

Impact of Cognitive Remediation Therapy on Working Memory, Episodic Memory, and Attention in individuals with diagnosed or possible dyslexia.

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Effect of CRT on episodic memory, working memory, and attention in individuals with diagnosed and possible dyslexia.

Background and aims: Working Memory focused, computerised, Cognitive Remediation has been found to be effective in improving cognitive deficits in a number of patient populations, such as schizophrenia and ADHD; particularly in relation to memory and attention. These deficits are also found in people with dyslexia, and as such it is possible that the same working memory programme might improve these deficits in the dyslexic population. The aim of this study is to see if that is the case, and if it also leads to improvements in reading skills.

Methods: 16 participants with dyslexia underwent a controlled experimental study. Neuropsychological testing was conducted on all participants both before and after the intervention, which lasted a period of 5 weeks. During this time the intervention group underwent computerised, working memory training (half an hour a day, 5 days a week), and the control group went about their lives as normal.

Analysis: A mixed covariance of analysis (ANCOVA) was used to compare the results between control and experimental group. The results were found to be non-significant.

Implications: If successful, this programme can be utilised by individuals with dyslexia to improve their cognitive deficits and reading skills. The computerised nature of the programme enables it to be used independently, at home or in school environments.

Contents

Title	Page Number
Introduction.....	1-11
Methods & Analysis.....	12-19
Results.....	20-27
Discussion.....	28-32
References.....	33-40
Appendix.....	40-54

List of Illustrations

Image 1 of CRT page	17
Image 2 of CRT page	19

List of Tables

Descriptive tables	20-26
ANCOVA table	27

List of Abbreviations

CRT.....	Cognitive Remediation Therapy
CG.....	Control Group
EG.....	Experimental Group
WM.....	Working Memory
EM.....	Episodic Memory

Introduction

This experiment investigates how Cognitive Remediation Therapy (CRT) can be used to help those with possible/diagnosed dyslexia. This therapy will be used to target one's Attention, Working Memory (WM) and Episodic Memory (EM). Dyslexia is a developmental disorder affecting more than 5% of the western population according to a study conducted on the western population (Menghini, Finzi, Carlesimo & Vicari, 2011). However, there is still a lot more research that is needed to be conducted on dyslexia, the causes, and remedies for it. Some mistake dyslexia as a lack of knowledge, which is not the case (Rosen, 2003). However, individuals with dyslexia find it harder to access and store information, therefore affecting their WM. It is argued that WM is very important in order to acquire knowledge and skills (Alloway, Gathercole, Adams, & Willis, 2005, Gathercole, Pickering, Knight, & Stegman, 2004). This gives us the reason to target it in this study. Evidence shows that WM is linked to skills such as mathematical skills (Alloway, Gathercole, Kirkwood, & Elliott, 2009), language comprehension and vocabulary (Oakhill, & Yuill, 2000) and reading ability (Gathercole et al, 2004), all which will be targeted in this experiment. Therefore, dyslexia can have detrimental effects on an individual with possible/diagnosed dyslexia if left untreated as it would cause them to fall back on their studies and their confidence. Further research needs to be done in this area to educate the public on this topic and to find the best option to aid individuals with dyslexia and to improve their WM and overall experiences in life. According to some studies, gender plays a role on the rate of dyslexia within a population (Vogel, 1990). Therefore, whether gender plays a role on the effectiveness of will be investigated. WM, how it interacts with executive functions, and the effects it has will be investigated along with its links to attention. Other remediations and therapies will be explored within dyslexia. Dyslexia and the ramifications it can have on learning difficulties will be researched into. Lastly, CRT in relation to other

disorders such as attention deficit hyperactivity disorder (ADHD) and schizophrenia will be explored.

