

PEDAGOGY OF LEARNING (POL)

International Refereed Journal of Education

E-ISSN: 2395-7344, P-ISSN: 2320-9526

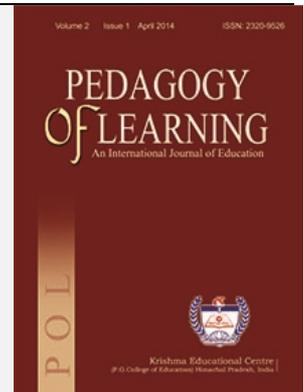
Abstracted and indexed in:

Google Scholar, Research Bib,
International Scientific Indexing (ISI),
Scientific Indexing Services (SIS),
WorldCat, Cite Factor,
Impact Factor: 0.787(GIF)

UGC (India) Approved Journal

(UGC Journal No. 44913, Education-1029)

Website: <http://pedagogyoflearning.com>



Efficacy of Computer Based Intervention in Improving Executive Function of Autism Spectrum Disorder Children

Kanwaljit Kaur

Research Scholar, Department of Education
Central University of Punjab, Bathinda
Email: nanokanwal@gmail.com

Sesadeba Pany, Ph.D.

Assistant Professor, Department of Education
Central University of Punjab, Bathinda
Email: drpany_s@gmail.com

Corresponding Author: Sesadeba Pany

E-mail: drpany_s@gmail.com

Article History:

Received 22 August 2017

Received in revised form 29 September 2017

Accepted 18 October 2017

Published online 24 October 2017

Abstract

Autism spectrum disorder is neurodevelopment disorder which effects how they perceive this world. Children with autism spectrum disorder mainly deficit in executive function, social skills and communications which halt their academic achievement in schools. For improving these domains, computer-based interventions are promising tool in improving executive function which later on

improves the social skills of the students. Executing maximum output from these games requires designing the games according to the needs of the students, access to these games and teachers should have skills to use these technologies as well as implementing these technologies in the classroom effectively. This paper divided in four sections. Section-I deals with the terms executive function and autism spectrum disorder, Section-II points towards relationship between executive function and autism, Section-III focuses on the computer based interventions and Section-IV deals with the how to access and implement these games in the classroom by the teacher.

Keywords: Autism spectrum disorder, computer-based interventions, executive function, Mental Disorder

Introduction

Autism spectrum disorder children are generally poor in planning, organization, working memory, attention, self-regulation and cognitive flexibility which comes under the executive function domain effect the daily activities of such category students like doing assignments on time, organized their work, managing the time. This paper through its four sections highlights the efficacy of computer based intervention for improving executive function of autism spectrum disorder children.

Section-I

Executive function is an umbrella term, used for the diversity in the cognitive process. For instance, before leaving from home to reach school, what you do? The majority of the children check whether their home work is done or not? What are teachers going to teach today? Here in these examples planning, organization, inhibition and cognitive flexibility play a key role which is the part of the executive function. Pribram (1973) was the first one who used "executive" when discussed prefrontal cortex. Pribram included 30 constructs of executive function which make it difficult to define this term. Naglieri and Goldstein (2013) view from their extensive study that executive function is a single phenomenon that can be defined by an individual's efficiency of how well they can solve their problems in nine areas (planning, organization, attention, inhibition, initiation, working memory, self-monitoring, emotion regulation, cognitive flexibility). Executive function is co-morbid of cognitive as well as behaviour skills which are responsible for goal- directed behaviour (Lezak, 1995). According to Delis (2012) *"Neither a single ability nor a comprehensive definition fully captures the conceptual scope of executive function; rather, executive function is the sum product of the collection of higher level skills that converge to enable an individual to adapt and thrive in complex psychosocial environments."* (p.14). Over the past years, some major features of the Executive functions have been

