fundamental
variations in cognitive representation of number that result from differences in numerical language characteristics that differentiate the two groups. Twenty four first graders from each country participated in the study. The result suggest that first graders in the United States and Japan differ in their cognitive representation of number, and that this difference may positively affect the Japanese children's understanding of place value and their subsequent mathematics performance.

Akpan (1991) studied the role of a number of variables (background, mathematical language, problem characteristics) to mathematical problem solving ability. Eight hundred and twenty junior secondary students (512 male and 308 female) were administered a number of tests to assess home background factors (Home Background Factors Questionnaire), cognitive abilities (Test of Comprehension and Application in Mathematics, Test of Computation in Mathematics, Test of Reasoning Ability in Mathematics) affective factors (Motivational Intensity Measurement Scale Creativity Assessment Scale) mathematical language factors (Test of Mathematical Terminology and Symbolism, Test of Mathematical Reading Ability) mathematical problem characteristics factors (Test of Understanding of Mathematical Problem Structure, Test of Understanding Mathematical Problem Content) and mathematical problem solving ability. Path analysis was used to develop a model of mathematical problem solving ability. Cognitive abilities (Comprehension of a Problem Situation, Application of prerequisite skills, computation and determination of most appropriate operations) were found to be the most important variables required in solving
problems in mathematics. Cognitive abilities also exerted positive and significant influence on student’s efforts to understand both mathematical language and problem characteristics factors. Students’ mental abilities were found to be very effective in enhancing their ability to understand both mathematical language and problem characteristics factors. Home environment factors exerted positive and significant effect on students acquisition of mathematical language variables. Student’s attitude towards mathematics, motivation to solve problems in mathematics and creative behaviours also affect understanding of mathematical language. Analysis indicated that cognitive abilities, mathematical language, home background variables and problem characteristics in descending order of magnitude exert positive and significant effects on students problem solving abilities.

Rickard, Healy and Bourne Jr. (1994) conducted two experiments in which college subjects practiced extensively on single-digit multiplication and division problems (e.g. 
- 6+9; 42 = x 6) and were tested on both practice problems and several altered versions of those problems, which were constructed by changing the required operation, operand order, or arithmetic symbol. There was strong positive transfer to test problems that had exactly the same elements (the number and the required operation) as a practice problem, regardless of whether other factors such as operand order or symbol were changed, but little if any positive transfer to test problems that did not have the same elements as practice problems. Thus, it appears that structure of factual arithmetic knowledge
changes as skill improves therefore, cognitive distinction between complementary operand orders largely disappear by adulthood.

Parmar, Cawley and Frazita (1996) compared performance on mathematics word problems having varying structure for students with and without mild disabilities. Subjects were 210 (3rd – 8th Grade) students, 197 of whom had been classified with either a learning disability or behaviour disorder. Subjects were administered 4 sets of word problems involving use of the 4 basic arithmetic operations (addition, subtraction, multiplication, and division), direct or indirect problem statements, extraneous information, and 1 or 2 step solutions. Subjects with disabilities performed at significantly lower levels than did those without disabilities in all cases, even when the problems involved only single – digit computation. Results highlight the need for focusing on problem solving activities rather than computation.

Kaufmann, Montanes, Jacquier, Matallana, Eibl and Delazer (2002) studied the relationship between basic numerical knowledge and arithmetic (facts and procedures) in 19 patients (mean age 74.9 yrs) with probable early dementia of the Alzheimer type (DAT). Results suggest that basic numerical knowledge need not be a prerequisite for the maintenance of arithmetic, but rather corroborate calculation models that postulate the functional independence of its components. The authors suggest that patient specific error types might serve to identify early AD. Follow-up, about 1 yr later, indicated significant qualitative, but only marginal quantitative performance changes.
Barnes, Pengelly, Dennis, Wilkinson, Rogers and Faulkner (2002) investigated the nature of arithmetic computation errors by comparing written subtraction errors in good readers with hydrocephalus, typically developing good readers of the same age, and younger children matched for math level to the children with hydrocephalus. Children with hydrocephalus made more procedural errors (although not more fact retrieval or visual spatial errors) than age matched controls. They made the same number of procedural errors as younger, math-level matched children. The authors also investigated a broad range of mathematical abilities, and found that children with hydrocephalus performed more poorly than age-matched controls on tests of geometry and applied math skills such as estimation and problem solving. Computation deficits in children with hydrocephalus reflect delayed development of procedural knowledge, problems in specific math domains such as geometry and applied math, were associated with deficits in constituent cognitive skills such as visual spatial competence, memory, and general knowledge.

