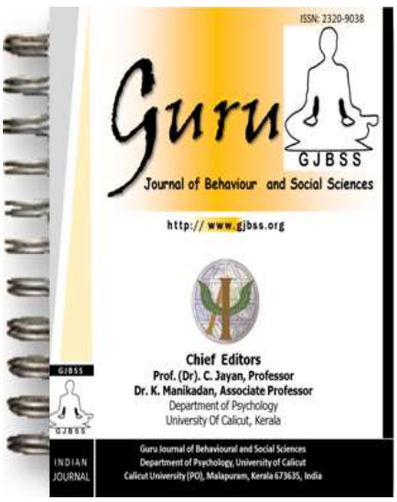
ISSN 2320-9038

Guru
Journal of Behaviour and Social Sciences



Article Title

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2014

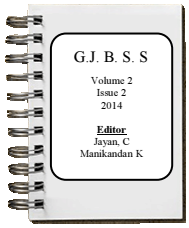
Volume: 2 **Issue: 2** **ISSN: 2320-9038**

Journal of Behavioral and Social Sciences

Department of Psychology, University of Calicut,

Calicut University (P.O) Malapuram, Kerala Pin: 673 632, India

Guru Journal of Behavioral and Social Sciences
Volume 2 Issue 2 (April – June, 2014)
ISSN: 2320-9038 www.gjbss.org



Efficacy of Training Program on Executive Functions in Children with Learning Disability

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Received: 13 April 2014
Revised: 09 May 2014
Accepted: 21 May 2014

Keywords:
Attention, Dyslexia, Executive function, Intervention, Working memory

Abstract

This study seeks to evaluate the efficacy of a Training Program on Executive Functions packaged for benefit of children with learning disabilities. A matched 2-group pre-post cross-over interventional design including a suspended treatment phase was employed on a purposive sample of four children diagnosed as learning disability in age range of 11-14 years. An assortment of standard tests and intervention activities validated against the identified executive functions were used through 20 individualized training sessions. Results show statistically significant gains, maintenance and generalization in executive functions even across classroom or academic performance and school settings.

Children with learning disabilities (CLDs) are characterized by specific processing problems. For example, students with reading disability (dyslexia) are shown to have impairments in single word reading, word fluency and reading comprehension usually resulting from deficient phonological processing (Pennington, Groisser, & Welsh, 1993). Neuropsychological, structural, functional imaging and electrophysiological studies have evidenced central nervous system dysfunction in these children (McCrory, Mechelli, Frith, & Price, 2005) as against age or grade matched unaffected peers (Lyon, Newby, Recht, & Caldwell, 1991). The role of frontal lobe (prefrontal cortex) is especially implicated for their poor executive functions (Elliott, 2003).

Executive Functions (EFs)(also called, Cognitive Control Functions) refer to a broad range of cognitive, behavioral and adaptive competencies, such as, creative and abstract thought, ability to effectively regulate and direct self-behavior, verbal reasoning, problem-solving, planning, sequencing, sustaining attention, showing resistance to interference, utilization of feedback, multi-tasking, cognitive flexibility, ability to deal with novelty, introspection, and forming a plan based often on recollections of past experience. These abilities play a critical role in complex social behavior. They help suppress improper actions and focus on purposeful information (Burgess, Veitch, de lacy Costello, & Shallice, 2000; Grafman & Litvan, 1999; Smith, & Jonides, 1999). These EFs are critical for success in school as well as in daily life (Diamond, Barnett, Thomas, & Munro, 2007).

A typical list of EFs include initiation, sustained attention, working memory, emotional control, inhibition, self monitoring, planning, organization, set-shifting, conceptual functioning, awareness, and insight (Gioia, Isquith, Kenworthy, & Barton, 2002). Even though the overall concept is basically the same, different investigators and practitioners have their own favorite lists of EF. There is evidence to suggest that CLDs show poor academic performance and have difficulties/deficits in various EFs, such as, attention, working memory, set shifting and inhibition (Meltzer, 2007; Wilcutt, Pennington, Olsen, Chhabildas, & Hulslander, 2005).

Neuropsychological models of developmental disorders conceptualize a child's learning strengths and weaknesses as manifestations of efficient or inefficient brain regions and/or systems (Rourke, Bakker, Fisk, & Strang, 1983). Neuropsychological intervention/training

follow *idiometric* or *ipsative* approaches to identify specific areas of neuropsychological functional assets and deficits for inter-comparisons and for evolving tailor-made structured and need-oriented training program for individuals with disability (Venkatesan, 2010).