identified, such as Inhibition, working memory, cognitive flexibility and planning (Barkley et al.,2011) and these form the construct of executive function. Still, not a single definition is universally accepted. Many studies associated executive function with frontal lobes of the brain. These studies reveal that prefrontal cortex part of the brain is more activated when an individual use executive function skill. (Jacobs et al.,2011; Miyake et al.,2000., Delis et al.,2001). Those individuals who deficit in Executive function, have a problem in cognitive, behavioural and emotional problems (Anderson et al.,2002) which makes them handicap, towards accomplice their daily life activities. The similar types of symptoms are shown by ASD students. Traditionally, executive functions considered as the unitary construct (Della Sala, Gray, Spinnler, &Trivelli, 1998; Shallice, 1990) but now it is considered as a combination of a different set of the constructs (Alexander &Stuss, 2000) which we discuss as follows;

Table 1: Constructs of Executive Function

Executive Function Domain	Description
Cognitive Flexibility	Cognitive flexibility deals with an individual how efficiently they can switch from the one task to another task. For example, you prepare yourself for an exam according to the previous syllabus, but if there is a sudden change in the syllabus, you immediately change strategies to crack the exam. In every day's activities, we change many of our strategies and perspectives. This is due to cognitive flexibility.
Inhibition	To inhibit the trivial things and execute the relevant things. For example, Apple is a fruit or a vegetable? You inhibit the response of vegetable and execute fruit response.
Working Memory	An ability of an individual to retain and manipulate the information to complete the task. For example: While reading a book, you remember what you read a few seconds ago, it is because only of working memory.
Planning and organization	Predetermined steps to accomplish task or goal, organize work logically. Example: Submission of assignments on 30 April 2017.To complete your assignment, you need planning and organization skills.

Executive function controls and manages all activities as traffic police manages traffic on the road by giving directions, in the same way, prefrontal areas of brain carry out this operation which activates when a person use their executive function. So, it is crucial for developing strategies and intervention to facilitate the development of executive function.

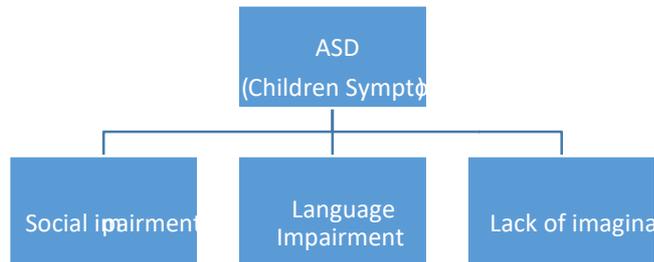
Autism Spectrum Disorder

Autism is a developmental disorder firstly identified by Leo Kanner (Kanner, 1943) This early study shows that individual with autism face problems in social and communication skills. These children characterized by the presence of three impairments: poor communication skills, poor social skills and a lack of imagination (Wing and Gould 1979).

One of the major impairment i.e. Social impairment means an individual finds it difficult, to form and maintain social relationships. They mainly fail to understand and follow the social norms (Lord, Storoschuk, Rutter& Pickles,1993; VanMeter, Fein, Morris, Waterhouse & Alien;1997). Most individuals with autism are profoundly delayed in their acquisition of language, and many never achieve how to speak (Camaioni, Perucchini, Muratori&Milone, 1997; Leekam, Hunnisett& Moore, 1998). Eisenmajer, R., Prior, M., et al.(1998) noted a lack of imagination in autism children which can be clearly seen in the development of play skills.

Fig.1. ASD children symptoms

Autism spectrum disorder (ASD) is a heterogeneous, lifelong neurobiological disorder which impacts all developmental domains and about 60 to 100 cases per 10,000 diagnosed as an autism spectrum disorder