The review of studies related to mathematical ability indicates that numerical languages tend to vary across cultures and differences in number representation tend to contribute to performance differences. Cognitive abilities (like comprehension of a problem situation) significantly influence the students efforts to understand both mathematical language and problem characteristics factors. Students mental ability are very effective in enhancing their ability to understand both mathematical language and problem characteristics factors. Further, mathematical facts and procedures
appear to be independent of basic numerical knowledge. Deficits of procedural knowledge lead to computation deficits, while problems in specific domains such as geometry and applied math may be associated with visual spatial memory, and general knowledge deficits.

Although research investigating the nature of mathematical ability is rather sparse, a number of researchers have implicated the role of language in mathematical ability as deficit in reading and mathematics have been found to coexist.

Lessenger (1925) analysed errors on the Stanford Achievement Test to determine loss in Arithmetic achievement as a result of faulty reading. He found that among poor readers, after one year of instruction in specific reading skills, the loss was all but eliminated.

Hansen (1943) compared sixth-grade children who were superior in solving verbal arithmetic problems with sixth-grade children who were inferior in this skill, and reported that general language ability and the ability to read graphs, charts, and tables were most closely related to the ability to solve arithmetic problems.

Eagle (1948) correlated the average of arithmetic reasoning and arithmetic computation scores on the Stanford Achievement Test, and Semester grades for 159 ninth grade pupils in general mathematics class with several variables including mental age, reading comprehension, reading speed, and general vocabulary. Data of similar character were secured from 162 ninth-grade pupils in an algebra class. High correlation with the average mathematics
score were found for vocabulary, reading comprehension, ability to interpret graphs, and ability to interpret formulas.

Significant positive relationship between reading and arithmetic reasoning was found by Harper (1957) who correlated average reading and arithmetic reasoning scores obtained on the Stanford Achievement Test by 2nd 159 grade pupils in Canada. Statistically significant correlations were obtained, even when age and intelligence were partialled out. He pointed to the advisability of teaching reading in such a way that transfer to problem-solving situations would be facilitated.

Balow (1964) also found that whenever reading skill was important in problem-solving ability, increase in reading ability might well be accompanied by an increase in problem-solving achievement. On the basis of study of 1400 sixth-graders, he concluded that general reading ability had an effect on problem-solving ability; and that one should consider children's reading ability as well as computation ability when teaching problem-solving skills in arithmetic.

Muth (1984) conducted a study of 200 sixth graders where Comprehensive Tests of Basic Skills (1976) and Arithmetic word problems (Arithmetic word-problem test was constructed for use in the present study) were used. Results show that reading ability and computational ability both play important roles in children's successful solution of word problems. The findings also suggest that the presence of extraneous information in word problems can impose a formidable demand on children's limited processing capacities.
Whittington (1988) studied a large sample of 10,000, (11 yr old) subjects. Verbal and non-verbal abilities tests along with reading comprehension and mathematics tests (specially constructed for use in the National Child Development Study by the NFER) were administered to the subjects. It was found that those children who had large verbal and nonverbal differences were more likely to be underachieving in reading comprehension and mathematics or both than children of the same overall ability with more similar verbal and nonverbal components. The rates for “severe” underachievement (2 standard errors below expectation, based on regression of achievement scores on ability scores) were two to ten times greater among the large Verbal-Nonverbal ability differences group of children, nearly 20 percent of whom were severely underachieving in reading comprehension, as were over 5 percent in mathematics.

