Chapter-2

REVIEW OF LITERATURE
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There is evidence to suggest that children with LDs have difficulties/deficits in various EFs, such as, attention, WM, set shifting and inhibition (Meltzer, 2007; Willcutt et al., 2005). There are various training programmes claiming to improve EFs in children. However, the scientific evidence for such claims is scanty. Nevertheless, there is increasing evidence suggesting that certain interventions that focus on cognitive/EFs are effective (Jaeggi, Buschkuehl, Jonides, & Shah, 2011).

The search for effective remedial methods for children with LDs has a long and productive history (Clark & Uhry, 1995). Bakker (1990, 1979) developed both diagnostic procedures and empirically investigated intervention procedures for the remedial training of persons with LD. Training or remedial intervention should focus on functions rather than specific academic skills (Kirks & Chalfant, 1984; Powell, 1981). The present study seeks to investigate whether training in EFs will be effective in children with LDs. Research studies on effectiveness of training in relation to EFs are presented below.

2.1 Effectiveness of Training on Executive Functions in Children with Learning Disabilities

National Status

Many studies have been conducted in the area of neuropsychological assessment of children with LDs such as attention and memory, as well as remedial training to improve reading comprehension. But there is a dearth of research studies pertaining
to individual training on EFs for children with LDs both, locally and globally. Though studies have been conducted on various issues with respect to LDs in India, they do not focus on training of EFs. These studies are restricted to only one or two cognitive domains. Thus, there is an immense need to work on individualized training on EFs in children with LDs. Some of the Indian studies that have focused on this domain are stated below:

Malhotra et al. (2010) examined the efficacy of cognitive retraining (CR) techniques and remedial training in children with LDs. With manualized CR and 36 hours of remedial education programme, significant improvement was noted in these children. Ramaa (1987) also noted the effectiveness of remedial training programme in children with LDs.

In another comparative study, Malhotra et al. (2009) conducted a pre and post experimental design study with 30 children with a diagnosis of mixed disorder of scholastic skills. Each subject was given 36 hours of manualized CR package over 18 weeks, consisting of activities for sustained attention, visuospatial skill, visual memory, and verbal learning and memory. Pre and post assessment was done using NIMHANS Index for Specific Learning Disability, Grade level assessment device and Indian adaptation of Rey’s Auditory Verbal Learning Test. The authors concluded that manualized CR over 36 hours can help to partially remediate cognitive deficits in children with LDs and improve their scholastic performance. Whereas, Rozario et al. (1994) evaluated effectiveness of a 25 sessions remedial package for 25 children with LDs, age range 9 to 11 years and reported significant improvement.

Sadasivan (2009) compared the effect of phonological awareness intervention (PAI) and neuropsychological intervention (NPI) in two groups of 10 children with reading disability (RD) each. The children with RD were also compared in their performance on reading, phonological and neuropsychological tests with a control group of 20 children of the same age and educational level, however, without a RD. Both the RD groups received intervention in 20 bi-weekly sessions of 40 minutes duration each. The PAI group received inputs to enhance phonological awareness skills such as segmentation, isolation, deletion and tracking of speech sounds using games and visual material. The NPI group on the other hand received inputs to
enhance their attention, concentration, WM, verbal learning strategies, planning, organization and memory skills. The results indicated that children with RD differed significantly from control group on reading abilities, attention, EFs and phonological awareness measures at phoneme and syllable levels before the intervention was carried out. Post the intervention, both the treatment groups showed significant improvements in their reading score which were maintained for three months after the intervention.

In a study by Rajender, Malhotra, Bhatia, Singh, and Kanwal (2011) wherein they used CR programme that was designed to improve attention and other cognitive abilities in ADHD, pre and post intervention study design was used with 20 children. Treatment and wait list control groups (n=10) were matched for age, sex, and medication status. The intervention comprised of 36 hours of CR activities aimed at enhancing selective, sustained and divided attention. Post intervention, the mean academic performance of the subjects of CR group was found to be higher than that of the wait list control group. CR thus carries the potential of enhancing attention of children with ADHD along with improving their academic performance.