Dyslexia within genders

There have been studies which claim there are many more males with dyslexia than females (Chan, Ho, Tsang, Lee, & Chung, 2007; Vogel, 1990). Research-identified samples show that the rate of dyslexia might be equal in both genders (Hawke, Olson, Willcut, Wadsworth, & DeFries, 2009). However, this data could be misrepresented as most female-rates are under-identified in the USA. Other countries such as Italy have lower rates of dyslexia, which could be attributed to the strict inclusion criteria. This could be due to the different inclusion criteria each country uses and the different methods of sampling which may be used. Biological factors have been suggested as to why more males may have dyslexia over females. Hawke et al., (200) suggest differences in brain functioning due to exposure to androgens, immunological factors, prenatal factors. Females are suggested to be less genetically susceptible to reading difficulties than males. Although a difference is seen in the gender difference in dyslexia, there is no gender difference in cognitive functioning (Vogel,1990). Given that more males are being diagnosed with dyslexia, it would be a good idea to compare the two genders to see if gender affects the outcome. In the Chan et al., (2007) study it showed that males tended to score higher in the visual memory tasks and lower on the phonological tasks, whereas girls tend to score higher in the phonological task and lower in the visual memory task. This shows that there may be cognitive differences present within the two genders which may affect their learning,. It would be a good idea to research whether this study can pick up differences and see if CRT has an effect on scores.

WM and executive functions

WM, executive functions, and reading skills are normally deficient in all individuals with dyslexia. Many adults with dyslexia complain about declines in their WM and executive

functioning (Smith-Spark, Henry, Messer, Edvardsdottir & Ziecik, 2016). They struggle to switch between cognitive operations experiencing greater difficulties updating their WM. As a result, people with dyslexia have problems with multiple phonological tasks (Laasonen et al, 2012). Difficulties in phonological tasks seem to be correlated to dyslexia, almost appearing to be a genetic issue (Rosen, 2003), which shows that verbal WM deficits might arise from phonological coding deficits. Studies show children with dyslexia produce poorer phonological and WM results (Gathercole, & Pickering, 2000) leading to reading and processing disabilities. The Stroop tests used in dyslexia, investigate individual's reading and processing abilities (Everatt, Warner, Miles & Thompson, 1997). These are common executive functions which would be absent in individuals with dyslexia and commonly show to be lacking. Therefore, children with dyslexia tend to be slower at grasping automatic reading compared to children without it (Faceotti et al., 2003). Which is why it is important to investigate possible remediations to facilitate students with dyslexia as it can pose learning difficulties on the individual.

WM and learning difficulties

Research shows that defects in the WM influences learning in a negative way (Jeffries, & Everatt, 2004), individuals can have trouble learning and remembering new things. Hence, WM needs to be strengthened. Jefferies and Everatt (2004) explain that the WM system comprises of the Central Executive (CE) and an Episodic Buffer. This is known as the tripartite WM model. The CE controls the coding and retrieval of certain input such as stimuli input and also plays a role in monitoring attentional changes. It is linked to visual and spatial input, and the phonological loop. The episodic buffer can temporarily store a limited amount of storage, by closely working with long-term memory and other executive processes (Baddeley, 2001). Meaning, a deficient WM can be linked to experiencing problems in phonetic, attentional, learning, and reading abilities. Jeffries and Everatt (2003) found a link

between poor WM and learning difficulties. Their study showed that individuals with dyslexia were poorer at recalling tasks involving the phonological loop. Studies show that WM training could positively affect intelligence, attention and in some cases, reduce symptoms of ADHD according to Shipstead, Redick, & Engle (2012). This study shows that WM capacity may be increased with the right training. Although, most of the conditions which are addressed by CRT are categorised with different symptoms and characteristics, CRT still aims to target the cognitive workings of the brain (Tchanturia, Lloyd, & Lang, 2013). This is to try and make a difference in the neuropathology of the individual to change their way of life. CRT takes simple exercises specially designed to target the specific area of the brain such as the prefrontal cortex (in individuals with dyslexia). The prefrontal cortex oversees the language areas, visual memory, WM and executive functions (Na et al., 2000). It is connected to procedural learning, reading, and language comprehension (Fisher, Holland, Merzenich & Vinogradov, 2009). Fisher et al., (2009) study included a computer-based treatment which involved 50 hours over the space of 10 weeks of learning and repetition. This implies that a lot of attention and repetition would be needed in order to improve WM, EM and attention and overcome reading difficulties. The concept of attention and repetition will be used in the design of this study.