Rangappa (1993) conducted a study where on 1000 students (Boys, n=587, Girls n=413) of VII grade from rural (n=400) as well as urban (n=600) schools were taken. They were categorized into three levels on the strength of their reading ability; namely high (n=276), normal (n=474) and low (n=250) on the criteria of their reading scores at Q₃, Q₂ and Q₁ respectively. Reading ability test (developed by Gowda and Shivananda) and achievement test for mathematics (constructed by the investigator) were used. Results indicate that reading ability was a potential determinant of achievement in mathematics and levels of reading ability showed a direct bearing on the standard of mathematical performances. High reading ability group displayed significantly higher excellence in mathematics whereas the low reading ability group scored lowest mean.
Light and Defries (1995) examined 148 identical twin and 111 fraternal twins pairs in which at least 1 member had a reading disability and 134 identical and 93 fraternal twin pairs (8-20 yrs) with normal reading comprehension who were administered tests of verbal and mathematics ability and I.Q. It was found that genetic and shared environmental influences appeared to contribute almost equally to the observed covariance between reading and mathematics scores.

Rasanen and Ahonen (1995) examined the relationship between reading performance (speed and accuracy) and arithmetic errors in 2 experiments with 80 Finnish 3rd-6th graders with retrieval deficit, arithmetic disabilities (AD) and 80 controls. Wide Range Achievement Test Revised (WRAT-R) and RMAT (Rasanen, 1992) tests were administered to the students. Data indicated that reading accuracy and speed were connected to errors in multiplication fact retrieval. It was concluded that difficulties in arithmetic fact retrieval and reading speed may share a common underlying factor.

Pancholi (2001) conducted a study on 780 pupils of standard VI. Anxiety Inventory (Desai), Reading Ability Test (by Patel and Vora), Junior Eysenck standardized inventory (JRPI) (translated and standardized by Desai), conceptual understanding of arithmetic vocabulary, conceptual understanding of arithmetic computation, conceptual understanding of geometrical vocabulary, conceptual understanding of geometrical computation were administered to the students. Results show that reading ability was the strongest predictor of conceptual understanding of mathematics, while sex was also a predictor of conceptual understanding of mathematics.
Jordan, Hanich & Kaplan ((2003) examined mathematical competencies of 180 children at 4 points between 2nd and 3rd grades (age range between 7 and 9 years). Children were initially classified into one of 4 groups: math difficulties but normal reading (MD only), math and reading difficulties (MD-RD), reading difficulties but normal math (RD only), and normal achievement in math and reading (NA). The groups did not differ significantly in rate of development. However, at the end of 3rd grade the MD only group performed better than the MD-RD group in problem solving but not in calculation. The NA and RD only groups performed better than the MD-RD group in most areas. Deficiencies in fact mastery and calculation fluency, in particular were found to be defining features of MD, with or without RD.

These studies show that there is a strong connection between reading and mathematical ability as reading deficits lead to lower arithmetic achievement. Genetic and shared environmental influences may contribute almost equally to the observed covariance between reading and math scores. High reading ability group show a better performance in mathematics although reading ability and computational ability both play important roles in children's successful solution of word problems. Children's reading accuracy and speed also correlated with errors in multiplication fact retrieval. It appears probable that difficulties in arithmetic fact retrieval and reading speed may share a common underlying factor. Reading ability also predicts the conceptual understanding of mathematics as students who have good vocabulary and reading comprehension skills, also have good ability to interpret graphs and formulas. Thus, it
appears that reading and mathematics might share a common underlying neuropsychological factor.

**NEUROPSYCHOLOGICAL BASIS OF READING AND MATHEMATICAL ABILITY**

A number of researches have implicated the role of neuropsychological functions and specific brain areas in reading and mathematical deficits.

**Reading Deficits:**

Batchelor, Kixmiller and Dean (1990) studied 1, 347 learning disabled children. Scores on the Halstead-Reitan Neuropsychological Test Battery and Wechsler Intelligence Scale for Children-Revised (WISC-R) were regressed on both reading and spelling subtests of the Wide Range Achievement Test. Data suggest that when reading and spelling problems coexist, deficits in verbal attention and short term memory, remote verbal memory, language integration, nonverbal concept formation, and upper-body motor functions may be expected for subjects with poor reading skills.

