CHAPTER I

INTRODUCTION

Language is a human ability which has contributed to the advancement of the human species. It affords us the opportunity to transgress the physical boundaries of time and space. We can know about the past, deal with the present or visualize the potential future. In fact, it is the central human activity which is used almost continuously, as people talk, read, write, listen to others or while thinking, listen to their own inner voice. Acquisition of language is seemingly effortless as it is acquired without formal training, at a genetically predisposed period, during development. A lot of researchers have debated on the basic nature of language i.e. whether it is biologically built into our system or it is a cultural artifact. The identification of a specific brain area which controls grammar (Broca's area, located in the posterior temporal region of the frontal lobe of the left cerebral hemisphere, at least for right handed people), critical developmental period for its acquisition and existence of a universal grammar, have provided support for the biological view. Chomsky (1980) proposed that the human brain has a representation of general principles common to all languages. During first language learning, the principles of that specific language are learnt. As the critical period ends, the brain becomes less flexible and the innate ability to acquire another language is reduced. Further, the universality of language, inspite of existence of diverse languages, is evident from the fact that all languages have three common features. Every language comprises of its specific vocabulary made up of
arbitrary associations between sounds and ideas, a set of grammar rules for combining sounds into words and sentences and a variety of medium (auditory and visual) by which it can be implemented. The auditory form of language involves speech production (speaking) and speech perception (listening) while the visual form involves graphemic presentation (reading) and production (writing).

The smallest unit of the spoken language is a phoneme while that of the written language is a grapheme. Graphemes/phonemes join together to form a morpheme which is the smallest meaningful unit, which can be combined to form complex words which further combine to form propositions or sentences. Thus, the smallest unit of language, whether spoken or written is a word. Generally at the time of initiation of reading an individual has good command on spoken language i.e. they have a wide vocabulary and comprehension skills. During the initial stage of learning to read, the visuals signs are analysed and linked to appropriate sounds which are combined to form words. The spoken form of the word helps the reader to access its meaning. However, sound production need not be oral, it can be in the form of covert speech where the sound is produced at a cognitive level i.e. inner speech. As the reader becomes most skillful dependence on the phonetic route gets reduced and the visual signs are directly converted into meaning. Generally two routes from print to sound, a lexical semantic route and a sublexical phonological route, have been proposed. However, a third route involving a direct connection between lexical-orthographic and lexical phonological representation has been hypothesized by some researchers. A model proposed by Ellis and Young (1988) presents an integrated
Figure 1  Cognitive routes for conversion of written word to speech (Ellis & Young, 1988)
form of these cognitive routes (Figure 1). They proposed that a written word initially enters the visual analysis system where letters are identified as a group. These are converted into the associated sounds at the cognitive level which in turn lead to the production of distinctive sounds which are associated with the written word (i.e. combination of phonemes to produce word). However, the conversion of written word into speech can also occur via two other alternative routes. Here input is passed from the visual analysis system directly to the visual input lexicon where the written word is recognized as familiar. From here, input passes to the speech output lexicon (store of spoken form of words) either directly or through the semantic lexicon (which contains meaning of words). Finally input is passed to the phoneme level, where speech is produced.

Thus, during reading, an individual can either convert letters directly into sounds which further combine to form a spoken word or the written word might directly be spoken and identified by activation of the visual-semantic/phonetic link. The interaction activation model (McClelland and Rumelhart, 1981) provides an account for this process. The model proposes the existence of a visual analysis system composed of a feature and a letter level. Beyond this is the visual word recognition system. Activation from feature moves to the appropriate letter and then word level, where at each level similar units are initially activated and in the end only one unit wins through and stays active. However, higher level units can be stimulated before a lower level decision is made and both bottom-up (feature to word) and top-down (word to letter) processing occurs. Reading however involves much more than only recognizing a word, as
meaning of the individual words has to be integrated to construct meaningful sentences, passages etc. The specific role played by the word in the sentence has to be judged which helps to access the meaning contained in the sentence. However, a sentence at times implies a fact which has to be identified by the reader, as already stored in his memory, in order to comprehend the sentence. The reader in turn, on the basis of past stored information, expects a certain form of content while reading a certain kind of text. Thus, reading appears to involve not only simple grapheme-phoneme conversion but banks heavily upon the cognitive reservoir of past knowledge and expectation. The cognitive processes involve in reading can be segregated into basic (structural) and higher order, (semantic) processes.