WM and attention

WM is important for reading comprehension due to attentional and executive components involved in these factors (Baddeley, Logie, Nimmo-Smith, & Brereton, 1985). Evidence relates low WM to low-attentional span (Reynolds and Besner, 2006). This is shown in children with low-attention spans whom are easily distracted and tend to forget instructions (Alloway, Gathercole, Adams, Willis, Eaglen, & Lamont, 2005). Which is why it is important to identify new methods to enhance one's WM and attention. Studies show that children with ADHD show that it is possible to improve WM and attention (Loosli,

Buschkuhl, Perrig, & Jaeggi, 2012; Klingberg et al., 2005). Therefore, the notion arises that attention in individuals with dyslexia could also be enhanced. Preliminary studies conducted suggest that pharmacotherapeutic agents could be used in to combat dyslexia (Shaywitz, & Shaywitz, 2008). Pharmaceutical drugs given to individuals with disorders of attention such as ADHD may help dyslexic students improve their reading abilities. Theories claim that reading progression occurs in stages. Starting from one learning to read a word slowly and accurately, which then over practice, leads to being able to read fluently and automatically (LaBerge & Samuels, 1974; Shallice, & Warrington, 1977). It is proposed that once one becomes accustomed to automatic reading, attention can be disassociated so that higher functions such as semantics and text comprehensions can be utilised (LaBerge & Samuels, 1974, p. 319). This happens over time through practice and repetition, one does not need to pay as much attention to detail, reducing the need to consciously be aware of the process of reading, shortening the time it takes them to read. It is also implied that EM and attention are linked (Klimesch et al., 2001; Lacroix et al., 2005). Which is why it is an element which will targeted along with WM and attention in this study. It is linked to the quick and automatic retrieval of representations in non-dyslexic people, as compared to the slow and effortful retrieval (seen normally when first learning to do a task), which is common in individuals with dyslexia. Good fluent readers can be said to be dependent on attention, which might be enhanced using CRT which relies on repetition. Other methods which could enhance these factors are also similar to CRT interventions.

Other remediation and therapies used in dyslexia

fMRI results showed dramatic changes in the brain activation profiles of individuals receiving an intensive remediation program for dyslexia (Simos et al., 2002). Increased activity was found in the posterior portion of the superior temporal gyrus in all 8 participants, as well as in the adjacent inferior parietal areas. This lead to increased phonological abilities.

Although the intervention used in this study was not specifically CRT, it did employ remedial training with the same aims as CRT, by being presented with reading and phonological decoding problems. Showing that there are other ways which could be utilized to try and remediate symptoms of dyslexia. (Simos et al., 2002) study resulted in increased blood flow in regions such as the left temporoparietal regions whereas before the intervention, it would be reduced during reading and phonological performance sessions. This shows that remedial interventions can impact the blood flow of the brain in a positive way and effect the neuroplasticity of the brain. One study showed improvements in reading skills which stayed stable after a 2 year follow up period after receiving intensive remedial instruction on a one-on-one basis for 8 weeks (Torgesen, 2001). Which could mean that remedial programs could affect one positively even after cessation of the program. People with dyslexia have a hard time acquiring the ability to properly read phonemes, hence, this deficit is targeted in the study. The instructions given were based around the intention to teach the children how to methodologically pick up how to identify phonemes. They were taught to associate each sound with a picture which illustrated the mouth making the sound. The children were given the opportunity to discover new methods of reading by teaching them to associate certain letters with each phoneme making it easier for them to retain this knowledge for future reading purposes. This shows that other therapies and remediation programs seem to work well for the most part. Therefore, it would be a good idea to look at the success rate of CRT to see if it can produce better results, an indication of this can be seen through studies which have utilized CRT for other disorders.

CRT in conjunction with other disorders

There are many studies which aim to enhance WM, attentional and executive functions such as attention, and EM within other disorders. The primary goal in any CRT targets the specific area that needs to be enhanced, such as WM in patients with ADHD,

schizophrenia (Wongupparaj, Kumari, & Morris, 2015), psychosis (Hargreaves et al., 2015; Lewandowski, 2016), and dyslexia. Some types of CRT target specific cognitive deficits. Others target global cognition. CRT treatment aims to target the way an individual processes and organises the everyday information they take in. It has been used in research areas such as CRT for anorexia nervosa (Brockmeyer et al., 2013; Tchanturia, 2010; Tchanturia, Lloyd, & Lang, 2013) Mood disorders (Bowie, Gupta, & Holshausen, 2013) Multiple Sclerosis (Hubacher et al., 2015) and Huntington's Disease (Zinzi et al., 2007). These are a few studies conducted with mostly positive outcomes. Although most of these conditions are categorised in their own way with different symptoms and characteristics, CRT still aims to target the cognitive workings of the brain (Tchanturia, Lloyd, & Lang, 2013) in order to try and make a difference in the neuropathology of the individual in order to change their way of life.