Kappers (1990) conducted a single case study involving neuropsychological treatment of a highly gifted dyslexic 8 – year old male. The relationship between cerebral lateralization and reading disability is outlined. Remedial perspective for weak readers on the basis of the amenability of hemispheric control by external factors are illustrated with this case. The neuropsychological changes during the treatment period appear to parallel improvement in reading strategy and level.
Leavell and Lewandowski (1990) examined the relationship between cerebral laterality and neuropsychological functions (particularly phonemic analysis) in 20 reading disabled (RD) and 20 non-reading disabled (NRD) 8-12 yrs. old boys. Compared with NRD subjects, RD subjects exhibited equivalent right ear and left hemispheric superiority for reporting dichotically presented words. However, even with experimental control for attention, RD subjects performance was poorer than that of NRD subjects in both left and right ears. RD children displayed poor performance on 9 scales of the Luria Nebraska Neuropsychological Battery (Children’s Revision) and had most difficulty with the scales and items designed to tap left-hemispheric dysfunction. Data were interpreted as supportive of the notion the RD children display similar patterns of general hemispheric specialization as NRD children, but have problems with specific, and predominantly left hemispheric, cognitive processes which are critical to reading.

Felton, Naylor and Wood (1990) assessed 115 adults (aged 20.2 - 44.6 yrs.) with well-documented childhood reading status using a series of neuropsychological tests including tests of memory, attention, phonological processing, and visual perceptual skills. Compared with 28 normal controls, subjects with a history of reading disability performed more poorly on most neuropsychological tests. However, after covarying for intelligence and socio-economic status (SES), only tests of rapid naming, phonological awareness, and non-word reading were significant discriminating measures, thus indicting that phonological processing comprise the core cognitive deficits in adults with a history of reading disability.
Cossu, da-Prati and Marshall (1995) report the case of a right-handed Italian boy who sustained extensive left hemisphere damage after a massive subarachnoid hemorrhage at the age of 12 years, while the right hemisphere was fully intact. Two years later, the subject had a residual anomic aphasia with good sentence construction and comprehension of speech. His reading aloud showed all the characteristics of deep dyslexia, although some minimal ability to read pseudowords remained. Writing and spelling were severally impaired, but without clear qualitative signs of deep dysgraphia. The subject’s pattern of performance is discussed with regard to the written language capacity of the non-dominant right hemisphere and its contribution to normal reading. It is concluded that the subject’s reading and writing may be mediated by a combination of left and right hemisphere sites.

Olson (2001) collected quantitative EEG data from 15 precocious readers, 15 age level matched readers and 15 reading level matched readers during eye closed, resting condition. Age level matched readers were normally reading children matched by age, gender, and full scale IQ. Reading level matched readers were normally reading children matched on variables of gender and reading level. Hypotheses predicted that early readers would display more mature brain functioning, and based on previous research, differences in lateralization, and EEG coherence in areas known to be associated with reading were predicted. Developmental correlates of brain maturation and reading ability were investigated. EEG relative power and coherence were the measures used. Significant differences were observed among the three groups and trends
suggest that early readers may have some areas of more mature brain functioning.

Brauer, Swerdloff, Miller, Geschwind, Razani, Lee, Gaw-Gonzalo, Haddal, Rankin, Lu and Paul (2001) examined whether 35 men (age 16-61 yrs) with Klinefelter syndrome would show deficits in language processing and a learning disability in reading and spelling. Klinefelter subjects and 22 male controls were evaluated with a comprehensive neuropsychological battery. Klinefelter subjects scored significantly below controls in language skills, verbal processing speed, verbal and non-verbal executive abilities, and motor dexterity. Within the Klinefelter sample, 3 cognitive subgroups were identified. Verbal IQ (VIQ) 7 or more points below Performance IQ (PIQ), VIQ within 6 points of PIQ, and PIQ 7 or more points below VIQ. The deficits detected in language, verbal processing speed, and verbal executive skills were found to be isolated to the VIQ<PIQ subgroup, while the abnormalities in motor dexterity and nonverbal executive skills were confined to the PIQ<VIQ subgroup. Older age was significantly correlated with increases in VIQ, relative to PIQ in the patient group, which suggests the possibility that the PIQ<VIQ subgroup, primarily emerges in young adulthood, perhaps in response to the reported hormonal abnormalities detected in Klinefelter syndrome patients during puberty.