Venkatesan and Purusotham (2011) conducted a single group pre-test post-test intervention study to investigate correctional strategies for number remediation in preschool and primary school children. A ten-session programme was designed to work on basic numeracy skills. The results highlighted that number remedial programme was highly effective in increasing the scores on a number screener device. There are many types of numerical activities. It is not clear as to which type of numerical ability had been assessed and intervened in this study. The tool used in the study did not pinpoint at any specific learning problem in numbers for children.

**International Status**

Swanson (2015) investigated the role of strategy instruction and working memory capacity (WMC) on problem solving solution accuracy in children with and without math disabilities (MD). Children in grade 3 (N=204) with and without MD subdivided into high and low WMC were randomly assigned to 1 of 4 conditions: verbal strategies, visual strategies, verbal + visual strategies and an untreated control. The
dependent measures for training were problem solving accuracy and two WM transfer measures (operation span and visual-spatial span). The main findings of the study were that children with MD, but high WM spans, were more likely to benefit from strategy conditions on target and transfer measures than children with lower WMC.

In another study, Roughan and Hadwin (2011) examined the impact of a WM training programme on measures of WM, IQ, behavioural inhibition, self-report test and trait anxiety and teacher reported emotional and behavioural difficulties and attentional control before and after WM training and at a 3 month follow-up. The WM training group showed significantly better post-training on measures of IQ, inhibition, test anxiety and teacher-reported behaviour, attention and emotional symptoms, compared with a non-intervention passive control group. Group differences in WM were also evident on follow-up. The results indicated that WM training has some potential to be used to reduce the development of school related difficulties and associated mental health problems in young people.

Dunning, Holmes, and Gathercole (2013) conducted randomized controlled trial on children with low WM and investigated whether the benefits of training extend beyond standard WM tasks to other more complex activities in which WM plays a role, and to other cognitive skills and developing academic abilities. Children aged 7-9 years received either adaptive WM training, non-adaptive WM training with low memory loads, or no training. Adaptive WM training was associated with selective improvements in multiple untrained tests of WM. Gains in VWM were sustained one year after training. The finding suggests the benefits of WM training delivered in this way may not extend beyond structured WM tasks.

Holmes and Gathercole (2014) carried out field trials, in which teachers administered WM training to their own students in the school. Twenty two children aged 8–9 years participated in Trial 1. In Trial 2, 50 children aged 9–11 years with the lowest academic performance completed the training. They were matched with a group of 50 children who were not trained. Following training, children in Trial 1 improved significantly in both trained and untrained WM tasks, with effect sizes comparable to those reported in research studies. Improvements on the trained tasks in
Trial 2 were comparable, and training was associated with significantly greater progress at school across the academic year in maths and English. These findings indicate that teacher administered training leads to generalized and robust gains in WM and significant gains in academic performance.

Some researchers tried neurofeedback training, which is a form of operant conditioning, in which the electrical brain activity is rewarded or repressed (Demos, 2005). Neurofeedback as an intervention has been useful in the treatment of LDs (Fernandez et al., 2007; Fernandez et al., 2003; Nazari, Mosanezhad, Hashemi, & Jahan, 2012). Tansey (1991) used EEG biofeedback training regimen for brain based LDs and training was found to have increased activation of the central and sensori-motor cortex’s neural activation network. Improvement was also observed in the Wechsler Intelligence Scale for Children-Revised.