Patients with schizophrenia suffer from poorer WM. After comparisons of the pre and post intervention results in certain studies, a significant improvement in WM and short-term memory was seen (Penner et al., 2010). In this case, computerised CRT was applied (Rass et al., 2012). This study amongst many others, showed significant learning potential once the training had been completed. This training was given for four weeks straight. This is a significant number, as other studies which administered CRT, seemed to find no results since they administered the computer-assisted training program on a bi-weekly basis for two hours only (Rass et al., 2012).

Ideal duration of CRT

Other studies (Choi, & Medalia, 2005; Kurtz, Seltzer, Fujimoto, Shagan, & Wexler 2009; Reeder, Smedley, Butt, Bogner, & Wykes, 2006), showed similar findings to the Rass et al., (2012) study which showed that CRT can in fact positively influence attentional span and WM. They claimed that the therapy continued to have effect on one's skills even after the study had been completed (Medalia, 2005). However, Dickinson and colleagues, (2010),

mention that from their results, even though participants showed an improvement on the tasks at hand, there was, no generalisable improvement on the neuropsychological aspect such as EM, WM, attention or executive functioning of the participants. They also claimed that there was no training effect even after the 3-month follow up, even though their study included 14 2-hour computerised sessions with each individual. Most studies that seemed to have better more positive results had 5-10 sessions (Tchanturia, Lloyd, & Lang, 2013), whereas Fisher et al., (2009) had it limited to at least 50 hours over 10 weeks of computerised training. This shows that interaction on a long scale level is needed for this intervention to work. This is also backed up by Torgesen et al., (1999), in which they had two comparison group where they spent different lengths of time on instructional teaching. The group that had spent 80% of their time on instructional time seemed to have significantly stronger phonological awareness, phonemic decoding, and untimed, context-free word reading. Although this program was conducted over a two-year period. The results found were stable enough to last over a two-year follow-up period as well. This shows that there is more than enough evidence to demonstrate that CRT could help improve one's WM, EM, attention and executive functions.

Conclusion

Although dyslexia is a disorder of the brain which targets the language specific areas of the brain, it is possible to alter the blood-flow through remedial therapies such as CRT and others, allowing blood to flow more freely into the superior temporal gyrus to increase WM (Simos et al., 2002) allowing learning to occur. Studies show that even in adulthood it is possible to improve one's WM, executive functions and attentional span. Therefore, it is important to find new and improved version of interventions to improve one's learning abilities. CRT has mainly been used in schizophrenia, psychosis, ADHD, anorexia nervosa and other disorders, meaning it is versatile, therefore, it could be fashioned for dyslexia. This

shows that there are ways to target WM, EM, executive functions and attention separately and enhance each of them as they are all seemingly linked. There are many studies which show that WM, attention and EM can be enhanced. However, the effectiveness of CRT should be looked into, as it is less invasive and time consuming as other therapies considering it can be completed at home within five weeks.. CRT based training does not require as much time compared to the intervention utilized in the Torgesen et al., (1999) study. Studies show that up to five weeks of regular training can still give significant and lasting results. Hence, it should be studied further to see if it will facilitate learning in individuals with dyslexia. Therefore, CRT is going to be the therapy of choice in this experiment due to all the benefits listed above.

Rationale

Cognitive skills testings support the evidence that individuals with dyslexia seem to generally have poorer working memory, executive functioning, memory storage and attention (Jeffries & Everatt, 2004; Smith-Spark & Fisk, 2007; Swanson & Siegel, 2001; Petkov et al, 2005). Therefore, it would be a good idea to test for ways to improve or remediate this as around 5% of the western population seems to be effected (Menghini et al., 2011). If it is found that CRT is effective in improving one's WM, EM, and Attention, it could be used within the classroom or at home to help improve these impairments and allow learning and reading to occur more fluently. Gray matter changes and their correlations with poorer working memory were also assessed. Recent studies conclude that gray matter density in the left posterior superior temporal stratus (STS) correlates with auditory short-term memory in adults (Männel et al, 2015). Errors in the rate of language and verbal working memory surged when rTMS was applied to the left posterior superior temporal gyrus (Richardson et al, 2013). This shows that the left superior posterior temporal gyrus has a part to play in working memory, which may be defected in individuals with dyslexia. These studies show that interventions and therapies can allow the brain to 're-mould' the affected areas allowing learning to occur. This study will last five weeks because other similar studies conducted lasted five weeks such as Luo, Wang, Wu, Zhu & Zhang, (2013) and McAvinue et al, (2013). There have been other studies that have employed the use of WM training with on children and adolescents with dyslexia (Luo, Wang, Wu, Zhu & Zhang, 2013; Karch et al, 2013). it is worth investigating whether this programme will help people with dyslexia to overcome their WM problems and improve on reading skills. Another aspect of this program which might show to be effective is the 'home-based' therapy approach which will be utilized. This will mean that the participant does not need to travel or use external resources in order to benefit from this. It could save them time which they could apply to the study, profiting from it more (McAvinue et al., 2013). If successful, this

