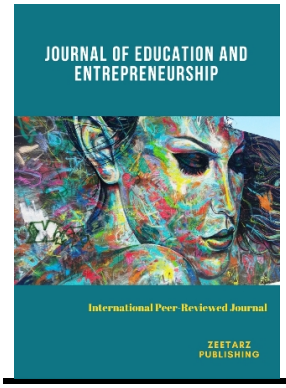

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Improving Working Memory and Processing Speed of Students with Dyslexia in Nigeria

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Abstract
This study investigated effective strategies for improving working memory and processing speed of students identified with dyslexia in Nigeria. The study adopted a quasi-experimental research design with the population made up of twenty four thousand seven hundred and twenty seven (24,727) senior secondary school students (S.S.2) in all the public secondary schools in Port Harcourt Rivers State Nigeria. The study adopted a purposive sampling method and three public schools were selected from the secondary schools in Phalga and Obio/Akpo LGA of Rivers State. The result proved that there is reasonable number of students suffering from dyslexia in Nigeria, and there is little or no attention given to the students living with dyslexia. Also, there is unchallengeable evidence that some students in Nigeria like other students in various parts of the world have dyslexia. The paper concludes by nothing that a child that has dyslexia may not outgrow it. But there are supports, teaching approaches, and strategies to help the child overcome the challenges.

Keywords: dyslexia, people living with dyslexia, working memory, processing speed

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Dyslexia is a reading and language disorder that is typically identified in children after they take assessments and evaluations to spot reading disorders in students. With this review of the learning disability, learn basic information about dyslexia and how it affects a student's reading, writing and language skills. It is also a precise disability in learning; children with dyslexia encounter series of troubles reading correctly and confidently. They have challenges with spelling and writing as well as reading comprehension. Dyslexia is a lifetime condition that makes it uneasy for children to read. It's a common learning problem, though the percentage of children suffering from dyslexia is known globally or regionally. But, many experts in the field acknowledged that number of children suffering from dyslexia is between 5-10 percent, while others say it's well over 17 percent globally. The reason for the wide range is because, experts define dyslexia is several ways.

It is important to understand that dyslexia is a syndrome, not all students with dyslexia will show the same pattern of difficulties (Alexander-Passe, 2006). Unless they have only recently been assessed, most students with dyslexia have developed some coping strategies in order to achieve in an academic setting. However, multi-sensory teaching methods and presenting material in a variety of ways are particularly successful and indeed can help all students to learn more effectively. People living with dyslexia may be able to read, but read at a level lower than expected for their age and level of study (Adubasim, 2017). Their proficiency in reading is poor and sometimes below average depending on the severity of the disability. This difficulty in reading is irrespective of required motivation from both teachers and learning environment. For a student to be labeled Dyslexic, such student's senses are intact and functions maximally. This also means that people diagnosed for dyslexia are not at the same time diagnosed for mental retardation, health impairments and behavioral or emotional disturbances. Thus a student is labeled dyslexic when these impairments and disturbances are carefully ruled out (Abbott, Larkin & Dunn, 2015).

There is increasing concern over people who are intelligent, normal, and healthy but at the same time struggle with reading, spelling and writing (Ramus, 2003). Reading and spelling difficulties are key features in the concept of dyslexia. IDA (2007) posits that an estimated 15-20% of the world's population experience at least one symptom of dyslexia or the other (IDA, 2007). Washburn, Binks-Cantrell & Joshi (2013) asserted that one out of every five persons in the United States of America show one or more symptoms of dyslexia. In an earlier survey by John- Alexander-Passe (2006) using six public primary schools involving 1350 pupils, it was revealed that approximately one out of every three children in the public primary schools in Port Harcourt Local Government Area (PHALGA) Rivers State had a reading problem which is a major pointer to dyslexia (Adubasim, 2017). This makes it a problem to be taken seriously by the educational system whose responsibility it is to combat this phenomenon with the required and necessary attention. Research conducted in Britain, America and Sweden indicates that 30-52% of prison inmates in these countries are dyslexic (Elias, 2014). These findings are very important, as they imply that as much as at least one out of every seven persons in the world shows one symptom of dyslexia or the other, and a hand full of the population of British, American and Swedish prisoners are dyslexic.

Epidemiology and management of the learning disabilities

The question on the lips of parents and teachers have always been why is it so easy for some students to read, solve mathematical problems, spell and write effectively while some others of the same age and in the same class struggle endlessly to achieve a pass grade on reading, math, spelling and writing tasks?. The greater part of this problem has been how to

effectively understand these disabilities and subsequently manage them. To this end lots of researches have been carried out and are ongoing into these learning disabilities with the aim of understanding the etiology, epidemiology and management of these learning disabilities.

Unfortunately for students living with dyslexia the most popular examination structures are based on time limit which students must adhere to, and demands speed and high levels of literacy (Mortimore & Crozier cited in Elias, 2014). This makes it difficult for students living with dyslexia to achieve as much as their counterparts who are not dyslexic, thus People living with dyslexia are continuously seen as failures or performing below average in virtually all academic evaluations. The persistent difficulties experienced by poor readers will make them get frustrated as their grades begin to continuously fail with the increasing difficulty they experience with school work. These difficulties if not attended to may cause the student to experience a catalogue of emotional and social problems; gradual loss of self esteem and frustration leading to some juvenile delinquencies which can linger to adulthood (Norton, Black, Stanley, Tanaka, Gabrielia, Sawyer & Hoeft, 2014; Elias, 2014).