During the initial stages of learning to read, or while reading unfamiliar text, where the words have not been earlier experienced in written form, orthographic processes assume primary importance. An experiment by Cosky (1976) provides support for this fact. He classified letters as easy or difficult and then tested the time required to pronounce words varying in the discriminability of the letters, length and frequency of usages. Shorter and more frequently occurring words were pronounced faster while there was no evidence of the discriminability of letter on reaction time. The reason for this could be that speed of recognition of a word depends on the speed of discriminating the least discriminable single letter, as the cognitive system processes several letters at the same time. Thus, a word can be recognized without recognizing all the letters which comprise the word as familiarity of the sequence of letters influences word
recognition. This is evident from the fact that orthographically regular strings are generally identified faster (Baron, 1979; Gibson, Pick, Osser & Hammond, 1962), but, this effect has not been found to be universal as some experimenters (Manelis, 1974; McClelland and Johnston, 1977) did not report such differences. However, shape of the word has been found to affect word recognition as is evident from experiments where word superiority effect has been reported (McClelland, 1976; Reicher, 1969). The fact that perception of a string of letters as a word inhibits identification of the letters that makes it up is evident from the fact that letter cancellation performance decreases when working with words in comparison to list of letters and errors are more with high frequency words (Healy, 1976). However, the role of orthographic mediation appears to be more pronounced in the early stage of lexical access where the reader cannot recognize the word (Feng, Miller, Shu, and Zhang, 2001).

Orthographic processing appears to be reciprocally related, rather than independent of phonological processing, as the written word provides the stimuli for vocalization of the word (Springer, Siegel, Bechennce & Scrnicaes, 2003). During reading the interpretation of visually presented words appears to be mediated by a phonic mechanism. Reading is accompanied by an inner speech or sub-vocalization where the individual has the experience of hearing the words by a mental voice. Another reason which implicates phonetic mediation is that a reader is better versed in speaking and listening and therefore converts the visual signs into the auditory form for ease of understanding. Poor phonological skill
have been found to be a characteristic of reading disabled children (Lopez & Gonzalez, 1999) who show a phonemic awareness deficit when they are compared with normal children and poor readers have pronunciation difficulty. However, phonetic mediation appears to be a strategy for regular words and at times the correct pronunciation is identified only after identification of the meaning (e.g. word such as minute and tear). Further, patients suffering from dyslexia, who are unable to read aloud nonsense words, indicating the absence of the usual sound conversion rules necessary for pronunciation (Funnell, 1983; Patterson, 1982), can pronounce and understand familiar words indicating that the phonic mediation is not the sole basis of reading.

The ability of a reader to combine words into sentences is influenced by his basic knowledge of syntax. A reader generally has a basic knowledge of grammar, which is gained unconsciously while learning the spoken language. Syntax provides the individual with a capability of deciphering sentences during reading. Syntactic knowledge allows prediction of syntactic categories and grammatical relations. A reader can figure out the meaning of novel phrases and sentences in terms of syntax as he is able to assign each word to a specific category such as noun, verb, adverb etc. Since every language have some consistent syntactic rules on the basis of which phrases are constructed (placement of syntactic head, use of inflections on the nouns etc.), knowledge of these rules helps the reader to assign correct roles to words within a phrase and phrases within the sentences. Another advantage of syntactic analysis is that the sentence is broken up into smaller units (chunk) which helps the
reader to transform a long sentence into three or four phrases where number of items within the phrase can be held in the working memory and thereafter processed (Kintsch & Van Dijk, 1978; Mandler & Johnson, 1977). It also provides a cue to the reader regarding the hierarchy of important aspects within the text. The information contained in the main clause is generally better remembered than that in a subordinate clause (Kintsch, 1974) because of the greater relevance given to the main clause.