Training Program on Executive Functions (TPEF) involves one-to-one instruction. It comprises a wide range of activities focused on attention, working memory and other cognitive functions/skills (Gupta & Venkatesan, 2014). Originally developed for the rehabilitation of Traumatic Brain Injury and Schizophrenia, TPEF needs to be tailored to address the unique characteristics of CLDs. This intervention method typically involves massed practice (learning with no intervals or short intervals between successive periods of learning), drill practice of isolated cognitive skills (Delahunty, Morice, & Frost, 1993), restorative or corrective approaches (such as, word-list learning, paragraph listening, visual imagery and use of mnemonic strategies) (Sohlberg, White, Evans, & Mateer, 1992). Some compensatory approaches use environmental manipulations in child's home and school setting by facilitating adjustment to the disability by increasing awareness and acceptance. These practices/approaches are often combined to optimize the effects of intervention (Cicerone, Dahlberg, Kalmar, et al., 2000).

While there is no gainsay that TPEF improve attention or organization skills in children and will help them achieve academic and social success by intrinsically motivating them (Singer & Bashir, 1999), it is seen that most available such programs address only typical children (Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009). Despite their day-to-day struggles of coping with academics in their school routines, it is rather unfortunate that exclusive studies on evaluating the efficacy of TPEF in CLDs are scanty (Meltzer & Krishnan, 2007; Akhutina, et al., 2003). Therefore, it is the felt need, rationale and justification (i) to undertake this beginning study on the feasibility of developing a package TPEF; and, (ii) to explore the preliminary efficacy of such a packaged intervention for benefit of children with learning disabilities.

Method

A matched 2-group pre-post cross-over interventional design including a suspended treatment phase was employed to verify the directional hypothesis that there would be significant gains in scores of EF for CLDs after implementation of the TPEF. The independent variable in the study is TPEF, dependent variables are 'EF Scores', and subject variables are age, gender, and grade.

Participants:

The study was initiated with recruitment of a sample of 6 children out of which 2 dropped out. The final sample included 4 boys in the age range between 11-14 years (Mean Age: 12.54 years; SD: 1.15) after they were formally diagnosed as 'Specific Developmental Disorders of Scholastic Skills' (SDDSS; Diagnosis Code: 315.0) based on ICD-9-CM (Linzer, 2011). The sample was recruited from Department of Clinical Psychology, All India Institute of Speech and Hearing, under Ministry of Health & Family Welfare, Government of India, located at Mysore (Karnataka). The period of study was between October, 2012, and December, 2013. Children with concurrent diagnosis of sensory impairments, disturbances of emotion-conduct, adjustment problems, epilepsy, major medical illness, previous exposure to cognitive behavioral intervention and those children who scored average on pre-intervention assessment were excluded. Participants were explained the procedure of study, informed consent was taken and confidentiality was assured as enshrined in the mandate on ethical guidelines followed at the institute (Venkatesan, 2009).

Instruments

1. Socio-Demographic Data Sheet: This instrument covered open ended items to elicit personal details of the participants.