programme can be utilised by individuals with dyslexia to improve their cognitive deficits and reading skills. The computerised nature of the programme enables it to be used independently, at home or in school environments.

Aims and Objectives

The aims of this study are to engage adults with diagnosed/possible dyslexia with CRT, the objectives being to assess its usefulness in improving common deficits such as EM, WM and Attention and to assess if it affects males and females differently. Some studies claim that males with possible/diagnosed dyslexia tend to do better in certain tasks over females (Chan et al., 2007). Gender will therefore, be used as a covariate. Participants were asked partake in a pre-intervention and post-intervention assessment to assess for whether the five weeks of CRT training in between improved their cognitive abilities (McAvinue et al, 2013). They were then compared to the control group whom did not receive any CRT in the five weeks but were assessed the same way as the experimental group. It is aimed for the experimental group to complete all nine tasks within the CRT training program. The reason why this intervention is being utilized is because it has shown positive effects in improving WM in adults with schizophrenia, ADHD (Donohoe et al, 2017; Hargreaves, 2018) and even in the older populations (McAvinue et al, 2013). Therefore, an objective for this study is to see if it will work the same way within the dyslexic population just as well.

Therefore, it is hypothesised that there will be an increase in Working Memory, Episodic Memory and Attention due to the Cognitive Remediation Therapy in people with possible dyslexia.

Methods and Analysis

Participants

Convenient sampling method was used in order to group participants into either control group or experimental group. 16 Participants were recruited via advertisements sent out to eligible sites such as Dyslexia Association of Ireland, Catherine McCauly, National Learning Network, Dyslexia Support Ireland, and the learning support centre in the National College of Ireland. While posters were also put up around the college, see appendix 2. Participants then got in touch via the email provided. Participants ranged in age from 18 to 46 years ($M = 25.44$, $SD = 8.79$). The sample was very much equal, including 8 males and 8 females. Two of the participants from the control group scored higher in most of the assessments over the other participants. There were 3 males and 3 females within the experimental group ($M = 339.00$, $SD = 39.60$) and 5 males and 5 females within the control group ($M = 310.00$, $SD = 47.42$) see table 1 in results for details. All participants had previously provided written, informed consent for their deidentified data to be used for research purposes. Those who met the inclusion criteria were included within the study.

Inclusion criteria

Participants were eligible to participate in the study if they met the following criteria:

- (1) They either had reason to believe they had dyslexia or had been diagnosed with dyslexia.
- (2) They were consenting adults above the age of 18 years old.
- (3) They were dedicated to trying to improve their WM, Attention and EM.
- (4) They resided within the borders of Dublin or had adequate transport to commute to the assessment centre.
- (5) To take part within the experimental group, the participants had to have use of a laptop or computer at their disposal.

Exclusion criteria

The exclusion criteria for this study included: (1) other diagnoses such as ADD/ADHD which may not be able to be controlled for. (2) Any person without the capacity to give

informed consent will not be considered. Including vulnerable groups such as people with intellectual disabilities, the very elderly and children under the age of 18.

Materials/Measures

Design

The study was a quantitative experimental study. A within-subjects design was used as each participant would have to go through each assessment individually. The independent variable was CRT, while, EM, WM and Attention would remain as dependent variables.

Stroop

This is a test of executive functions such as attention which is associated with dyslexia and WM (Olk, 2011). Three sections are included within. (1) *Stroop-words*. (2) *Stroop-colours*. (3) *Stroop-coloured words*. Each section is timed for 40-seconds. Each participant is instructed to read down the list, out-loud, as fast as possible within the 40 seconds, starting over if they've reached the end of it before time is up. In section 1, participants were required to read through the list of words printed in black and white (RED, BLUE, GREEN). In section 2. Participants were required to read down the list with different coloured ('xxxx', 'xxxx') and were instructed to say the colour of the 'xxxx' out loud. In section 3, participants were instructed to say the colour of the word out loud rather than what is written. For example, **BLUE**, participants were required to say red, rather than what is written. Cronbach's α was calculated as an index of internal reliability which was .91 for the Stroop task, meaning it was reliable. See appendix 4 for list.