Thus processing at the structural level enable a reader to identify and decipher visual information and effect necessary conversions which are a prerequisite for the higher order processing which leads to accessing the meaning of the written text. Higher, order processing relates to assigning meaning to the visual/auditory signs contained within the context of the sentence. Processing at this level is also interactive in nature, as the reader vacillates between the word and sentence level. During reading, recognition of word and activation of its corresponding unit in the semantic lexicon is necessary. The written form of the word gains access to the semantic store by the visual auditory route. The existence of the semantic lexicon which contains decoded form of the written word has been established from studies of patients who can repeat familiar word but find it difficult to understand it i.e. word meaning deafness (Ellis, 1984) and deep dysphasics who say words related in meaning to the words they are supposed to be saying. However, these patients do not make errors while reading the words (Michael & Andreewsky, 1983) indicating that the access to the semantic system can be made independently by the visual and auditory input. Word recognition
skills are more important in determining the overall reading skill of children as compared to adults. However, adult skilled readers have been found to pronounce words faster than less skilled readers (Perfetti, 1985). Surprisingly, speed with which words are pronounced has been found to be more predictive of reading comprehension than accuracy of pronunciation. The reason could be that speed of pronunciation, which reflects the extend to which word recognition has become automatic, reflects the degree to which the now surplus attention processes can be used for comprehension purposes. In fact good readers are able to assign meaning to words independently while poor readers use the sentence context to speed up word recognition (Stanovich, 1980). They also recognize words twice, as faster as compared to poor readers (Perfetti, 1985). Thus, a rich vocabulary and decoding skills contribute to better reading performance.

However, a good vocabulary is acquired not through rote associations but rather it is learnt by using contextual information to draw plausible inferences about the meaning of an unknown word (Sterberg, 1985). A similar active processing and inference drawing is also used in reading comprehension. Reading comprehension deficits have been found at two levels i.e. a local (word meaning) level and at the text level. At a local level, the meanings of individual words are necessary to understand texts and certain difficult words are difficult for children to understand (Beck, Perfetti & McKeown, 1982). This can account for the close link between vocabulary and reading skills. Infact, the use of a new word in a different context and linking related words together, by poor readers has been found to
lead to better comprehension of those words rather than simple learning of word definitions (McKean, Beck, Omanson & Pople, 1985). Approximately 10-15% of children between 7-9 years have been identified to have specific reading comprehension difficulties (Stothard & Hulme, 1992; Yuill & Oakhill, 1991). Since a relationship between reader’s comprehension and working memory performance has also been found, poor working memory has been attributed to learning disabled reader’s comprehension of text (Shankweiller & Crain, 1990; Swanson, 1993). However, when individual differences in word knowledge are partialled out, the relation between working memory and comprehension become weak which suggests that word knowledge plays an important role in the relationship between working memory and comprehension.

Thus, the command of a reader on language contributes to a large extend to comprehension. At the text level, the syntactic, semantic and inferential cues assume importance as failure to identify the underlying structure i.e. the main theme of the text, can lead to reading skill deficits. Children with poor comprehension skills, when trained to think about the structure of the text being read and to ask questions in order to pinpoint the main theme, show drastic improvement (Palincsar and Brown, 1984). Other important factors which contribute to the comprehension process at the text level is the schema and relevant knowledge as they enable the reader to draw appropriate inferences (Bransford & Johnson, 1972; Pearson, Hansen & Gordon, 1979). Thus, reading involves complex information processing, which can be in a bottom-up or top-down manner (Pearson & Spiro, 1980). Bottom up or outside in processing is
considered to be text driven where information presented on a page and represented by written symbols is visually and linguistically analyzed to determine meaning. The second type is top-down or inside-out (Smith, 1975) processing. Unlike text based processing, top down processing requires that the reader make hypotheses regarding the information based on knowledge already possessed. This knowledge of course results from previous learning and experiences as well as from the values and attitudes the reader has acquired.