2. Digits Forward & Digits Backward Test (Adapted from Intelligence Scale for Indian Children; Malin, 1969): This popular test of attention-concentration requires subjects to repeat the 2-9 digits immediately after it is read out by the examiner in a random order, albeit at a specified rates. There are two series of number lists, viz., forward and the other is reversed/backward. Scoring is carried out on all-or-none basis by allotting one mark for each correct repetition. The correct performance of this task requires successive processing, auditory attention, vigilance, immediate, short term and numerical memory. The digits forward series measures phonological short-term memory and digits backward series is categorized under executive or verbal working memory.
3. Working Memory Subtests (Adams & Sheslow, 2003): These subtests tap verbal working memory and symbolic working memory. In *verbal working memory*, subjects repeat all the words by recalling animal words first and followed by non-animal words in any order. Participants are then asked to perform a second, but more difficult task. After hearing the list of animal and non-animal words, they are first asked to recall the animals in order of their typical size (smallest to largest), followed by all non-animal words in any order. In *symbolic working memory,* the task is similar to verbal working memory subtest. It requires the subject to actively "manipulate" information presented prior to recall. In a manner similar to verbal working memory, participants are challenged at two levels of difficulty. For the first level, the examiner randomly dictates a series of numbers and asks the subject to point out the numbers dictated in correct numerical order as on the number stimulus card. For the second task, a random number-letter series is dictated and the subject is required to point, both, the dictated numbers followed by the dictated letters in correct order as on the Number-Alphabet Stimulus Card.
4. Children's Color Trails Test 1 & 2 (Llorente, Williams, Satz, & D'Elia, 2003)**:** This test is available in four alternate and equivalent forms although normative data and cross cultural validation is provided only for Form K as applicable for children between 8-16 years. The test task requires children to connect circles. Therefore, they must possess eye-hand and grapho-motor coordination, recognition of Arabic numbers 1 through 15 and differentiation of the colors pink and yellow. This test covers EFs like sustained attention, sequencing, psychomotor speed, cognitive flexibility and inhibition-disinhibition.
5. Stroop Color & Word Test-Children Version (Golden, Freshwater, & Golden, 2003): This test booklet contains three pages: word, color and color-word page. Each page has 100 items presented in 5 columns of 20 items. (a) The *Word Page* consists of the words "RED", "GREEN"' and "BLUE" arranged randomly and printed in black ink on a white 8.5" x 11" sheet of paper. No word is allowed to follow itself within a column; (b) The *Color Page* consists of 100 items, all written as XXXX, printed in red, green, or blue ink; (c) The *Color-Word page* consists of the words from the Word page printed in colors from Color Page. It is a speed test and participants were asked to read the Words on the Word page, name the Colors on the Color page, and name the Colors on the Color-Word page as quickly as possible. The total time to read all the words on each page and number of errors on each page were recorded as the outcome measures of the tests. It can be used with 5 to 14 year old children. The test was designed to investigate attention and executive functions and also measures inhibition/interference control.
6. Wisconsin Card Sorting Test (WCST)(Heaton, Chelune, Talley, Kay, & Curtiss, 1993**)**: This test is considered a measure of "executive function," requiring the ability to develop and maintain an appropriate problem-solving strategy across changing stimulus conditions in order to achieve a future goal (Luria, 1973). It consists of 4 stimulus and 128 response cards that depict figures of varying forms (crosses, circles, triangles and stars), colors (red, blue, yellow and green) and number of figures (one, two, three and four). The WCST is standardized and has norms for all age groups.

Clients should have normal or corrected normal vision and hearing to comprehend the test instructions and to visually discriminate the stimulus parameters of color, form, and number.

Therapeutic Program:

The TPEF was administered on each subject through 20 training hourly sessions spread across 4-8 weeks with a fixed interval between sessions. There were 2-3 sessions per week. The process, sequence and timeline for each session covered explanation of objectives (5 minutes), stimuli presentation and demonstration of the task (10 minutes), practice (30 minutes), questions and feedbacks (5 minutes), and finally, discussion about the strategies employed to perform the tasks with home assignments (10 minutes) respectively.

The content of TPEF was drawn from several sources available in literature and divided into three sub-categories: attention, working memory and executive function skills. The difficulty level was adjusted considering the type of processing involved and both the 'floor effect' as well as 'ceiling effect' were maintained. Both, auditory and visual modalities were used in the activities. For the segment on *attention,* tasks involved scanning, vigilance and discrimination in the presence of distracters; color, alphabet and number cancellation; continuous performance, trailing and tracking mazes. In the *working memory* segment, tasks involved verbal and visual recall arranged in increasing levels of difficulty. For *executive functions*, the tasks involved scanning, planning, organization and problem solving. The therapeutic regime included stimulus-driven and goal-directed voluntary procedure, whereas the intervention techniques included standard cognitive behavior procedures like reinforcement, prompting, chaining, shaping, modeling, differential reinforcement, supplying meta-cognitive strategies involving self-monitoring and self-evaluation (Menzies, Lane, & Lee, 2009). Additionally, de-stressing and relaxation technique, use of hobby and training on extracurricular activities at school and home was also encouraged (Diamond & Lee, 2011). The effect of training was evaluated through repeated measures administered throughout training.

Procedure:

CLDs and their parents were informed about the purpose and procedure of the study. There were two randomly formed experimental groups: Group A (N-2) and Group B (N-2). There were three points of assessment: pre-intervention, post-intervention and re-assessment without intervention. Initially, group A was given TPEF while group B participants were not given any training. After the period of one month, group B was given training while group A was rested (Figure 1).