(Baird et al.,2006; Brugha et al.,2011). As rainbow consists of seven colours and form spectrum same as ASD includes a wide "spectrum," in which wide range of symptoms and disorders come under this spectrum defined by National Institute of Mental Health(NIH). In the past, Asperger's Syndrome and Autistic Disorder were different disorders. The latest fifth edition of the manual from the American Psychiatric Association, the *Diagnostic and Statistical Manual of Mental Disorders (DSM-5,2013)*, highlights Autism spectrum disorder incorporates Asperger Disorder, Childhood Disintegrative Disorder, Rett syndrome and pervasive development disorder-not otherwise specified(PDD-NOS). The combination of this disorder is referred as an autism spectrum disorder. ASD can be diagnosed at early stage, at the age of 18 months (Rapin,2008; Volkmar, Lord and Bailey,2004). Approximately 70% of the individuals with ASD having IQ

below 80, indicating an intellectual disability (Fombonne,2005; Matson& Boisjoli,2008).ASD can occur with other disorder also like ADHD, mood disorders and anxiety (Hofvander et al.,2009; Leyfer et al.,2006; Matson & Nebel,2007). The Cognitive theory of ASD observed that Symptoms observed in an individual with ASD arise from executive function deficits (Pennington & Ozonoff, 1996; Russell, 1997; Russo et al., 2007).

Section-II

Executive Function and Autism

Executive functioning in autism spectrum disorders is a matter of Investigation. Those individuals who suffer with ASD deficit in domain of executive function i.e. working memory (Bennetto et al., 1996), planning (Prior & Hoffman, 1990), and cognitive flexibility (Bennetto et al., 1996; Minsheu, Goldstein, Muenz, & Payton, 1992; Ozonoff, Pennington, & Rogers, 1991; Ozonoff & McEvoy, 1994; Ozonoff, Strayer, McMahon, Filloux & 1994; Szatmari, Finlayson, & Bartolucci, 1990).The domain of an executive function is interrelated in a complex manner so it is tough to understand the development of specific components. For example, when children are doing tower task then they use planning skills, as well as inhibition. Development of Executive function is non-linear and is linked to the maturation of prefrontal cortex. (Cummings, 1993; Hale, Bronik, & Fry, 1997; Yakovlev & Lecours, 1967).

Examining of executive function in an individual with ASD at various stage yield different results. Several studies (Griffith, Pennington, Wehner, & Rogers, 1999; Rutherford & Rogers, 2003; Yerys, Hepburn, Pennington, & Rogers, 2007) have not found evidence of executive impairment in pre-schoolers and young children with ASD compared to typically developing controls. Researches based on older children and adolescents with ASD indicate deficits in executive functioning (Luna et al., 2004; Ozonoff&McEvoy, 1994). To sum up, we can say that Executive function impairment progress through childhood to adolescent stage.

Section -III

Computer based Interventions: Improving Executive Function

There is a huge literature as it has been discussed above, which conclude that executive functions deficit in autistic spectrum disorder but there are a few studies related to intervention that helps in improving executive functions. Earlier, studies done by Kleinberg et al. (2005) demonstrated the effects of computer-based training on ADHD and ASD students and found that there was a significant effect on executive functions especially on verbal working memory, response inhibition and reasoning. Studies focus on the working memory training and found that there is improvement in executive function (Brehmer et al.,2009,2011;

Dahlin,2010; Klingberg et al.,2005; McNab et al.,2009; Olesen et al.,2004; Thorell et al.,2009; Westerberg & Klingberg,2007). Similarly, many investigators have noticed the improvement in verbal working memory using computer based intervention (Dunning, Gathercole, &Holmesetal,2013; Lundqvist et al.,2010; Mezzcappa& Buckner,2010; Roughan& Hadwin,2011).

Fisher and Happe (2005) initiated to train executive function of ASD student but found that student showed improvement in TOM task but not in executive function task. This is the starting point where it seems that executive function training can be an effective intervention for ASD student. De Vries (2011) found that computer games based on working memory and cognitive flexibility improved ASD children day to day life activities like improved social skills as well as executive function.

Cogmed working memory training an effective intervention in the academic achievement of ADHD and ASD students which resultant from the improved executive function (Holmes & Gathercole;2013) and these finding accompanied by Beck et al.,2010; Roording et al., 2016.