Incongruence between the two levels of processing i.e. basic and higher order have been reported in children with reading difficulties and disabilities. Poor readers have been reported to have inappropriate patterns of eye movements (Pavildis, 1981; Rayner, 1978), do not use 'word attack' skills effectively and do not follow the normal sequence of skill development (Frith, 1985). Although, it had been purported that poor readers have problems in extracting visual information from their environment, contradictory results have also been reported (Done and Miles, 1978; Mitchell, 1982). Dyslexic children have normal range intellectual abilities but have difficulty in learning to decode printed words. In contrast to their weak word recognition, many dyslexic children comprehend well (Showling, 1987; Shywitz, 1996). Patients suffering from phonological dyslexia (surface dyslexics) can pronounce and understand familiar real words but are unable to read simple non-words (trigrams). Their route for translating words to sound by reading aloud is damaged but that from visual analysis process to the semantic lexicon remains intact (Patterson, 1982). However, deep dyslexics who also suffer
from the same problem, commit many more visual and semantic errors, thereby suggesting a failure in the identification of word meaning (Ellis, 1993). On the other hand hyperlexic children have comprehension difficulties but possess well developed word-recognition skills. Individual differences in word recognition are largely accounted for by differences in phonological skills, whereas individual differences in comprehension may be a consequence of differences in semantic and syntactic processing skills. Thus, it appears that the structural and semantic processes involved in reading are independent and there is an interaction between the two levels independently at the word and syntactic level.

Another area of cognitive processing i.e. mathematical ability which has often been found to be closely associated with reading ability, presents a similar cognitive picture. The smallest units of processing - numerals and operands - like phonemes and graphemes are abstract symbols which are assigned an arbitrary meaning by association with a particular concrete unit or process. The association is learnt and the representation of the symbols can be in varied forms such as numerals (Arabic, or Roman), verbal, (visual or auditory), concrete (pictorial arrays) or collection of concrete units. It is assumed that at the cognitive level the mental representation of these units form an analogal abstract mental representation which might be an integral associative representation (Campbell and Clark, 1992), an analogal representation (Dehaene, 1992), amodal abstract representation (McCloskey, 1992; McCloskey, Macaruso & Whetstone, 1992; McCloskey, Sokol & Goodman, 1986; Sokol, McCloskey, Cohen & Alimomina, 1991) or a
single uniform representation which is specific to each individual (Noel & Seron, 1992, 1993).

The symbols, i.e. numerals and operands can be combined to assume an absolutely different meaning in very much the same way as letter combine to form words and words to sentences. Single digit numerals can be combined to form multidigit numbers where meaning of a digit assumes a different meaning in terms of its position in the digit i.e. tens, hundred, thousand etc. The digit can further be combined with different operands to give rise to completely different relations and meaning. The synthesis of the digit and operand is governed by specific rules as formation of words and sentences are governed by syntactic rules. Learning of these rules occurs through algorithmic learning (Gagne, 1970) as various kinds of situations are experienced by the learner. During this process the relationship between the various operations and facts are learnt e.g. initially for working out single digit problem (3 \times 7 or 7 +7) consciously mediated counting algorithms are used but with repeated practice the same can be retrieved directly from memory (Rickard, Healy and Bourne Jr., 1994). Thus, acquisition of arithmetic skills leads to faster computation as the necessity of consciously combining individual units to form the meaningful whole or consciously processing the units is vastly reduced. The basic processes are thus executed in an automatic manner in very much the same way as reading becomes automatic with learning to read and the individual progresses to the next level i.e. reading to learn. Here also, in case of mathematics after acquisition of the basic skills an individual can proceed to the next level where computations are
no longer of primary importance. Here also the processing has been reported to be interactive in nature. During retrieval multiple facts become active to the extent that they are in some way similar with the problem or have been primed and these primed units compete with one another, until one representing (generally the correct one) reaches a high enough level of activation to be selected as the answer.