<table>
<tr><td colspan="2">Subject Recruitment with Informed Consent</td></tr>
<tr><td colspan="2">↓</td></tr>
<tr><td colspan="2">Establishing Rapport</td></tr>
<tr><td>Subjects (N=2)</td><td>Subjects (N=2)</td></tr>
<tr><td>Pre intervention assessment</td><td>Pre intervention assessment</td></tr>
<tr><td>Training (20 sessions)</td><td>No Treatment</td></tr>
<tr><td>Post intervention assessment</td><td>Re-assessment without Intervention</td></tr>
<tr><td>No Treatment</td><td>Training (20 sessions)</td></tr>
<tr><td>Re-assessment without Intervention</td><td>Post intervention assessment</td></tr>
<tr><td colspan="2">↓</td></tr>
<tr><td colspan="2">Scoring and statistical analysis of data</td></tr>
</table>

***Figure 1*:** Plan of the present study

Each subject of both experimental groups was tested in a quiet milieu on all the five measures chosen for this study. The sequence of test administration was maintained uniformly across subjects to exclude bias, order, practice or fatigue effects. The tests were administered three days prior to the commencement of the first session of the training program. The actual training program was also preceded by at least two practice trials with feedback to the participants.

The TPEF package was subjected to consensual validation to determine the degree of agreement for the identification and matching of the EFs against chosen intervention activities between five mutually blinded and independent reviewers not below pre-doctoral level qualifications and 3-5 years teaching/clinical experience in the field of Clinical Psychology. The inter rater agreement coefficients was measured as r: 0.95. The percentage of pre, post and re-assessment without intervention was compared. Chi-square test of significance was used to compare the significance of percent gain. The collected data as raw scores on respondent ratings were compiled and subjected to statistical analysis by using SPSS/PC (Carver & Nash 2009).

Results and Discussion

All the participants (N: 4) are boys, right handed and studying in English medium schools between grades VI (N: 2) and VIII (N: 2). Subject A & C were reported to have changed the school once and subject A was reported to have changed syllabus once (Table 1).

Table 1

Descriptive data of the participants

Particulars	**Subject A**	**Subject B**	**Subject C**	**Subject D**
Chronological Age (years)	11.08	11.75	13.83	13.5
Gender	M	M	M	M
RPM* (raw scores)	39	45	46	45
Handedness	Right	Right	Right	Right
Grades	VI	VI	VIII	VIII
Syllabus	State	State	CBSE**	State
Medium of Instruction	English	English	English	English
Change of School	Once	No	Once	No
Change of medium of Instruction	No	No	No	No
Change of Syllabus	Once	No	No	No

*RPM- Raven's Progressive Matrices (Raven, Court, & Raven, 1983), **CBSE-Central Board of Secondary Education.

The result of this study shows that TPEF can be effective in improving EFs in CLDs after implementing structured, need based, play based, and individualized 20 hours training in the area of attention, working memory and executive function skills. On analysis of individual cases result indicates that there is significant improvement in the function of verbal working memory, symbolic working memory, motor speed, shifting set, attention and inhibition control in both the group. Thus the significant change was observed in the pre-post scores of both the group A (X^2 =16.5, df=8, p: < 0.05) and B (X^2 =35.3, df=8, p: < 0.001)(Table 2).

Table 2
Comparison of scores among pre, post and re-assessment without intervention in CLD

Measures	Children with LD (N-4)											
	Exp. Group A						Exp. Group B					
	Subjects A & C (N-2)						Subjects B & D (N-2)					
	Pre Int.	Post Int.	IG (%)	RW Int.	RG (%)	CG (%)	Pre Int.	RW Int.	RG (%)	Post Int.	IG (%)	CG (%)
DF & DB	8.5	11	29.41	10.5	-4.54	33.95	11	12	9.09	14.5	20.83	11.74
VWM	21	24.5	16.66	25.5	4.08	12.58	23.5	26	10.63	33.5	28.84	18.21
SWM	14	20.5	46.42	20	-50	96.42	16.5	17	3.03	22	29.41	26.38
CCTT-1 (Time in Seconds)	36.5	32	12.32	26.5	17.18	-4.86	42	31.5	25	23	26.98	1.98
CCTT-2 Time in Seconds)	91.5	56	38.79	37	33.92	4.87	73	53	27.39	28.5	46.22	18.83
Stroop-W	44	61.5	39.77	63.5	3.25	36.52	65	71	9.23	80.5	13.38	4.15
Stroop-C	48.5	54	11.34	51	-5.88	17.22	46	49	6.52	60.5	23.46	16.94
Stroop-CW	30	37	23.33	36	-2.70	25.92	25.5	25.5	00	37	45.09	45.09
WCST-Category completed	3	4.5	50	5.5	22.22	27.78	4.5	5	11.11	6.5	30	18.89
WCST-Correct response	66	88	33.33	104	18.18	15.15	91	95.5	4.94	103.5	8.37	3.43
X^2	16.5									35.3		
Df	8									8		
Probability	*0.035									**0.001		