Autism spectrum disorder children mainly find difficulty in reasoning, attention and executive function, in order to help these children SIGUEME technology based intervention is given to the children which includes six phases (attention phase, video phase, image phase, drawing phase, game phase) so that they understand the graphic material as well as the objects (Velez Coto et al.,2017).

Neuro feedback is new technique which used to improve the working memory, inhibition and behavioural problems. Neurofeedback refers to an operant conditioning of brain activity, in which the desirable activity of the brain is encourage and undesirable activity is inhibited (Kouijzer,2009). Neurofeedback training is mainly given to ADHD category of children and shows positive resultin improving executive function (Monastra et al.,2005; Johnstone, S. J., Roodenrys, S. J., Johnson, K., Bonfield, R., & Bennett, S. J. ,2017).Efficacy of this intervention should be applied on autism spectrum disorder children so that more positive outcome will be come.Hence, to determine which intervention is more effective on improvement of EF skills and social skills of ASD children, future research is needed.

Section-IV

How to access and Implement the Computer Based Intervention in Classrooms

Computer-based interventions have a potential to improve executive function as a result quality of life of ASD students will be improved. But a big question arises

how the parents and teachers access these interventions. Following are the points of accessing and implementing these games in the classroom:

- Most of educational games freely available and can be easily downloaded (www.cogmedworkingmemory.com, www.samenslim.nl.com) in Smartphone or laptop. In this manner, Government initiative of "Digital India" helps teachers and parents to access internet and connectivity in cheaper rate.

How teachers' use these interventions effectively?

- To use technology efficiently, we should have knowledge of how, when and where it will be implemented or in other words, teachers should have the scientific temperament and scientific awareness which is our fundamental duty as described in article 51 A ("It shall be duty of every citizen of India to develop the scientific temper, humanism and the spirit of inquiry and reform.")
- Technology advances rapidly but skills acquired by the teacher in a very slow manner as a consequence the gap between the technology advancement and skills acquired by the teachers are going to be widened. To reduce this gap, Firstly, we should be providing periodically workshops to the teachers. Workshops should be used as a lab by the teachers where teacher experiment their experiences and work on the skills so that maximum output is achieved. Secondly, bridge the gap through internet, TV, 24X7 educational channel (SWAYAM), Web portal for Science & Technology to reach out and increase the scientific awareness and building the scientific temper among the people.
- In pre and post teacher training, inclusive education should not teach as a theoretical subject but the practical application should be there. So, that teacher equips them in changing an environment.
- Teacher's mind-set towards using technology should be positive.
- Infrastructure is a prerequisite for using computer games in the schools. But many schools always blaming the government for the funds. We should rid out from the habit of blaming game and working on the optimum utilization of the resources. If anyone have a passion to change, then the solution will automatically come out, for this we need Vision and Passion.
- The teacher should be evaluated frequently in certain benchmarks. For this, one committee should form in each district which keeps checking on the activities and output of the teachers.

- Teachers should be part of in designing the computer games which based on the needs of the students.

Autism children deficit in executive function, social skills and communications which halt the academic achievement of these students in schools. For improving these domains, Computer-based intervention is a very promising tool in improving executive function which later on improves the social skills of the students. Executing maximum output from this games requires designing the games according to the needs of the students, access to these games, teachers should have skills to use these technologies as well as implementing these technologies in the classroom. Using above solution, we can get the maximum benefit of this.