Thus, it appears the basic structural processes, involved in both reading and mathematics are very much similar.

At the higher order processing level i.e. semantic level also, a simile can be drawn between the processes involved in reading and mathematics. Here, two higher order processes i.e. vocabulary (concepts identification) and selection of problem solving strategy can be identified. Mathematical vocabulary plays the same role as language vocabulary plays in reading. Mathematical vocabulary can be conceptualized as the mental representations of mathematical concepts and facts which are acquired through past experiences, i.e. initial algorithmic learning. It has been reported that extent of mathematical vocabulary plays an important role in comprehension of mathematical problem (Sen, 1949). Thus, the units of mathematical vocabulary can be conceptualized as a kind of network of mental representation where connections are established between concepts as in the case of fraction, ratio rate, percentage, decimal etc. This leads to the development of the ability of selection and exchange between the various kinds of operations. As the mathematical skills of an individual improves the concepts progress from a concrete to formal operation stage as nature of concepts changes from logical
and concrete to an abstract form involving computation and permutation (Piaget and Inhelder, 1975).

Similar to reading an active and inference drawing process helps in comprehension of complex problems. Here a hypothetical, concrete or abstract situation presented to the individual assumes meaning when the conceptual units, operand and relationship between them, are comprehended in the given context. This further leads to the selection of appropriate problem solving strategies.

Considered together it can be seen that the cognitive processes involved in mathematics can be broken down into structural and semantic components in very much the same way as in reading. However, the basic structural processes of mathematical ability are generally referred to as computational processes while the higher order semantic i.e. comprehension processes while the higher order semantic i.e. comprehension processes are refer to as the conceptual processes. However, the basic structural processes of mathematical ability are generally refer to as computational processes while the higher order semantic i.e. comprehension processes are refer to as the conceptual processes. Further support for the independence of the structural and semantic components of reading and mathematical abilities is available from investigations of learning disabilities where specific functional deficits or brain areas have been implicated in reading / mathematical deficits at the basic or higher order level. Neuropsychological deficit in visual-perceptual skills, auditory processing, language skills, attention and motor skills have been found to result in learning disabilities. Performance of children with both mathematical (MD) and reading disability (RD) and
only MD children, on neuropsychological measures indicate that a left hemispheric deficit resulting in verbal deficit can be implicated in RD and MD. However, MD only group showed visuo-spatial deficit implicating the role of right hemisphere (Rourke and Finlayson, 1978; Rourke and Strong, 1978). Spatial skills have been found to be related with strategy choices in addition but not speed of retrieval. Further, visuo-spatial skills are important for counting and solution of arithmetic problem and thus their importance declines once fact retrieval becomes automatic (Hartje, 1987). In most individuals, the left hemisphere responds to language stimuli such as inner thought, words, symbols that have verbal meaning, and memory for verbal material (Luria, 1976). Because of the left hemisphere's use of words to reason, it plays an important role in skilled reading, mathematics analysis, and computation.

Damage to the posterior regions of the left hemisphere have been found to result in difficulty in the retrieval of mathematical facts from long term memory (McCloskey, Aliminos & Sokol, 1991; Warrington, 1982). Difficulties in execution of arithmetic procedures (Ashcraft & Faust, 1992 Spires, 1987) and verbal deficits are found to co-occur typically with these fact-retrieval deficits (McCloskey, Aliminos & Sokol, 1991; Richman, 1983; Rourke & Strang, 1978; Sokal, McCloskey, Cohen & Aliminos, 1991).