People living with dyslexia have been found to have weak cognitive skills amongst others; poor working memory and processing speed. Working memory is very important in the learning processes (Szmalec, Loncke, Page & Duyck, 2011). It helps students to store information in their minds for a short period of time which was useful in thinking. Holmes (2012), sees working memory as a mental workplace which an individual uses for many aspects of his daily life. This includes reading comprehension, mental arithmetic and planning a series of thoughts or actions. Working memory also plays a crucial role both in supporting learning and maintaining focused behaviour in the learning environment. There is usually a limit to how much information we can retain or hold on to as well as how much we can manipulate in working memory at any given time. The capacity to retain and manipulate information varies greatly amongst individuals even of the same age, it increases with maturity and declines with age (Holmes, 2012; Gathercole & Alloway, 2008). Changes in the memory cuts across one's lifespan with capacity to increase steadily up to the age of 14/15 years at which point it matches that of an adult (Alloway, Gathercole & Pickering, 2006).

Earlier works of Westerberg, Hivikoski, Forssberg & Kingberg, (2004) posited that this assertion is for typically developing children, whereas for their counterparts the atypically developing children, there is an atypical developmental route that presents in a smaller capacity than is observed in their mates who are typically developing. Children with developmental disability and specific learning disorders like Dyslexia, dyscalculia, Attention Deficit Hyper activity Disorder (ADHD), Specific Language Impairment, notably show evidence of working memory deficits (Holmes, Gathercole, Hilton, Place, Alloway, Elliot 2012). Suffice it to say that a student with poor working memory is at risk of poor educational progress or academic achievement (Gathercole & Alloway, 2008).

An experiment by Holmes et al. 2012 shows that students with ADHD in a rating of 60 to 120, scored below 100 while the control of the same age scored above 100 in all ratings on verbal short term memory, visuo-spatial short term memory, verbal working memory as well as visuo-spatial working memory (Ramus et al., 2013; Majerus & Cowan, 2016).

A good and functional working memory helps in the processing and storage of information while one is embarking on complex and demanding tasks. It is useful during most routine activities children partake in at schools and homes. The process of reading a sentence, holding them in and integrating the information to understand its meaning relies heavily on the capacity of the brain to simultaneously process and store information over the short term

memory. Suffice it to say that following a set of complex instructions which a child will often have to do in the classroom relies heavily also on the child's ability to remember the various parts or bites of the instruction while carrying out the numerous steps to complete the actions successfully (Holmes, et al., 2012; Alloway, 2012).

Research findings (Gathercole, Lamont & Alloway, 2006; Gathercole & Alloway, 2008; Gathercole & Alloway, 2007) show that the majority of students with working memory deficit or difficulty present poor academic achievement and progress, failure to complete common classroom activities that require multiple instructions or information to bear in mind, easily distracted, inability to keep their place in demanding and complex activities such as writing, difficulty with multi step instructions. These burdensome tasks involved in the classroom laden the working memory, thus a defective or deficit working memory will subsequently lead to poor educational attainment.

Deficit working memory

Some students in addition to deficit working memory also have issues with processing speed. Students with slow processing speed often take extra hours to complete class work. Slow or poor processing speed is not a formal learning disability but could contribute immensely to poor academic achievement thereby frustrating the students, teachers and parents. Sometimes a gifted child can be either misdiagnosed or misunderstood, and as such is discouraged, depressed, undereducated etc. On the contrary when students are properly understood, diagnosed and well addressed educationally, they are given a platform to thrive and achieve their maximum potentials. A child with slow processing speed can be identified by the speed at which they handle homework or chores. They take much time to dress up than usual or expected for their age, they usually leave out important information or instruction when made to speed up. An early medical, psychological and educational diagnoses or evaluation is important as there could be other causes of slow processing speed or slow work pace (Callens, Tops & Brysbaert 2012; Alloway, 2012).

The collection of linguistic complications that students living with dyslexia stumble upon requires complete understanding and expertise on the part of educators to make certain they employ the suitable intervention strategies (Moats, 2010). There is need for greater concentration and interval of instruction due to the increased specificity of tutoring for children at risk of reading failure (Torgesen, 2002; Tunmer & Greaney, 2008), thus teachers awareness and access to the various instructional techniques and ability to employ them is very important (Lowell, 2014). There are many different strategies employed to help students living with dyslexia cope with academic life especially in the early years. The initial focus basically before fifth and sixth grades is on remediation; here strategies which are aimed at helping the child to improve deficits in the particular area of disability are employed. Areas of disability include reading decoding, reading comprehension, or speed of reading. The child living with dyslexia is helped to identity, recognise and correlate the sounds of alphabets (graphemes). He is also helped to build focus on decoding with abilities to blend sounds (Phonemes) into words (morphemes) and break words into component sounds. With time the child is taught to focus on the content of the reading material and not just on individual words. The tactic of guided oral reading provides feedback to the child so as to spot areas of errors and teach other ways of tackling the task at hand.

Problem Statement

Current researches have proved that there are indications that, in addition to reading challenges, students who suffer dyslexia are likely to experience difficulties with written

language and other language related areas. Take for instance; there are children that have difficulties with phonological awareness, verbal memory, and rapid naming ability. These skills relate to a child's ability to master the sound/symbol systems involved in reading and the necessary storage and retrieval skills required for a child to understand the printed language and to acquire the speed and automaticity needed for fluency in reading. Students suffering from these challenges often get frustrated as their performances in school repeatedly fail. Some students in addition to deficit working memory also have issues with processing speed. Some also have difficulties in understanding that each letter is connected to a sound and that these sounds produce words, also known as lack of phonemic awareness. If there are no innovative strategies for handling/ managing the students with such challenges, they may be exposed to a catalogue of emotional and social problems; gradual loss of self esteem and frustration leading to some juvenile delinquencies which may have a lifetime consequences on them. Hence this study aim to determine effective strategies for improving working memory and processing speed of students identified with dyslexia in Nigeria. Specifically, the study was built under three major objectives; (i) improvement of the working memory of students living with dyslexia in the control group receiving pretest and post test; (ii) determine the working memory of students living with dyslexia in the experimental and control groups who received only post-test; (iii) determine the processing speed of students in the control group who were assessed at pretest and post stages; determine the processing speed of students living with dyslexia in the experimental and control groups who received only post-test assessment.