Taylor and Regard (2003) studied evidence for a right hemispheric involvement in language processing, in particular at the level of word meaning. Hemispheric functional specializations were found to be dynamic; right hemispheric language participation significantly increased under certain conditions, such as during an
epileptic seizure and during recovery from stroke. Interhemispheric connections via the corpus callosum critically mediated these and other higher cortical functions.

Larsen, Baynes and Swick (2004) investigated the implicit, or covert, reading ability of a global alexic patient (EA) to help determine the contribution of the right hemisphere to reading. Previous studies of alexic patients with left hemisphere damage have suggested that the ability to derive meaning from printed words that cannot be read out loud may reflect right hemisphere reading mechanisms. Other investigators have argued that residual left hemisphere abilities are sufficient to account for implicit reading and moreover do not require the postulation of right hemispheric mediation. However, very few studies have assessed covert reading in patients with lesions as extensive as the one in EA, which affected left medial, inferior temporal-occipital cortex, hippocampus, splenium, and dorsal white matter. EA was presented with lexical decision, semantic categorization, phonemic categorization and letter matching tasks. Although EA was unable to access phonology and could not overtly name words or letters, she was nevertheless capable to making lexical and semantic decisions at above chance levels, with an advantage for concrete versus abstract words. Her oral and written spellings were relatively intact, suggesting that orthographic knowledge was retained, although inaccessible through the visual modality. Based on her ability to access lexical and semantic information without contacting phonological representations, it was proposed that EA’s implicit reading emerges from, and was
supported, by the right hemisphere, thus indicating that her spelling and writing abilities were supported by left hemisphere mechanisms.

**Mathematical deficits:**

Golden and Berg (1983) examined the intercorrelations among the items on the Arithmetic scale of the Luria-Nebraska Neuropsychological Battery and the remaining items on the test battery. This examination allowed an empirical investigation of the common skills or cortical areas involved in the performance of seemingly different items across the scales of the battery. The correlations demonstrated the commonality between scores on Arithmetic items and a wide variety of both verbal and nonverbal skills, reflecting the complexity of performance on arithmetic type items. In general, the correlations were supportive of Luria's (1973) ideas regarding the multi-factorial nature of basic arithmetic skills. The interpretation of deficits demonstrated that performance on the Arithmetic scale was not a single matter and could be aided and clarified to some degree, although the use of other Luria test items in conjunction with those that comprise the Arithmetic scale yield a more complete picture of the extent and nature of a deficit.

Deloche, Seron, Larroque and Magnien (1994) described the structure and contents of the EC 301 (Deloche et al, 1989), a standardized testing battery for the evaluation of brain-damaged adults in the areas of calculation and number processing. The battery was administered to 180 normal adults (aged 20-69 yrs) stratified by education, age and gender. The EC 301 is composed of a large variety of tasks dealing with basic arithmetic skills and their linguistic,
spatial, and amnesic dimensions. The 3 main notational systems for numbers (Arabic digit, written verbal, and spoken verbal number forms) are explored. Analysis of error rates indicated the effect of some demographic factors (principally, education; incidentally, gender) on performance in some tasks.

Fayol, Barrouillet and Marinthe (1998) conducted a study to determine whether a neuropsychological test could predict performance on arithmetic tests independent of the level of development of the subjects. One hundred eighty nine nursery school children participated in the first battery of tests and 177 of the same children participated in second battery the following year. Three types of tests were administered in each battery, neuropsychological tests, an intellectual development test, and arithmetic tests. A correlation was found between performance on neuropsychological tests and arithmetical performance. The longitudinal nature of the study allowed the researcher to predict the direction of the connection as the neuropsychological test predicted > 20 % of the variance on the arithmetic test administered to the same children one year later. Thus, neuropsychological score appeared to be a determining factor of arithmetic performance.