Thorell et al. (2009) investigated training and transfer effects of EFs in preschool children. Preschool children received computerized training of either visuo-spatial WM or inhibition for 5 weeks. An active control group played commercially available computer games, and a passive control group took part in only pre and post testing. Children trained on WM improved significantly on trained tasks; they showed training effects on non-trained tests of spatial and VWM. Children trained on inhibition showed a significant improvement over time on two out of three trained task paradigms, but no significant improvements relative to the control groups was noted on tasks measuring WM or attention. In neither of the two interventions were there effects on non-trained inhibitory tasks. The results suggest that WM training can have significant effects also among preschool children. The finding that inhibition could not be improved by either one of the two training programmes might be due to the particular training programme used in the present study or it could possibly indicate that EFs differ in how easily they can be improved by training, which in turn might relate to differences in their underlying psychological and neural processes.

Mezzacappa and Buckner (2010) studied a computer programme to train WM for children with attention problems or hyperactivity who attended an urban public school serving economically disadvantaged neighborhoods. Training was conducted.
daily for 5 weeks during school hours. Teachers rated children’s behaviours before and after the intervention, and standardized assessments of verbal and visuo-spatial WM were also conducted. No attrition occurred due to an inability or unwillingness on the part of children to complete the training. Overall, children’s behaviour and WM improved following training, compared to baseline. Our findings suggest that school-based WM training may be a viable means for treating children with attention problems or hyperactivity that warrants further investigation. This approach may also overcome barriers to care delivery for economically disadvantaged children who are known to be at higher risk for poor school outcomes.

Diamond (2012) emphasized that EFs can be improved. Various activities appear to improve children’s EFs. The best evidence exists for computer-based training, and traditional martial arts. EFs need to be progressively challenged as children improve and that repeated practice is key. Children devote time and effort to activities they love; therefore, EF interventions might use children’s motivation to advantage. Focusing narrowly on EFs or aerobic activity alone appears not to be as efficacious in improving EFs as also addressing children’s emotional, social, and character development (as do martial arts, yoga, and curricula shown to improve EFs). Children with poorer EFs benefit more from training; hence, training might provide them an opportunity to “catch up” with their peers and not be left behind.

Brehmer, Westerberg, and Bäckman (2012) attempted to develop process-specific WM training procedures, which may lead to general cognitive improvement. Adaptivity of the training as well as the comparison of training gains to performance changes of an active control group are key factors in evaluating the effectiveness of a specific training programme. Performance was assessed using criterion, near-transfer, and far-transfer tasks before training, after 5 weeks of intervention, as well as after a 3-month follow-up interval. Results indicate that (a) adaptive training generally led to larger training gains than low-level practice, (b) training and transfer gains were somewhat greater for younger than for older adults in some tasks, but comparable across age groups in other tasks, (c) far-transfer was observed to a test on sustained attention and for a self-rating scale on cognitive functioning in daily life for both
young and old, and (d) training gains and transfer effects were maintained across the 3-month follow-up interval across age.

Prins, Dovis, Ponsioen, Ten Brink, and Van der Oord (2011) examined the benefits of adding game elements to standard computerized WM training. Specifically, it examined whether game elements would enhance motivation and training performance of children with ADHD, and whether it would improve training efficacy. The study concluded that WM training with game elements significantly improves the motivation, training performance, and WM of children with ADHD. The findings of this study are encouraging and may have wide-reaching practical implications in terms of the role of game elements in the design and implementation of new intervention efforts for children with ADHD.

Working memory plays a crucial role in supporting learning, with poor progress in reading and mathematics characterizing children with low memory skills. Mathematical ability improved significantly for 6 months following adaptive training. These findings indicate that common impairments in WM and associated learning difficulties may be overcome with this behavioural treatment (Holmes et al., 2009). WM training may enhance some aspects of WM in youths with LD/ADHD (Gray et al., 2012). Transfer of the training effects to non-trained WM tasks is consistent with the notion of training-induced plasticity in a common neural network for WM. The observed training effects suggest that WM training could be used as a remediating intervention for individuals with low WM capacity as a limiting factor in academic performance or in everyday life (Klingberg, 2010).