References

- Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology*, 8(2), 71-82.
- Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., & Charman, T. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *The Lancet*, 368 (9531), 210-215.
- Barkley, R. A., & Fischer, M. (2011). Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: Self-reported executive function (EF) deficits versus EF tests. *Developmental Neuropsychology*, 36(2), 137-161.
- Beck, S. J., Hanson, C. A., Puffenberger, S. S., Benninger, K. L., & Benninger, W. B. (2010). A controlled trial of working memory training for children and adolescents with ADHD. *Journal of Clinical Child & Adolescent Psychology*, 39(6), 825-836
- Bennetto, L., Pennington, B. F., & Rogers, S. J. (1996). Intact and impaired memory functions in autism. *Child Development*, 67(4), 1816-1835.
- Brehmer, Y., Westerberg, H., & Bäckman, L. (2012). Working-memory training in younger and older adults: training gains, transfer, and maintenance. *Frontiers in Human Neuroscience*, 6.
- Brehmer, Y., Westerberg, H., Bellander, M., Fürth, D., Karlsson, S., & Bäckman, L. (2009). Working memory plasticity modulated by dopamine transporter genotype. *Neuroscience Letters*, 467(2), 117-120.
- Brugha, T. S., McManus, S., Bankart, J., Scott, F., Purdon, S., Smith, J., ... & Meltzer, H. (2011). Epidemiology of autism spectrum disorders in adults in the community in England. *Archives of General Psychiatry*, 68(5), 459-465.
- Camaioni, L., Perucchini, P., Muratori, F., & Milone, A. (1997). Brief report: A longitudinal examination of the communicative gestures deficit in young

- children with autism. *Journal of Autism and Developmental Disorders*, 27 (6), 715-725.
- Clark, L. R., Schiehser, D. M., Weissberger, G. H., Salmon, D. P., Delis, D. C., & Bondi, M. W. (2012). Specific measures of executive function predict cognitive decline in older adults. *Journal of the International Neuropsychological Society*, 18 (1), 118-127.
- Cummings, J. L. (1993). Frontal-subcortical circuits and human behaviour. *Archives of Neurology*, 50 (8), 873-880.
- Dahlin, K. I. (2011). Effects of working memory training on reading in children with special needs. *Reading and Writing*, 24(4), 479-491.
- Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan executive function system: Technical manual*. Psychological Corporation.
- Della Sala, S., Gray, C., Spinnler, H., & Trivelli, C. (1998). Frontal lobe functioning in man: the riddle revisited. *Archives of Clinical Neuropsychology*, 13(8), 663-682.
- DSM-5 American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. *Arlington: American Psychiatric Publishing*.
- Dunning, D. L., Holmes, J., & Gathercole, S. E. (2013). Does working memory training lead to generalized improvements in children with low working memory? A randomized controlled trial. *Developmental Science*, 16(6), 915-925.
- Eisenmajer, R., Prior, M., Leekam, S., Wing, L., Ong, B., Gould, J., & Welham, M. (1998). Delayed language onset as a predictor of clinical symptoms in pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, 28 (6), 527-533.
- Fisher, N., & Happé, F. (2005). A training study of theory of mind and executive function in children with autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, 35 (6), 757-771.
- Fombonne, E. (2005). The changing epidemiology of autism. *Journal of Applied Research in Intellectual Disabilities*, 18 (4), 281-294.
- Griffith, E. M., Pennington, B. F., Wehner, E. A., & Rogers, S. J. (1999). Executive functions in young children with autism. *Child Development*, 70 (4), 817-832.
- Hale, S., Bronik, M. D., & Fry, A. F. (1997). Verbal and spatial working memory in school-age children: Developmental differences in susceptibility to interference. *Developmental Psychology*, 33 (2), 364-371.
- Hofvander, B., Delorme, R., Chaste, P., Nydén, A., Wentz, E., Ståhlberg, O., ... & Råstam, M. (2009). Psychiatric and psychosocial problems in adults with normal-intelligence autism spectrum disorders. *BMC Psychiatry*, 9 (1), 35.