Research Questions

This study was guided by the following research questions;

- What is the working memory of students living with dyslexia in the control group who were assessed pre-test and post-test stages?
- What is the working memory of students living with dyslexia in the experimental and control groups who received only post-test?
- What is the processing speed of students in the control group who were assessed at pretest and post stages?
- What is the processing speed of students living with dyslexia in the experimental and control groups who received only post-test assessment?

Hypothesis

- There is no significant improvement in the working memory of students living with dyslexia in the control group receiving pretest and posttest
- There is no significant difference in the working memory of students living with dyslexia who received only post-test in the experimental and control groups.
- There is no significant improvement in processing speed of students living with dyslexia in the control group receiving pretest and posttest.
- There is no significant difference in the working memory of students living with dyslexia who received only post-test in the experimental and control groups.
- There is no significant difference in the post mean scores of the students living with dyslexia in the cognitive skills of processing speed based on their groups.

It is hoped that findings of this research will help to strengthen teachers relationship with the students living with dyslexia; it will educate the teachers that the slow work pace exhibited by these students is not intentional or as a result of laziness, but as a result of a neurological condition which the student may not have contributed to, and which the student may also be ignorant of. Parents will not be left out as they will better understand the possible causes of

slow work pace especially with house chores and students personal upkeep. They will also become more sensitive to their children's struggles and the awareness that they can seek help and early diagnosis for any condition they suspect as unusual with their children's personal and academic progress. Future researchers will also benefit from the empirical statistics and literatures reviewed in this study.

Theoretical Underpin for Improving Working Memory and Processing Speed

There are a number of theories of learning and intelligence which have formed the premise and backing for alternative intervention programmes; this study tries to review some of them most appropriate for the current study. A lot of researches by neurologists, psychologist, and educationist have paved the way to greater understanding of the nature of dyslexia. They have significantly contributed to knowledge and awareness of the causes, definition, diagnosis as well as intervention for dyslexia (Snowling, 2009; Washburn et al, 2013). Various reviewed theories and hypothesis have tried to explain the nature of dyslexia, all of which suggests that dyslexia is a language-based learning disability in which individuals experience difficulty with phonological coding. This implies that dyslexia affects how an individual processes language and may be evidenced in language related tasks such as word recognition or single word reading, spelling, reading comprehension and speaking. This varies according to level of severity. Dyslexia is not due to lack of intelligence or poverty, but can occur even in children with high IQ or from affluent families, It is said to run in families and can be hereditary reviewed (Pennington and lefly, 2001). Further research also shows that dyslexia is not peculiar to English language alone but prevalent in other alphabetic languages such as German, Norwegian, French, Spanish, Dutch, Portuguese (Joshi, Dahlgren & Boulware-Gooden, 2002; Washburn et al, 2013).

A few theories have tried to describe the causes of dyslexia;

Phonological Deficit Theory: The Phonological Deficit Theory is more predominantly recognised in the conceptualisation of dyslexia. It is of the view that learners with dyslexia have problems in associating sounds with symbols in reading and spelling. Thus they experience problem with alphabetic principle. Thus it is phoneme or sound manipulation impairment. (Hulme , Goetz , Gooch , Adams and Snowling , 2007; Ikediashi, 2012; Elias, 2014).

The Cerebella Deficit Theory: this theory proposes that the cerebellum is the region of the brain that fosters automatic cognition, thus in students living with dyslexia there is reasonable difficulty in central processing related to learning and automaticity (Ikediashi, 2012; Fawcett, Maclagan & Nicolson, 2001)

Automatisation Deficit Hypothesis: This theory sees children living with dyslexia as having problems with making skills automatic and needs to consciously compensate even for simple skills.

Magnocellullar Deficit Theory: The magnocellular deficit theory views the students living with dyslexia as having a basic problem resulting from visual and auditory deficits (Elias, 2014).

The Naming Speed deficit theory: This theory is of the view that inability for rapid automatic naming is a strong pointer to dyslexia.

Double-Deficit Hypothesis of Dyslexia: Functional neuro-anatomical researches have given credence to the double deficit hypothesis of dyslexia. The double deficit theory of dyslexia posits that Rapid Naming deficit and Phonological deficit are responsible for most reading

difficulties (Norton, Black, Stanley, Tanaka, Gabrielia, Sawyer & Hoeft, 2014). It also showed that people with both deficits encountered more reading difficulties compared to persons who had either RN or Phonological deficits. It is important to note that deficit in phonological awareness single-handedly is not responsible for all cases of dyslexia (Lovett, Steinbach & Frijters, 2000). RAN is the speed with which one can name a sequence of visually presented known stimuli such as numbers, letters, colours or objects out loud, this reflects the automaticity of processes which are also important for reading (Norton and Wolf, 2012). The double deficit hypothesis posits that RAN is an autonomous core deficit that can cause reading difficulties, in addition to or in the absence of phonological processing deficits observed in many individuals with developmental dyslexia (Wadlington & Wadlington, 2005; Norton, Black, Stanley, Tanaka, Gabrieli, Sawyer and Hoeft, 2014). Accordingly, this theory posits that impairments in either RAN or PA can cause reading difficulties and persons with a double deficit have more severe deficits in reading than persons with single deficits. There is growing evidence that reading difficulties encountered by persons with dyslexia have neurobiological substrates and there may be apparent differences in the brain basis of phonological vs. RAN deficit. Functional magnetic resonance imaging (FMRI) studies have recognized brain regions significant to skilled reading and discrepancy functioning has been noticed in dyslexia in each area (Gilbert & Sigman, 2007; Gilger & Kaplan, 2001).