Franceschini et al. (2013) demonstrated that only 12 hours of playing action video games, not involving any direct phonological or orthographic training can drastically improve the reading abilities of children with dyslexia. They tested reading, phonological, and attentional skills in two matched groups of children with dyslexia before and after they played action or non action video games for nine sessions of 80 minutes per day. When compared, it was found that children who played action video games showed greater improvement in reading speed, than those who received one year of spontaneous reading development and other traditional
reading treatments. It has been demonstrated that action video games efficiently improve attention abilities (Green & Bavelier, 2003; Green, Pouget, & Bavelier, 2010) the results showed that this attention improvement can directly translate into better reading abilities, providing a new, fast, fun remediation of dyslexia that has theoretical relevance in unveiling the causal role of attention in reading acquisition.

Söderqvist, Nutley, Ottersen, Grill, and Klingberg (2012) investigated the feasibility of cognitive training for improving WM and non-verbal reasoning ability in children with intellectual disability. Participants were randomized into a 5-week adaptive training programme (intervention group) and a non-adaptive version of the programme (active control group). Cognitive assessments were conducted prior to and directly after training and also after a period of one year to examine effects of the training. Improvements during training varied largely and progress during training predicted transfer to WM and comprehension of instructions, with higher training progress being associated with greater transfer improvements. The strongest predictors for training progress were found to be gender, co-morbidity, and baseline capacity on verbal WM. In particular, females without an additional diagnosis and with higher baseline performance showed greater progress. No significant effects of training were observed at the 1-year follow-up, suggesting that training should be more intense or repeated in order for effects to persist in children with intellectual disabilities. The main finding of this study is that cognitive training is feasible in this clinical sample and can help improve their cognitive performance. However, a minimum cognitive capacity or training ability seems necessary for the training to be beneficial, with some individuals showing little improvement in performance.

2.2 Factors Affecting Executive Functions in Children with Learning Disabilities

There are multiple factors that may affect EFs development in children with LDs. They are as follows:

a) Internal factors that can affect EFs in a child include struggles with physical and mental health and poor general mental ability.
b) Environmental factors that can influence a child’s EF development include economic crisis, abusive or neglectful caregivers, violence at home or in the community, chaotic surroundings, poor access to nutritious food and cognition-stimulating activities during the developmental period.

c) Socioeconomic status is systematically related to EF, with low-socioeconomic status children showing worse performance across many tasks, ages, and methodological approaches (Lawson et al., 2014).

d) Other factors may include the access and response to training, genetic and medical conditions, co-morbid conditions such as ADHD, delinquency etc. These factors can actually alter a child’s brain and disrupt normal development of executive functioning.

2.3 Factors Promoting Executive Functions in Children with Learning Disabilities

Children are not born with EF skills but they do have potential to develop them over a period of time. Stimulating environments provide children with “scaffolding” that helps them practice necessary skills before performing them alone. The following factors can promote EFs in children:

a) Parents and/or caregivers can promote the development of a child’s EF skills by establishing routines, modeling social behaviour, creating and maintaining supportive and reliable relationships.

b) It is important for children to exercise their developing skills through activities that foster creative play and social connection, train themselves how to cope with stress and provide opportunities for directing their own actions with decreasing caregivers’ supervision.

c) Some of the factors that are essential in the development of EF skills are adequate and sound sleep, good nutrition, safe surroundings, and a pain-free
body. Lack of any of these elements can come in the way of development of higher order cognitive skills in children.

d) Progress in executive functioning is based on a host of both internal and external influences. Parents and caregivers can take specific steps to foster growth of these skills in all children.

e) Children learn EF skills through experience, cumulatively, over time. Some children can learn skills such as time management by trial and error. Many others learn best when given explicit strategies to gain awareness of time and to stay on schedule.

2.4 Limitations of Training on Executive Functions in Children with Learning Disabilities

Transfer of training to academic performance is critically dependent on the extent of improvement on the EF task. Why did some children fail to improve on the training task and subsequently failed to show transfer to untrained reasoning? Two possible explanations could be one, the lack of interest during training, and two, the difficulties in coping with the frustrations of the task as it became more challenging (Jaeggi et al., 2011).