The multifactorial nature of basic arithmetic skills has also been demonstrated by the correlations observed between common skills, cognitive skills, and cortical areas with arithmetic items on Luria Nebraska Neuropsychological Battery (Golden and Berg, 1983). Further performance on neuropsychological tests have been reported
to predict 20% of the variance to the arithmetic test administered to the same children one year later (Fayol, Barrouillet and Marinthe, 1998).

Thus, these studies indicate that dysfunction can occur in a particular component of mathematical ability while others might be relatively unaffected. Further, different areas appear to be responsible for different mathematical functions. Similarly in case of reading ability both, right and left hemisphere have been implicated.

Neuropsychological studies reveal that several portions of the temporal, prefrontal, and visual areas of the brain are involved in language processing (Neville, Mehler, Newport, Werker and McClelland, 2001). Two specific regions in the left hemisphere have been found to play a special role in the ability to use language. The first is Broca’s area, located in the left frontal region near the motor cortex. Patients who have damage in this region evidence expressive aphasia, or the inability to speak fluently, although their comprehension abilities remain intact. The second region, Wernicke’s area, is in the temporal region of the left hemisphere, close to the areas of the brain responsible for auditory processing. Damage in Wernicke's area results in receptive or sensory aphasia, in which speech seems fluent – at least on the surface but contains nonsense or incomprehensible words; the ability to understand the speech of others is also impaired. An important finding is that these children are more likely than adults to recover language functions following injury to the left hemisphere (Annett, 1973; Basser, 1962), an illustration of the brain’s greater plasticity during childhood. Temporal Parietal lesions have been found to result in an inability to mentally visualize
letters and words. However, access to the visual lexicon could be
gained through mental imagery for non-orthographically (kinesthetic)
perceived items showing that separate codes i.e. visual or motor can
be used to access the mental representation of the visual form of
letters and words (Bartolome, Bachoud, Chokron & Degos, 2002).
Studies of dyslexic and hyperlexic patients have provided a major
insight into the neuropsychological basis of reading. Studies show
that surface and deep dyslexics differ in terms of the route of
processing of written word into speech where surface dyslexics use
the grapheme-phoneme conversion and deep dyslexic use the
semantic route. Phonological dyslexic on the other hand use the
visual input speech output lexical. Further, deep dyslexia represents
reading which relies extensively on right hemispheric, orthographic
and semantic processing.

In Aphasic patients grouped according to their type of aphasia
(Amnesia, Broca, Global, Wernicke or none), overall error rate in
various transcoding and calculation tasks was found to be correlated
with the severity of the language deficit. Global aphasics were found
to be most impaired, Broca’s and Wernicke’s aphasics scored
similarly at the quantitative level and amnesia aphasics were least
impaired. Qualitative analysis of numerical errors reflected the nature
of the language problems. In simple calculations multiplication was
found to be the most impaired operation, in particular in Broca’s
aphasics implicating the role of verbal processing in mediation of
multiplication facts. Calculation procedures were mainly impaired in
Wernicke’s and Global aphasics (Delazer, Girelli, Semenza & Denes,
1999).
These studies indicate that RD and MD might co-occurs because of a common underlying neuropsychological deficit, perhaps involving the posterior region of left hemisphere. At the cognitive level, this deficit manifests itself as difficulties in the representation and retrieval of semantic information from long term memory. It seems that different areas of brain are involved in different components of reading and mathematical ability. Left hemispheric regions seems to be important for writing, comprehension, language functions etc. Further, it has been demonstrated that retrieval of arithmetic fact from long term memory and underlying memory representation show the same characteristic as representation and retrieval of verbal information.