There are three key areas of the brain reading network; left hemisphere occipito-temporal region which encompasses the visual word from area (VWFA) of the fusiform gyrus which helps the automatic recognition of printed words (Schlaggar & McCandliss, 2007). The temporo-parietal region which includes the inferior parietal lobule or IPL is concerned with phonological storage and recovery ((Vigneau, Beaucousin, Hervé, Duffau, Crivello, Houdé, Mazoyer & Tzourio-Mazoyer, 2006) as well as the incorporation of orthography and phonology (Newman and Joanisse, 2011). Atypical function in this brain region would be expected to compromise the phonological and phonological-to-orthographic mapping processes necessary for developing fluent reading. The reduced functional activation and connectivity in these left posterior brains systems; temporo-parietal and occipito-temporal regions seems to be connected to the pathophysiology of dyslexia rather than to present level of reading ability ((Hoeft, Ueno, Reiss, Meyler, Whitfield-Gabrieli, Glover, Keller, Gabrieli, 2007).

Theories of Working Memory

There are couples of theoretical models of working memory. The different conceptualisation of the structure and functions of the working memory all concur that the short term memory is a temporary storage and manipulation of information (Baddeley, 2010; Smith, 2016). There are lots of structures in the working memory amongst which the verbal are and visuo-spatial short term memory systems.

The Multi-Component Model of Working Memory

The multi-component model of working memory seems to be the most prominent model (Bradley, Summers, Wood & Bryson, 2004). This theory was put forth by Baddeley and Hitch in 1974 suggesting that there are a number of mechanism of the working memory that work together to influence and analyse information (Mathew, 2016). This theory recommended three key mechanisms – the phonological loop which analyses the phonological and verbal information, the visuo-spatial sketchpad which is responsible for

storage of information that have visual and spatial features, the episodic buffer and the central executive

Theories of Processing Speed

Processing speed theory is a general theory of cognitive aging based on the foundation that cognitive declines in several areas are due to general slowing of cognitive processes.

The Sensory Deprivation Hypotheses states that a lack of adequate sensory input over a prolonged period is likely to result in cognitive deterioration due to prior neuronal atrophy (Ebaid, Crewther, MacCalman, Brown & Crewther, 2017).

The Degradation Hypotheses states that when perceptual signals are weakened or degraded, either due to experimental manipulations or age related impaired perception, higher order cognitive processes are in turn affected. This is resultant of the fact that there is greater cognitive load for weaker perceptual signals thus more of cognitive resources are needed to interpret the signal, this in turn affects cognitive performances (Wilson, Andrewes, Struthers, Rowe, Bogdanovic, & Waldie, 2014). Sensory and cognitive functions are both prone to be an expression of the physiological design of the aging brain.

The Common-Cause Hypotheses is of the view that concurrent peripheral and central decline occurs simultaneously with declines in aspects of cognition such as memory and processing speed (Wilson, Andrewes, Struthers, Rowe, Bogdanovic, & Waldie, 2014).

Theory of Structural Cognitive Modifiability (SCM)

Reuven Feuerstein views intelligence as a dynamic construct. It is on the premise of achievable remediation as a result of targeted intervention that Reuven Feurstein proposed a theory of modifiability of cognition within a person (Feurstein, 1990 in Pfister, 2012). He is of the view that through environmental enhancement, the cognitive functioning of a person can be modified and improved. This theory is based on the fundamental assumption that every human being is capable of modifying his or her cognitive structure no matter the severity of the challenge (mental, physical or emotional) through adequate mediated learning experience, thus human cognitive faculty is flexible and not fixed (Feuerstein, Rand, Hoffman & Miller, 1979). Cognitive Modifiability refers to structural changes brought about by a deliberated program of intervention. This theory posits that teaching thinking goes beyond using of tools and skills and involves addressing the complete cognitive structure. Thus it believes in the plasticity and modifiability of cognition and proposes that by changing the total cognitive structure rather than chosen dimensions of behavior a more lasting and stable modifiability can be achieved. Feuerstein emphasized the need to recognize what is going on in the mind of the learner by identifying the Deficient Cognitive Functions (Ebaid et al, 2017). These are unplanned impulsive and unsystematic exploratory behavior as a result of lack of mediated learning experience (Ebaid et al, 2017).

The concept of modifiability in the context of Structural Cognitive Modifiability theory means that the changes that occur are not a disjointed episodic result of exposure to experiences but rather a type of change that affects the basic formation of behavior, thus this evidence challenges the belief that unpleasant early experiences results in permanent and irreversible damage. It signifies that there is solution to challenges that are related to cognitive functioning. Thus mind and intelligence are not static but flexible and can change under the right conditions. This leaves cognitive psychologist with the burden of working out modalities of how this can be effectively done. It is on this premise that recent research into

cognitive enhancing therapy and programmes have been carried out and many programmes have emerged and many more are on the way. Thus these theories and findings have paved way for development of various computer based programmes and exercises specifically designed to target core brain areas for cognitive training. Evidence from various researches showed that most of these training programmes have improved processing speed, attention and working memory in people with specific learning disability, ADHD, Aphasia and elderly respectively (Bruce, Edmundson, Aviet and Willison, 2010). Based on these theories and literature reviewed, this study focuses on improving working memory and processing speed of students identified with dyslexia in Nigeria.

Methodology

This study adopted a quasi-experimental research design. Quasi- experimental research design is an investigation that uses designs suitable in estimating situations of true experiment in a circumstance that does not allow the direct manipulation of relevant variables (Kaplan, Dewey, Crawford, & Wilson, 2001). Thus when total randomization cannot be applied to manage all extraneous variables necessary for a true experiment, a quasi-experimental research design is the most suitable research design. Nwankwo (2013) defined quasi experimental study as that in which some threats to validity cannot be appropriately controlled due to unavoidable situations associated with the study when human beings are used for experimental study. Nwankwo (2013) is of the view that amongst other conditions, when subjects for a study are selected and randomisation of the subject is not feasible, so that intact classes are used, such study is quasi-experimental. This research design is appropriate as it provides opportunity to investigate the effect of the independent variables on the dependent variables of the study.