Individualized training can be effective and long-lasting, but there are limiting factors that must be considered to evaluate the effects of this training, one of which is individual differences in training performance. Jaeggi et al. (2011) proposed that future research should not investigate whether cognitive training works, but rather should determine what training regimens and what training conditions result in the best transfer effects, investigate the underlying neural and cognitive mechanisms, and finally, investigate for whom cognitive training is most useful. The following factors should be kept in mind to avoid any loopholes in the training of children with LDs.

a) Accurate assessment of EF deficits is essential to include the training activities in the training programme.
b) There should be uniformity in training provision to ensure that training protocol is being administered uniformly in research.

c) Individually-tailored training programmes can be more effective in directly and explicitly ameliorating disability in children.

d) Training activities should be exciting, attractive, motivating and interesting to the child.

e) Training regimens should be age appropriate or as per the intellectual ability and interest of the child. It should not be too easy or too difficult for the child.

f) Number of training sessions should not be less than 20 and more than 30.

g) The duration of each training session should not be more than 60 minutes.

h) Implementation of the training programme should be stepwise from simple to complex.

i) Presentation of the activities can be rotated after two or three sessions.

j) After each activity, feedback has to be given to the subject about his/her performance.

k) Self-monitoring of the training performance is important by the child.

l) Error elimination during learning is essential for favorable outcome of training.

m) Continued practice is required at home as well as the clinic or school to see the learning transfer into academic performance.
n) Booster sessions can be given to the child, as and when required.

2.5 Rationale and Justification of the Present study

The above studies show that very little progress has been made in the understanding of the intervention or training aspects of EFs in children with LDs. Children with LDs have difficulty with numerous facets of EFs (Meltzer, 2007). Snow and Iversen’s (1995) results indicated marked increase in the developmental patterns of EFs for children and adolescents with LDs from the 7 to 11-12 years level with subsequent leveling. Thus, the results of Snow and Iversen’s study indicate the importance of assessing EFs in children and adolescents with LDs.

Kohli, Malhotra, Mohanty, Khehra, and Kaur (2005) aimed to assess the deficits and neuropsychological functioning in children with SLD. 35 children in the age range of 7-14 years were assessed using the NIMHANS Index of SLD and neuropsychological tests consisting of the PGIMER memory scale for children, the WCST, the BVMGT and MISIC. The results indicated impairments in specific areas of memory, EFs and perceptuo-motor tasks. The authors concluded that identification of specific deficits would aid in the planning of individualized intervention plans.

Rankin and Hood (2005) suggest that successful long-term interventions require flexibility to adapt to the context of the child, careful monitoring, and adjustment by professionals. The literature on EF training intended that it is an effective therapeutic module for enhancing executive functions/skills. Considering high cerebral plasticity in children and the relation between EFs and academic performance, if one uses EF training, it is highly likely that this training would enhance the executive functioning of children and thus, potentially enhance their academic performance (Gupta & Venkatesan, 2014a).

The widespread use of computer assisted cognitive rehabilitation and/or cognitive retraining procedures can largely be attributed to the fact that computers provide accurate timing of stimulus presentation. Further, it is possible to regulate the time of stimulus presentation based on the individual’s performance. However, the drawback of these programmes is their rigidity which may not meet a child’s need. The floor and ceiling level along with the task content are relatively fixed. Further, the
cost of CR software is another major limitation. Manualized CR programmes overcome these limitations though at the cost of precision (Malhotra et al., 2009). However, Batchelor, Shores, Marosszeky, Sandanam, Lovarini (1988) found no difference when the outcomes of computer assisted and manualized CR programmes were compared. Thus, the latter is more suitable to the Indian context.

Due to lack of follow up and long term EF training studies; there is a dire need for further research in this area both, locally and globally. Hence, this study highlights the role of individual training on EFs in children with LDs. Children with LDs must be given individual or one to one training to build connection between their EFs and academic performance.