WAIS-III

Wechsler Adult Intelligence Scale vocabulary subtest was used in order to calculate an individual's WM (Wechsler, 1981). This was used in conjunction with the matrix reasoning subtest. Each participant was read out loud a word from a list of 33 words. The participant was instructed to give a word, or a brief definition of the word presented to them. Points ranged

from 0-1. Each word had a maximum of 2 points, with a maximum score of 66 points that could be given (Wechsler, 1997). Cronbach's α was calculated as an index of internal reliability which was .93, meaning it was reliable. See appendix 5 for list.

Letter-Number Sequencing

Wechsler Memory Scale 3rd edition (Wechsler, 1981). The WMS III is said to provide the most internally consistent scores (Iverson, 2001). This task tested for individuals EM. They were read out loud a list of numbers and words jumbled up (3-L-T-5). They were instructed to place the numbers before the letter in ascending order, and the letter after the number in alphabetical order (3-5-L-T). The list got longer and longer after each item of three trials. There were 7 items with three trials altogether. Possible scores ranged from 0-21. See appendix 6 for full list. The session was ceased if the participant managed to score '0' on all three trials of an item.

Matrix reasoning

This assessment was also used in order to test for IQ (Ryan, 2000). Participants were required to fill in the pattern presented to them from the 5 options presented to them. Starting at item 4, there were 24 items to fill in. If two points were not scored by items 4 and 5, it was required to continue with items 1-3 in reverse. The session was discontinued after a score of 4 consecutive '0s' or 4 '0s' in 5 consecutive answers. Cronbach's α was calculated as an index of internal reliability which was .76, meaning it was reliable. See appendix 7 for list.

WTAR

Test of adult reading and pronunciation of words level as a correlate to IQ (Green et al., 2006). A word list of 50 words were presented to the participant. The participant was instructed to go down the list and read each word out loud as they normally would even if they are unsure of the word. They were scored on their pronunciation of each word, a maximum score of 1 was given for each item. A maximum score of 50 was obtainable. See appendix 8 for list.

Cronbach's α was calculated as an index of internal reliability which was .85, meaning it was reliable.

Procedures

Once participants had read the information letter on the study and agreed on a time and date to meet up, they were chosen to either take part in the control group (CG) or the experimental group (EG). Each participant was then asked to make their way to the assessment base located in the National College of Ireland. The same room was booked off for each participant. They were asked to read and sign the consent form asking for their permission to use the data collected for research purposes. If they agreed, they were presented with 5 assessments to test for IQ, WM, EM, and Attention.

Baseline Assessment (Pre-Intervention)

Baseline Assessment was performed using the Stroop Test, and the WAIS-III Test along with its subtests, Letter-Number Sequencing, the Matrix Reasoning task and the WTAR Test. This lasted approximately 45 minutes. After this assessment, the control group were asked to continue on as normal and to expect emails every week to check up on how they are doing. They were then told they would be contacted in five-weeks' time to participate in the final assessment, the post-Intervention assessment. The EG were kept back for another half an hour to train them in how to use the CRT program that they will be using for the next five weeks. Any questions they had were answered. They were also told that they will be contacted every week via email for an update on how they are getting on, this is also how any problems encountered by participants were taken into account and resolved.

Post-Intervention

Five weeks later each participant from both the CG and EG was asked to do the same assessments as in the baseline assessments. This was performed under the same conditions as

the baseline assessment. This took half an hour to complete. After the assessment was complete, the participant was thanked for their assistance.

CBT Working Memory Training Scheme

CBT'S primary role was to present each participant from the experimental group a task or a memory game each day. This was designed to improve an individual's WM, EM and Attention as Baddeley (2000) outlines in his model. The model shows that the visuospatial short-term and WM are targeted. Each participant of the EG was given a login user-ID and a password to access the online program. These exercises were gradually brought in over the space of five weeks. Each participant was advised to practice the training exercises for 30 minutes a day, five days a week, for five weeks straight. The program consisted of a number of auditory and visual memory tasks which aim to target Memory and Attention through the use of psycho-education through the use of nine training exercises. The faster the participants completed the tasks and the more time they spent on them, the harder they got and the more they levelled up on the tasks. See image 1.