*(p: < 0.05) ** (p: < 0.001); Pre Int.: Pre Intervention; Post Int.: Post Intervention; RW Int.: Re-assessment without Intervention; IG: Immediate Gain; RG: residual gain; CG: Cumulative gain; DF & DB : Digits Forward & Digits Backward; VWM: Verbal working memory; SWM: Symbolic working memory; CCTT-1 & 2: Children's Color Trails Test 1 & 2;Stroop-W: Word; Stroop-C: Colour; Stroop-CW: Colour word; WCST: Wisconsin Card Sorting Test.

Findings of this study is consistent with Malhotra, Rajender, Sharma, & Singh (2009) reporting significant improvements after evaluating effectiveness of 36 hours of manualized cognitive retraining package administered over 18 weeks. The activities covered in that study were focused on sustained attention, visuospatial skills, visual memory, verbal learning and memory. Pre and post assessments were done using NIMHANS Index for Specific Learning Disability, Grade Level Assessment Device and Indian adaptation of Rey's Auditory Verbal Learning Test. Their findings are also supported by Rozario, Kapur, and Rao (1994) wherein significant improvements were noticed after evaluating effectiveness of a remedial package carried out for 25 sessions on 25 CLDs with the age range 9 and 11 years.

In another comparative study, Malhotra, Rajender, Bhatia, Kanwal, & Singh, (2010) examined efficacy of cognitive retraining techniques and remedial training in CLDs to conclude that both-manualized cognitive retraining along with 36 hours of remedial education improved scholastic performance in these children. Meanwhile, Sadasivan (2009) investigated the effect of phonological awareness intervention and neuropsychological intervention in two groups of 10 children with reading disabilities between 10-13 years covering 20 bi-weekly sessions of 40 minutes duration. The two interventions were found to be effective in enhancing reading accuracy. In addition, the two interventions also improved specific cognitions which were maintained over time.

Other researcher have used computer assisted training program by focusing on training attention, executive, visuo-spatial and problem solving skills in 12-14 year old children and reporting significant gains in executive functioning (Navarro et al. 2003; Bracy et al. 1999).

In sum, TPEF is found to play a focal role in academic success. Academic success is based on children ability to plan their time, organize and prioritize information, separate main ideas from details, monitor their progress, and reflects on their work. These core EF processes are the underpinning of most academic work from as early as fourth grade, when the school curriculum increasingly emphasizes performance on tasks that require the coordination, integration, and synthesis of many of these executive function processes. Children with weaknesses in these important processes often understand complex concepts easily but struggle to show what they know, due to difficulties on planning, setting realistic goals, prioritizing, initiating tasks, organizing materials and information (Meltzer, Pollica, & Barzillai, 2007). These skills are rarely taught. They can be taught even to preschoolers. It could make a huge difference especially for CLDs (Diamond, Barnett, Thomas, & Munro, 2007). Hence, TPEF is indispensable to deal such children.

Conclusion

This study indicates that TPEF is effective in improving attention, working memory and executive functions in CLDs. It calls for further research in this area. Plausibly this training would also enhance their academic performance. This was not the purpose of this study. Probably, future research can examine the efficacy of TPEF in relation to academic achievements and performance. The findings also highlight the need and importance of early screening, assessment of executive functions and planning for early intervention to achieve optimum benefits for such children to prevent what is described as 'Matthew Effect' (Stanovich, 1986). This therapeutic module is also appears to be cost effective, handy, suitable and feasible for implementation under Indian conditions in home, school or clinical setting in comparison to expensive computer based training packages. But, computer based and long-term cognitive TPEF programs can also be used to train such larger sample size of children. Neural effects of TPEF in CLDs can be investigated with the help of fMRI and ERPs. More methodologically sound studies are required to establish the efficacy of TPEF in CLDs, durability and generalization of the acquired therapeutic gains. Thus, the results of this study needs to be interpreted in the light of these limitations.

Acknowledgements

Authors are thankful to Dr. S. R. Savithri, Director, All India Institute of Speech and Hearing, Mysore, India for permitting us for study. We wish to express our sincere gratitude to the students participated in the study.

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