This experimental design is a combination of between subject before-after designs and between subject after-only designs to determine the strategies for improving the working memory and processing speed of dyslexics. This design contains two experimental groups and two control groups. One experimental group takes both the pre test and post test, while the other experimental group takes only post test. One control group takes both the pre test and post tests while the other control group takes just the post test.

Table I: Randomized Solomon 4 group design**.**

Groups	Pre-test	Treatment	Post-test
EG1	01	X	02
CG1	03	-	04
EG2	-	X	05
CG2	-	-	06

Randomized Solomon 4 group design key

EG1	Represents Experimental group1
EG 2	Represents Experimental group2
CG1	Represents Control group1
CG2	Represents Control group2
X	Represents Treatment
O1, O3	Represents Pre test
02,04,05,06	Represents Post tests
-	Represents no Treatment
--	Represents no Pre test.

The population of this study is made up of twenty four thousand seven hundred and twenty seven (24,727) senior secondary school students (S.S.2) in all the public secondary schools in Port Harcourt Local Government Area (Phalga and Obio/Akpo Local Government Areas of) Rivers State used for the study. (Statistical records at Rivers State senior secondary schools board 2017). The choice of using this population is based on the belief of the researcher that the students in the senior secondary class will do well as participants in the research.

The study adopted a purposive sampling method. Three public schools were selected from the secondary schools in Phalga and Obio/Akpo LGA of Rivers State. These schools were chosen because of their proximity, suitable learning environment and other amenities to enable the application of the testing conditions and the treatment regimen. This consideration is to enable easy administration of the programme in its digital form and the need for the researcher to administer and supervise the participants during the training. To get the final sample for the study, series of tests was conducted. Firstly, an adapted form of Davis Dyslexia Association International (DDAI) pre assessment (informal assessment) questionnaire was administered to the senior secondary two (SS2) students; Respondents responded to the questionnaire using a 3 point scale of Absolutely, Sometimes and Rarely, to indicate their level of agreement or disagreement with the issues raised, this was used to determine students' eligibility for the study, and also reveal the areas of students' major struggles. Respondents who scored 40 points and above were selected for further assessments; in addition, the following test were administered; Rapid Automatic Naming (RAN) test which is a test comprising of similar items like letters, numbers, and objects, to which a child is required to name the items as quickly as possible. A Reading and spelling test from Dyslexia international and University of London. A pre-test of Gibsons test of Cognitive Skills of Cognitive Skills was administered to further determine dyslexic students with working memory and processing speed deficits. All students whose raw scores are less than 90 in auditory processing, visual processing are selected as having dyslexia, and those who scored less than 90 in working memory and processing speed are considered below average and will form sample for this study. All the students selected for this study were between the ages of 13-20 years old during the periods of this study and finished from a public junior secondary school. This is to ensure that the participants have similar characteristics.

An adapted version of the Davis Dyslexia Association International Questionnaire (DDAIQ) titled Dyslexia Assessment Questionnaire (DAQ). The original version of the DDAIQ was developed by the Dyslexia International and contained 41 items constructed in a 3-point likert scale. The researcher adapted the instrument by modifying the items in the instrument reducing the items to 20 and was constructed using a modified 3 point Likert scale of Always, Sometimes and Rarely/Never which was scored as 3, 2, and 1 point(s) respectively. To get the criterion of students with dyslexic symptoms, the criterion mean of each item (2) was multiplied with the number of items (20), which yielded 40. Therefore, students that scored 40 points and above was considered as displaying dyslexic symptoms. Thereafter, the RAN object test developed by Dyslexia International was used. The test consists of a framework, presented in A4 paper, with four different figures that are repeated in random order, making a total of forty figures, number and or letter games, and the student was told to name quickly the figures, presented in sequence, from left to right. To mark the time required for the rapid naming, the researcher used a stopwatch. The scoring procedure of the instrument involves naming letters, numbers and objects and contains 40 items to be named by respondents. A threshold of 25 seconds was established to identify those who are

symptomatic of dyslexia based on the recommendation of Atkins, Sprenger, Colflesh, Briner, Buchanan, Chavis & Doherty, 2014).

For the actual data collection the Gibson test of Cognitive Skills was administered as pre-test for working memory and processing speed on the sample to know their present working memory and processing speed status, and as post test at the end of the treatment period. Gibson test of Cognitive Skills is a screening tool used to ascertain a person's cognitive performance. It includes tasks which measure working memory, long term memory, processing speed, auditory processing, visual processing, logic and reasoning as well as word attack.

Validity of Instrument

The validity of the instruments for this research is based on extensive review of related literature and decades of applied research in the field of dyslexia and cognitive skills necessary for learning which includes; memory, attention, processing speed, phonological awareness, visual processing, logic and reasoning etc. The researcher ensured that the contents of the dyslexia questionnaire meets the criteria for dyslexia diagnosis and the Gibson test of Cognitive Skills instrument meets the factors for intelligence as identified by the Cattell-Horn-Carroll (CHC) theory of cognitive abilities. In addition, copies of these instruments was given to two expert psychometricians, two lecturers in the Department of Educational Psychology, Guidance and Counselling, University of Port Harcourt and two experts in the field of dyslexia to validate it for content and face validity. Face validity confirmed that the instrument can measure what it intends to measure (dyslexia) and the content validity confirmed that the instruments contents cover the necessary. The input of these experts was put into consideration in the final copies of the instrument