Image 1:

Working Memory Training
5 weeks programme

[Home](#) [Logout](#)

Introduction
 Week 1 - Day 1
 Week 1 - Day 1: Review using your mental blackboard in everyday life
Week 1 - Day 2
 Week 1 - Day 2: Homework
 Week 1 - Day 3
 Week 1 - Day 4
 Week 1 - Day 4: Homework
 Week 1 - Day 5
 Week 1 - Day 5: Homework
 Week 2 - Day 6
 Week 3 - Day 11
 Week 4 - Day 16
 Week 5 - Day 21
 Recommendations
 Exercises
 Results

There are two Span exercises – Span Numbers and Span Colours. These are designed to expand your mental blackboard or to increase the amount of information you can hold in your working memory at any one time. Think of a time when you had to hold a mobile phone number in your mind. Could you hold the entire number in mind? The Span exercises will help you to hold more information on your mental blackboard.

Try the Span Numbers first. The computer will play a series of numbers, which you will hear one at a time. You should listen to these numbers and try to remember them. When the sequence ends, re-enter the numbers you heard in the same order that they appeared. For example, if the computer plays '1, 7, 3, 9, 2', you should type, '1, 7, 3, 9, 2'. (Note that there are two versions of this task, the 'Normal' version and the 'Reverse' version, which is more difficult. Try the Normal version today and we will introduce the Reverse version tomorrow.)

Click on the Span Numbers button below to begin the task.

Span Numbers

Now try the Span Colours task. This time, the computer will show you a grid containing four coloured squares, which will light up in a certain sequence. Once again, you should watch the squares as they light up one by one and try to remember the order in which they flashed. When the sequence is finished, you should reproduce it by using the mouse to click on each colour in order. Try the Normal version today. Click on the Span Colours button below to start the task.

These tasks consisted of;

Span Exercises

Span Numbers- Participants were instructed to listen to a series of numbers called out by the program. Participants had to recall the series of numbers and type them into the spaces provided. They were given the option to do either the normal version (*Span Numbers Normal*) or the reverse version (*Span Numbers Reverse*). The reverse version being where they entered the numbers in the reverse order which they were given.

Span Colours- Participants were presented with a grid of colours. The colours lit up in a pattern formation and the participants were assigned with the task to reproduce the same pattern. As with the span numbers task, two options were also provided for the colours task. (*Span Colours*

Normal) or (*Span Colours Reverse*) this meant they could either relay the pattern the normal way or enter it in reverse. These tasks were created after the digit span task (Wechsler, 1997).

Focus Exercises

Focus Faces- In this exercise, participants were tasked with observing a series of faces appearing on their screens. At the end they had to choose the last n -faces appeared out of a number of other faces.

Focus Names- Participants were required to observe the series of names on the screen materialising on the screen. They were then tasked with choosing which n names were part of the sequence once it ended. These tasks were similar to the span tasks (Pollack, Johnson, & Knaff, (1959).

Snap Exercises

Snap Exercises- These exercises involved participants to observe or listen to a series of stimuli and respond by pressing keys indicated on the keyboard once two of the stimuli presented occurred in the same sequence or n stimuli apart. These exercises are modelled on the n -back task by Kirchner, (1958)