Delazer, Girelli Semenza and Denes (1999) investigated numerical difficulties in 50 patients (aged 22-83 yrs) with left hemisphere lesions. The overall error rate in various transcoding and calculation tasks was clearly correlated with the severity of the language deficit, global aphasics being the most impaired patients. The results supports the fact that the retrieval of multiplication facts is preferentially mediated by verbal processing.
Seidman, Biederman, Monuteaux, Dajle and Faraone (2001) studied the effect of comorbid reading or arithmetic learning disabilities (LDs) on neuropsychological function in attention–deficit/hyper activity disorder (ADHD). Participants were young males diagnosed with ADHD, with and without LD, and non–ADHD and non-LD male controls of similar age. Children who had both ADHD and LD were significantly more impaired on both executive and non-executive functions than ADHD children without LD. Neuropsychological performance was most impaired in ADHD with combined arithmetic and reading disability. Thus, this data indicates that comorbid LD, especially arithmetic disability, significantly increases the severity of executive function impairment in ADHD.

Taken together, these studies indicate that verbal attention and short term deficits, remote verbal memory, language integration, non-verbal concept formation and upper body motor functions are associated with reading and spelling problems. With regard to hemispheric mediation, it appears that reading and writing are mediated by a combination of left and right hemispheric sites. Neuropsychological change parallel improvements in reading strategy and level. Further deficits in language, verbal processing speed and verbal executive skills exist in individuals, whose verbal I.Q. is more than 7 points below performance I.Q. Earlier studies have also shown than large verbal-nonverbal I.Q. differences are associated with lower reading achievement thereby implicating the role of these functions in reading. Although research in neuropsychological basis of mathematics is rather sparse, it is evident that neuropsychological scores are good predictors of
arithmetic performance. Further left hemispheric deficits have been found to be associated with numerical deficits. However, co-existence of reading and mathematical deficits implicate the existence of a neuropsychological link between the two abilities.

Considered together the review of studies indicated that there was a positive relationship between reading ability and school achievement. Intelligence seems to an important predictor of reading ability and mathematical ability. In case of mathematical ability a positive correlation was reported between verbal intelligence test score and school examination marks in elementary mathematics. Gender differences were observed only in the case of mathematical ability. Females were found to be better at the computational and males at the conceptual and application aspect. Studies of reading ability indicated that phonological ability seems to be a good predictor of reading ability. It is found that children, who have language problems in early age, suffer from both phonological processing and oral language. Phonological ability of a child is influenced by his/her knowledge of orthographic and syntactic rules. All these also affect the reading ability of a child. On the higher order processing, word recognition and comprehension factors also play an important role in reading ability. Comprehension of text requires extraction of meaning both as the word as well as sentence level. Strategy of comprehending the material used by the reader makes the material more effective. Studies indicated that both structural and semantic levels are important for reading. But studies related to reading ability focuses more on the phonological aspect as compare to other aspects. It seems that phonological aspect is a good predictor of
reading ability. Mathematical ability has also been found to be multicomponential. Studies related to mathematical ability indicate cross cultural differences in mathematical ability. Cognitive abilities (like comprehension of a problem situation) significantly influence the student’s efforts to understand both mathematical language and problem characteristics factors. It is found that different students use different type of strategy for solving the problems. Deficits of procedural knowledge lead to computational deficits. Both the abilities seem to very important for a student’s success. Studies related to reading and mathematical ability show a strong relationship between these two abilities. It is found those children who have a good command on reading ability, show good academic achievement in mathematics. Mathematical computational skills are also influenced by reading skill. Those students, who have good vocabulary and reading comprehension skills, also have good ability to interpret graphs and formulas. Thus, it is evident that reading and mathematical abilities share a number of commonalities at the cognitive level. Reading and have been found to be mediated by a combination of left and right hemispheric sites. Earlier studies have also shown that large verbal-nonverbal I.Q. differences are associated with lower reading achievement thereby implicating the role of these functions in reading. It is found that neuropsychological scores are also good predictors of arithmetic performance. However, co-existence of reading and mathematical deficits implicate the existence of a neuropsychological link between these two abilities.