Reliability of Instrument

For the reliability of the instruments in this research, different reliability techniques were used. For the DAQ, split-half reliability technique was used. In doing this, the instrument was administered on 10 students who were identified as dyslexic on the basis of their performance in the DAQ, RAN and GTCS. The scores from the administration were subjected to split half analysis which yielded a Spearman Brown coefficient of 0.94. For the RAN, test-retest reliability was used to estimate the reliability of the instrument. The instrument was administered twice on 10 students and the times in seconds it took them to responds were correlated using Pearson Product Moment Correlation. From the administration of the instruments, it was discovered that the correlation coefficient of both administration was 0.803. This indicates that the instrument possessed adequate reliability. The instrument was pilot-tested upon, (dyslexia questionnaire, Gibson test of Cognitive Skills). A Test-Retest method of reliability was employed. This is an estimation of the reliability of a test which is determined by correlating the scores on two different administrations of that test to the same sample. These Tests were administered twice to same set of persons within two weeks interval. Same test items was shuffled and reworded to reduce the effect of the inherent weaknesses of Test-Retest method of reliability. The test retest reliability coefficients were determined by correlating the scores of the two separate test administrations. Split half method was used to measure the internal consistence. Experimental studies were conducted in stages as can be seen from data analysis tables below.

Methods of Data Analysis

The research questions was answered using mean, standard deviation of the pre test and post test scores, while dependent t-test, one way and two way analysis of covariance (ANCOVA) was used to analyse the null hypothesis.

Results

Improvement in the working memory of students living with dyslexia in the control group receiving pretest and posttest

On the basis of the result displayed in table 2, students living with dyslexia in the control group had a pretest working memory score of 79.60 (Sd = 10.09) and a post-test mean score of 79.73 (sd. = 9.70). This showed a mean difference of -0.133, which showed a small degree of improvement in the working memory. When these values were subjected to a dependent sample t-test analysis, a t-value of 0.381 was obtained at 14 degrees of freedom and a p-value of 0.709 which was statistically not significant at 0.05 level of significance. Furthermore, the Cohen's d value obtained was 0.01 which showed a small effect size. This result therefore showed that there was no significant improvement in the working memory of students living with dyslexia in who were not treated with brainfeed intervention programme in Rivers State. The null hypothesis was therefore accepted. The scores of students in the control group who received pretest and posttest assessment of their working memory using the Gibson's test were subjected to mean and standard deviation analysis. For testing of hypothesis five, the mean and standard deviation of the pretest and posttest of control group I on working memory was subjected to dependent samples' t-test (see table 2).

Table 2
Dependent samples t-test of working memory for pretest-posttest control group

Experimental Group I	**n**	**Mean**	**Sd**	**Mean**	**df**	**t**	**Sig**	**d**
Pretest:	15	79.60	10.09	0.13	14	0.381	0.709	0.01
Posttest:	15	79.73	9.70					

Working memory of students living with dyslexia in the experimental and control groups who received only post-test

Table 3 below shows the mean and standard deviation of students in the experimental and control groups who received only posttest assessment of the Gibson test. From the data shown in the table, those in the experimental groups had a mean score of 96.40 (sd = 6.84) while those in the control group had a mean value of 75.26 (Sd. = 13.77), which yielded a mean difference of 13.77. This result showed that those who received treatment in the experimental group had an improvement in working memory that was 13.77 greater than those in the control groups who did not receive any treatment. When these values were subjected to an independent sample t-test analysis, a t-value of 5.232 was obtained at 28 degrees of freedom and a p-value of 0.000 which was significant at 0.05 level of significance. This result therefore suggests that there was a significant improvement in the working memory of students living with dyslexia who received only posttest after treatment

compared to those not treated but who received posttest. The null hypothesis was therefore rejected. The research question by subjecting the post-test working memory scores from the Gibson test of students' in the control and experimental groups who had only posttest assessment to descriptive statistics of mean and standard deviation. The values obtained were further subjected to independent sample-test analysis (see table 3).

Table 3

Independent samples t-test of working memory of post-test only experimental and control groups

Group	**n**	**Mean**	**Sd**	**Mean**	**df**	**t**	**Sig**	**d**
Experimental:	15	96.40	6.84	21.13	28	5.323	0.000	Rejected
Control	15	75.25	13.77					

The processing speed of students in the control group who were assessed at pretest and post stages

From data analysis, the pretest and posttest score of students living with dyslexia in the control group, who did not receive any brainfeed intervention programme are displayed. From the result shown, the pretest processing speed mean score was 81.80 (sd.), while the posttest mean score 81.53 (sd = 8.77) with a mean difference of only 0.26. This value showed that the difference in pretest and post-test processing speed score of students who did not receive brainfeed intervention was small. When these values were subjected to a dependent sample t-test analysis, a t-value of 0.639 was obtained at 14 degrees of freedom and a p-value of 0.480 which was insignificant at 0.05 level of significance. Furthermore, the Cohen's d value obtained was 0.04 which showed a small effect size. This result therefore suggests that there was no significant improvement in the processing speed of students living with dyslexia in who were not treated with brainfeed intervention programme in Rivers State where the researcher conducted the study. The processing speed scores of students in the control group who received pretest and posttest assessment using the Gibson's test were subjected to mean and standard deviation analysis, while the corresponding null hypothesis was tested using paired sample t-test (see table 4).