The relationship between reading and mathematical ability receives further support from the fact that general intelligence and non-cognitive abilities have been observed to have a similar effect on both the abilities. Intelligence has been found to be an important contributor to both where even the non-verbal component plays an important role. Differences in verbal and non-verbal abilities are not just the natural extremes of a continuum and they may have disturbing consequences in terms of school achievement. It is possible that relative strengths of verbal and nonverbal abilities fluctuate during development with corresponding variation in levels of achievement in reading and mathematics. In this case it is possible that persistently large verbal-nonverbal differences are predictive of long-term underachievement and of neurological abnormality (Whittington, 1988).
Both reading and mathematical abilities are also associated with school achievement. Research findings revealed that there is a significant correlation between reading ability and school achievement (Olson, 1966). The role of home and school factors in the acquisition of both abilities cannot be ignored as level of preschool language acquisition is a major contributing factor to both. Home environmental factors exert positive and significant effect on student’s acquisition of mathematical language variables. Findings provide evidence that parent’s occupation, academic qualification and the amount of English spoken at home have significant causal influence on students’ acquisition of mathematical language (Akpan, 1991). The nature of instructions during the initial learning stages is of paramount importance for both. Children develop intuitive concepts about how letters, words, numbers and concepts can be manipulated even before the beginning of formal education. Young preschool children, who receive exposure to written material, can decipher written word.

Similarly children by age four have a good grasp of basic concepts such as fraction (Mix, Levine & Huttenlocher, 1999). Further, cross cultural comparisons have shown marked differences especially in mathematical achievement, among Asian and Western children. Here the major factors held responsible for the difference are parents’ expectations and attribution of efforts of the child to his academic success (Hess, Azuma, Kashiwagi, Dickson, Nagano, Holloway, Miyake, Price, Hatano & McDevitt, 1986; Mordkowitz & Ginsburg, 1987, Stevenson, Lee & Stigler, 1986). However, differences in basic instructional strategies have also been invoked
as a major contributor to this difference. It has been found that Asian children (Korean and Japanese) use the concept of Base 10 system even for basic computation such as addition and subtraction whereas American children are taught by use of concrete manipulative units. The children who think in terms of tens i.e. Asian, are found to be better at the computation level. Asian children use this strategy more frequently, to solve mathematics problem than American children generally do. In Asian languages, name of numbers in the tens are ten one (eleven), ten two (twelve) and so on (Miura and Okamoto, 1989). Thus, children may be used to thinking in terms of tens. Addition and subtraction strategies based on a system of tens are also taught explicitly in Korea and Japan (Fuson & Kwon, 1992; Naito and Miura, 2001). As amount of schooling increases, so does children’s use of the base ten approach (Naito and Miura, 2001). Surprisingly, gender differences have been observed only in case of mathematical ability while variations in reading ability has not been found to be gender specific. Males show a greater ability to apply mathematics and understanding mathematical concepts but 4th and 6th grade females performed better in mathematics computation (Park, Bauer and Sullivan, 1998). Jacklin (1989) suggested that the male superiority in mathematical reasoning could be primarily due to society’s gender-stereotyped beliefs and the greater perceived value of math to boys. In other words, it is largely societal beliefs, which discourage and diminish mathematical abilities of girls.

In conclusion it appears that reading and mathematical ability share a lot of non-cognitive and cognitive similarities. Both are multicomponential in nature, where the components can be classified
into basic structural and higher order semantic processes. The basic structural processes of both the abilities appear to be susceptible to non-cognitive influences. Both these abilities are positively related with intelligence and academic achievement. Although reading ability has a global relationship with scholastic achievement, mathematical ability is related with achievement in mathematics and related disciplines. Nature of instructions at the primary level appears to be of paramount importance in the development of both these abilities. Further, deficits in both the abilities have been found to coexist, where nature of deficit also appear to be in cognisance. The similarities between the two abilities and the coexistence of the deficits implicate a common underlying neuropsychological mechanism. Thus, delineation of the similarities between the cognitive and neuropsychological processes underlying these two abilities could help in furthering the understanding of the nature of mathematical ability as relatively little is known about this ability in comparison to reading ability.

In order to gain insight into the specific role and contribution of the various components of these abilities a review of the literature over the preceding 15 years was carried out with special reference to the contribution of the cognitive and neuropsychological factors of the two abilities.