- Jacobs, R., Harvey, A. S., & Anderson, V. (2011). Are executive skills mediated by the prefrontal cortex in childhood? Examination of focal brain lesions in childhood. *Cortex*, 47, 808-824.
- Johnstone, S. J., Roodenrys, S. J., Johnson, K., Bonfield, R., & Bennett, S. J. (2017). Game-based combined cognitive and neurofeedback training using Focus Pocus reduces symptom severity in children with diagnosed AD/HD and subclinical AD/HD. *International Journal of Psychophysiology*, 116, 32-44.
- Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlström, K., ... & Westerberg, H. (2005). Computerized training of working memory in children with ADHD—a randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, 44(2), 177-186.
- Kouijzer, M. E., de Moor, J. M., Gerrits, B. J., Buitelaar, J. K., & van Schie, H. T. (2009). Long-term effects of neurofeedback treatment in autism. *Research in Autism Spectrum Disorders*, 3(2), 496-501.
- Leekam, S. R., Hunnisett, E., & Moore, C. (1998). Targets and cues: Gaze-following in children with autism. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, 39(7), 951-962.
- Leyfer, O. T., Woodruff-Borden, J., Klein-Tasman, B. P., Fricke, J. S., & Mervis, C. B. (2006). Prevalence of psychiatric disorders in 4 to 16 year olds with Williams syndrome. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, 141(6), 615-622.
- Liu, Z. X., Glizer, D., Tannock, R., & Woltering, S. (2016). EEG alpha power during maintenance of information in working memory in adults with ADHD and its plasticity due to working memory training: A randomized controlled trial. *Clinical Neurophysiology*, 127(2), 1307-1320.
- Lord, C., Storoschuk, S., Rutter, M., & Pickles, A. (1993). Using the ADI-R to diagnose autism in preschool children. *Infant Mental Health Journal*, 14(3), 234-252.
- Luna, B., Doll, S. K., Hegedus, S. J., Minshew, N. J., & Sweeney, J. A. (2007). Maturation of executive function in autism. *Biological Psychiatry*, 61(4), 474-481.
- Lundquist, T. J., Woertz, I. C., Quinn, N. W. T., & Benemann, J. R. (2010). A realistic technology and engineering assessment of algae biofuel production. *Energy Biosciences Institute*, 1.
- Matson, J. L. and Boisjoli, J. A. (2008). Strategies for assessing Asperger's syndrome: A critical review of data based methods. *Research in Autism Spectrum Disorders*, 2(2): 237-248.

- Matson, J. L., & Nebel-Schwalm, M. S. (2007). Comorbid psychopathology with autism spectrum disorder in children: An overview. *Research in developmental disabilities, 28*(4), 341-352.
- Mazurek, M. O., Engelhardt, C. R., & Clark, K. E. (2015). Video games from the perspective of adults with autism spectrum disorder. *Computers in Human Behavior, 51*, 122-130.
- McNab, F., Varrone, A., Farde, L., Jucaite, A., Bystritsky, P., Forsberg, H., & Klingberg, T. (2009). Changes in cortical dopamine D1 receptor binding associated with cognitive training. *Science, 323*(5915), 800-802.
- Minshew, N. J., Muenz, L. R., Goldstein, G., & Payton, J. B. (1992). Neuropsychological functioning in nonmentally retarded autistic individuals. *Journal of Clinical and Experimental Neuropsychology, 14*(5), 749-761.
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive psychology, 41*(1), 49-100.
- Monastra, V. J. (2005). Electroencephalographic biofeedback (neurotherapy) as a treatment for attention deficit hyperactivity disorder: rationale and empirical foundation. *Child and Adolescent Psychiatric Clinics of North America, 14*(1), 55-82.
- Naglieri, J., & Goldstein, S. (2013). *Comprehensive executive functioning inventory technical manual*. Toronto, Canada: Multi-Health Systems.
- Olesen, P. J., Westerberg, H., & Klingberg, T. (2004). Increased prefrontal and parietal activity after training of working memory. *Nature neuroscience, 7*(1), 75-79.
- Ozonoff, S., & McEvoy, R. E. (1994). A longitudinal study of executive function and theory of mind development in autism. *Development and psychopathology, 6*(3), 415-431.
- Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *Journal of child Psychology and Psychiatry, 32*(7), 1081-1105.
- Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *Journal of child Psychology and Psychiatry, 32*(7), 1081-1105.
- Ozonoff, S., Strayer, D. L., McMahon, W. M., & Filloux, F. (1994). Executive function abilities in autism and Tourette syndrome: An information processing approach. *Journal of child Psychology and Psychiatry, 35*(6), 1015-1032.

- Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of child psychology and psychiatry*, 37 (1), 51-87.
- Pribram, K. H. (1973). The primate frontal cortex—executive of the brain. *Psychophysiology of the frontal lobes*, 293-314.
- Prior, M., & Hoffmann, W. (1990). Brief report: Neuropsychological testing of autistic children through an exploration with frontal lobe tests. *Journal of autism and developmental disorders*, 20(4), 581-590.
- Rapin, I., & Tuchman, R. F. (2008). Autism: definition, neurobiology, screening, diagnosis. *Pediatric Clinics of North America*, 55(5), 1129-1146.
- Roording-Ragetlie, S., Klip, H., Buitelaar, J., & Slaats-Willemse, D. (2016). Working Memory Training in Children with Neurodevelopmental Disorders. *Psychology*, 7(03), 310.
- Roughan, L., & Hadwin, J. A. (2011). The impact of working memory training in young people with social, emotional and behavioural difficulties. *Learning and Individual Differences*, 21(6), 759-764.
- Russell, J. E. (1997). *Autism as an executive disorder*. Oxford University Press.
- Russo, N., Flanagan, T., Iarocci, G., Berringer, D., Zelazo, P. D., & Burack, J. A. (2007). computerized *Brain and cognition*, 65(1), 77-86.
- Rutherford, M. D., & Rogers, S. J. (2003). Cognitive underpinnings of pretend play in autism. *Journal of autism and developmental disorders*, 33(3), 289-302.
- Shallice, T., & Vallar, G. (1990). The impairment of auditory-verbal short-term storage. *Neuropsychological Impairments of Short-term Memory*, 11-53.
- Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: a conceptual view. *Psychological Research*, 63 (3), 289-298.
- Szatmari, P., Tuff, L., Finlayson, M. A. J., & Bartolucci, G. (1990). Asperger's syndrome and autism: Neurocognitive aspects. *Journal of the American Academy of Child & Adolescent Psychiatry*, 29 (1), 130-136.
- Thorell, L. B., Lindqvist, S., Bergman Nutley, S., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental science*, 12(1), 106-113.
- VanMeter, L., Fein, D., Morris, R., Waterhouse, L., & Allen, D. (1997). Delay versus deviance in autistic social behaviour. *Journal of Autism and Developmental Disorders*, 27 (5), 557-569.
- Vélez-Coto, M., Rodríguez-Fórtiz, M. J., Rodríguez-Almendros, M. L., Cabrera-Cuevas, M., Rodríguez-Domínguez, C., Ruiz-López, T., ... & Martos-Pérez, J. (2017). SIGUEME: Technology-based intervention for low-functioning

- autism to train skills to work with visual signifiers and concepts. *Research in Developmental Disabilities, 64*, 25-36.
- Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 45* (1), 135-170.
- Westerberg, H., & Klingberg, T. (2007). Changes in cortical activity after training of working memory—a single-subject analysis. *Physiology & Behavior, 92*(1), 186-192.
- Wing, L. (1979). Mentally retarded children in Camberwell (London). In *Estimating Needs for Mental Health Care* (pp. 107-112). Springer, Berlin, Heidelberg.
- Yakovlev, P., & Lecours, A. a. L., A. (1967) The myelinogenetic cycles of regional maturation of the brain. *Regional Development of the Brain Early in Life. Blackwell Scientific Publications, 3-70.*
- Yerys, B. E., Hepburn, S. L., Pennington, B. F., & Rogers, S. J. (2007). Executive function in preschoolers with autism: Evidence consistent with a secondary deficit. *Journal of Autism and Developmental Disorders, 37*(6), 1068-1079.

Recommended Citation for this Publication

Kaur, K. & Pany, S. (2017). Efficacy of computer based intervention in improving executive function of autism spectrum disorder children. *Pedagogy of Learning, Vol. 3* (4) , 01-13. Available at: www.pedagogyoflearning.com.