Table 4

Dependent samples t-test of processing speed for pretest-posttest control group

Control Group I	**n**	**Mean**	**Sd**	**Mean**	**df**	**t**	**Sig**	**d**
Pretest:	15	81.80	6.91	0.27	14	0.639	0.480	0.04
Posttest:	15	81.53	7.29					

The processing speed of students living with dyslexia in the experimental and control groups who received only post-test assessment

In Table 5 below, the mean and standard deviation processing speed of students in the experimental and control groups who received only posttest assessment of the Gibson test were displayed. From the data shown in the table, those in the experimental groups had a mean score of 99.26 (sd = 11.03) while those in the control group had a mean value of 79.40 (Sd. = 8.77), which yielded a mean difference of 19.86. This result showed that the posttest processing speed of those who received treatment in the experimental group improved with about 19.86 greater than those in the control groups who did not receive any treatment. When these values were subjected to an independent sample t-test analysis, a t-value of 5.45 was obtained at 28 degrees of freedom and a p-value of 0.000 which was significant at 0.05 level of significance. This result therefore suggests that there was a significant improvement in the processing speed of students living with dyslexia who received only posttest after treatment compared to those not treated but who received posttest. The null hypothesis was therefore rejected. In order to answer research question eight the post-test processing speed scores from the Gibson test of students' in the experimental and control groups who had only posttest assessment and were not pretested, were subjected to descriptive statistics of mean and standard deviation. The corresponding null hypothesis was tested using independent samples t-test (see table 5).

Table 5

Independent t-test of processing speed of post-test only experimental and control groups

Group	**n**	**Mean**	**Sd**	**Mean**	**df**	**t**	**Sig**	**d**
Experimental	15	99.26	11.03	19.86	28	5.45	0.000	Reject
Control	15	79.43	8.77					

Discussion

A number of known factors can have effect on one's processing speed. Basically neurological factors such as the balance and effectiveness of neurotransmitters in the brain, the development of the myelin sheath involved with the spread of information along the nerves, the magnitude of the synaptic gaps between nerves and the general efficiency of areas of the frontal lobes concerned in organizing and directing the course of information. Other neurological conditions such as epilepsy and Attention-Deficit/Hyperactivity Disorder can also have a negative effect on the processing speed of a person (Jacobson et al, 2011). Some anti convulsion medications and traumatic brain injuries can negatively affect processing speed depending on the extent of the injury. Some transient mental states such as those caused by lack of sleep can have negative effect on processing speed. Emotional problems such as depression and anxiety can influence processing speed. Knowledge base and experience can also affect a person's processing speed. The additional knowledge one has about something, due to experience, the more the chances are that his processing speed on related information was enhanced. Perfectionist tendencies and fine motor skills can also affect ones processing speed because of the intricacy in completing pencil-and-paper tasks that are involved in measuring processing speed and the need to do the tasks in a faultless manner (Hinshaw et al, 2002; Rucklidge and Tannock, 2002); thus, the need for the test administrator to be considerate when making an interpretation of the test results. Slow

processing speed is like having a partially closed valve in the water pipe. Water flows more when the valve is opened wide and reduces in rate of flow when closed to some extent.

Impact of Deficit Processing Speed

The obvious effect of slow processing speed can be categorized into three general functional areas; academic and cognitive, social and self esteem (Willcutt et al, 2005; Alexander-Passe, 2006; Hinshaw, et al, 2002). Slow processing speed can result in problems such as slowed execution of easy academic tasks, poor acquisition of new materials, becoming overwhelmed by more complex academic demands, need for extra time in responding to even well practiced and automatic tasks and trouble making quick and accurate conceptual decisions (Willcutt et al, 2005). Deficit processing speed can as well lead to difficulty keeping up with normal friendly conversation amongst peers or with adults; this can lead one been mislabelled or misjudged (Hattie, 2012). The aftermath of the various problems encountered by slow processors can lead to a low self esteem, this will leave the student vulnerable to feelings of incompetence, self consciousness and depression is eminent, as a result of feeling stupid because they cannot meet up with the pace of other students.

Psychologist and neuroscientist have gone into research to mediate on the condition of students with learning difficulties. Parts of these researches have centred on interventions in order to provide required support and encouragement. For processing speed deficit that involves numbers and letters, there is usually a reduction in reading fluency and conceptual competence; this can result to a poor comprehension, motivation and consequent frustration. Instructional materials geared towards increasing skills like rapid and automatic recognizing of common letter sequences, basic arithmetic facts like addition, subtraction, multiplication, division etc. to the point of automaticity and developing an extended sight-word vocabulary (Hattie, 2012).

Applications and activities intended to improve the student's rate of production should be provided, such application that incorporate brief speed tasks such as 'mad math minute' for enhancing arithmetic fluency, Reading from a list of 'high-frequency words to enhance reading fluency. A record of the student's progress will help in assessing the effectiveness of the programme on the processing speed of the student. For Braaten & Willoughby, (2014) and Burgess, (2016) apart from the interventions, a number of adjustments need to be made to accommodate students with slow processing speed, these include;

- Replacing timed tests with different assessment procedures such as untimed verbal testing.
- Extra time should be given for reading, writing math tasks, but in a way to minimize negative attention which could lead to stigmatization.
- Slow processers should not be made to work under time strain. On the contrary, Evaluation should be based on correctness rather than speed.
- Appropriate assistive technology should be provided to enable student get used to and benefit from the facility for example 'Dragon Speaks' which is a word-to-printed text software. This can help with written assignment.
- Cut down practice coursework and drill exercise that involves visual motor skill information.
- Extra time should be given for formal and standardised test that measures achievement such as SAT or JAMB.
- Students with slow processing speed need extra time to finish up tasks and assignments. Same should be provided to enable them catch up with other students.

- Instructional materials that allows for the students slow processing speed should be provided. This can present in form of slower pace and in simpler language.

Working Memory and Dyslexia

Working memory is a mental workspace where important information is kept in a highly active state available for a variety of other cognitive processes; encoding, storage, and manipulation of information (Fougnie, 2008). It can be viewed as a subset of knowledge in the long term memory that is currently activated with independent stores for verbal, spatial, and visual information (Oberauer, 2002). The capacity to selectively scrutinise information (attention) and to preserve that information in an available state (working memory) are important aspects of a person's cognitive competence. There is a close interaction and overlap between these two constructs especially during encoding and manipulation of information (Fougnie, 2008). The ability to perform some complex tasks depends critically on the capacity of the person to scrutinize, select and preserve the relevant information for such tasks in a retrievable state in the working memory. Working memory is that part of the brain we use when we are working through a question or problem. It continues to keep information unless we dismiss or move it to the long term memory for storage. Students with deficient working memory and normal IQ will experience some difficulty in school.

This means that the student can get information but doesn't have the ability to keep it long enough to get it into a longer and permanent storage in order to get through with task at hand (Szmalec et al., 2011). This implies that such student will read and read as it where in circles but not able to grabs full or permanent understanding of the concept. They may be able to do well in quiz but not able to master skills that are needed to pass final examination. Poor working memory also accounts for inability to complete homework and assessments as the student usually does not have sufficient space to accumulate all the information that is required to get through such task.

Awh, Vogel & Oh, (2006) are of the view that the relationship between working memory and attention is dependent on the stage of attention and type of the information available in the working memory. Attention is the process of selection of some information at the expense of other information. The stage at which attentional selection occurs has been greatly debated. While some schools of thought are in strong support of the notion that attention can affect early perceptual processing others show equally strong support for the notion that attention can affect late perceptual processing (Fougnie, 2008). This invariably indicates that there could possibly be more than one form of attentional selection (Milne, 2005). There are three attention network that perform distinct roles; i) alerting network which coordinates the overall state of alertness to sensory stimulations, ii) orienting (perceptual) network which selects a division of sensory information for advantaged processing (Strauss, 2011 and (iii) executive (central) attention network which acts on post sensory representations and useful when there is competition for access to a central, limited-capacity system (Fougnie, 2008).

The central executive has five distinct roles in distributing attention and inhibition, divided attention, updating, switching attention, storing and manipulating information in and out of the long term memory (Smith, 2016). On the other hand, the visuospatial sketch pad helps in recalling spatial information as well as visual character and does not control decision making or attention (Henry, 2011). The phonological loop is the system responsible for the storage of auditory information. It interacts with the phonological short term store and a subordinate vocal rehearsal (recitation of information) process and can hold some seconds worth of

auditory matter. The rehearsal in the phonological reservoir enhances the time information is sustained. The Episodic buffer brings together information from the supplementary mechanisms and long term memory (Nadler and Archibald, 2014; Smith, 2016).

One major deficit that is visible amongst learners with dyslexia is a deficient verbal short term working memory. Studies have shown that short term memory ability is important as it is a predictor of oral and written language development in children (Nadler and Archibald, 2014; Majerus and Cowan, 2016). This entail that a deficit verbal short-term memory will impair and further increase difficulties carrying out academic task. A deficit verbal working memory can contribute to difficulties in applying the alphabetic principle as this affects the phonological and graphemic information during reading especially when it is not automatized (Smith, 2016).

There is a link between dyslexia and verbal short term memory deficit. For information to be stored in the long term memory, the language systems have to be involved a great deal. The likelihood for the verbal short memory to recall or retrieve a verbal task is dependent on the already existing linguistic representations in the long term memory. It is easier for a physics student to read and be able to recall information related to physics than it is for a government student. This is because there are already existing linguistic representations in the long term memory (Majerus et al., 2012; Majerus and Cowan, 2016). The same is applicable to non words, as long as there is a phonotactic structure established in the long term memory, there is the likelihood for higher frequency or fluency of reading and recall and low phonotactic frequency with non words which has no structure in the long term (Alloway, 2012; Majerus & Cowan, 2016; Ramus et al., 2013).

Conclusion

This study determined effective strategies for improving the improving working memory and processing speed of students identified with dyslexia in Nigeria. The core cognitive skills include; attention, logic and reasoning, long term memory, working memory, processing speed, visual processing and auditory processing skills. The focus was on the working memory and processing speed skills of students living with dyslexia. The choice of these two core cognitive skills for this study is because of its wide range of coverage, the researcher observed that the other core cognitive skills though interferes and overlaps on each other, are greatly influenced by the working memory and processing speed skills. There are lots of alternative intervention programmes namely Cogmed, BrainRx, LesrningRx, Pace etc. that challenge the core cognitive skills deficit in students living with dyslexia, but the cost implication and logistics of its implementation necessitated the choice of Brainfeed programme which is an innovation of the researcher based on the many years of research on the cognitive deficits of students living with dyslexia. Thus working memory and processing speed skills was the dependent variables for this study. There is little or no attention given to the students living with dyslexia in Nigeria, while there is unchallengeable evidence that some students in Nigeria like other students in various parts of the world have dyslexia. Thus the researcher is motivated to carry out further study amongst Senior Secondary School two (SS2) of the public Senior Secondary Schools in other parts of Sub-Saharan African nations, because to the researchers knowledge, there is little or no studies in these areas and field.

Implication of the study

The implications of this study includes amongst others are;

- Students living with dyslexia show evidence of weak cognitive skills, which implies that both male and female students can have weak cognitive skills.

- Dyslexia is not gender based learning disability as both males and female students showed evidence of dyslexia.
- The brain can be rewired as weak skills can be targeted and remediated using relevant cognitive skills training programmes.
- Working memory and processing speed of students living with dyslexia may not significantly improve without an alternative intervention.
- Brainfeed alternative intervention programme can significantly improve working memory and processing speed.

Limitation of the study

This study encountered some obstacles that accounted for limitation of this study;

- Most students were not willing to participate in the study even after answering the questionnaire.
- Most students did not complete their 20hrs training period and were dropped. This affected the final sample for the study.
- The logistics for the study in terms of space, devices, funding and supervision was really demanding.

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