Face Snap- using faces as stimuli

Spaces Snap- White blocks lighting up different areas of the screen

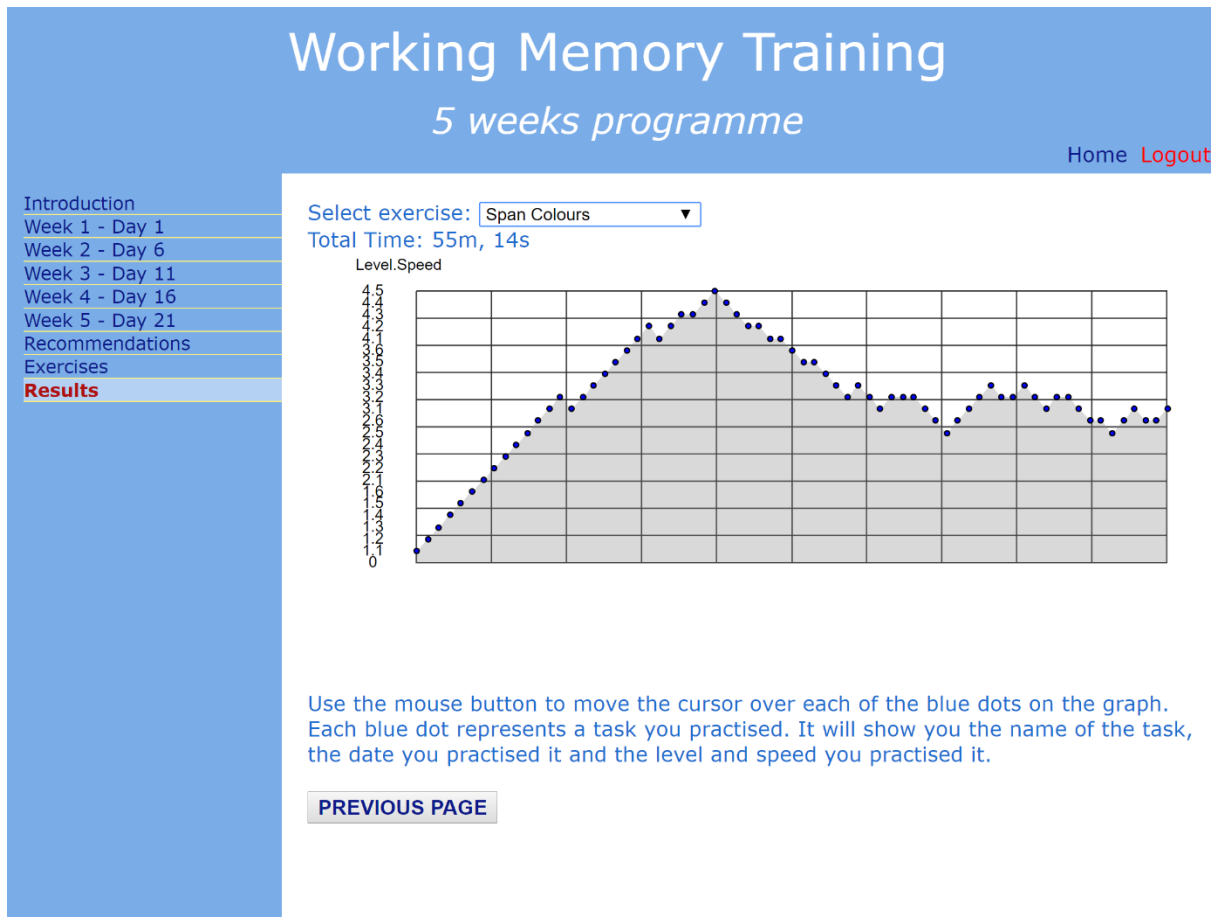
Names Snap- Names played out loud, the participant is required to press the space key once a name is said out twice in a row

Double Snap- requires participant to press two types of key due to there being two types of snap tasks involved. They are required to press the space key for the visual stimuli and the shift key for the auditory stimuli.

After each task, the participant was given a results chart of all the exercises they had completed this was in the format of a graph. The time they spent on it, the date they completed it, the level

they are on and the speed in which they completed the task were all accessible to them on within the graph. See image 2.

Image 2:



Statistical Analysis

IBM SPSS Statistics Version 23.0.0.0 was used for all demographic and behavioural data analysis. Attention, WM and EM were compared between EG and CG using five variables; Letter number sequence, Matrix, Stroop, WAIS III and WTAR in an repeated measures ANOVA. Gender was compared between EG and CG using Analysis of Covariance (ANCOVA). In this analysis, performance on CRT was designated as the dependent variable, group (eg versus CG) was designated as the independent variable along with the five variables listed above. Gender was included as a covariate in this analysis due to some studies claiming that gender may influence the level of dyslexia and learning.

Results

Table 1

Frequencies for the current sample of individuals in both groups on each demographic variable (N = 16)

Variable	N	Valid Percentage
Gender		
Male	8	50.0
Female	8	50.0
Groups		
Control	10	62.25
Experimental	6	37.5

Tables 2.0 to 3.2 represent the mean and standard deviations obtained by the CGs and EGs on each objective memory measure.

The two CGs represented in tables 2.0 and 2.1 did not differ in terms of IQ, as estimated from performance on Matrix patterns task, pre-intervention mean of 17.2 (SD =3.77) vs. post-intervention control mean of 18.5 (SD =5.5), nor did they differ significantly in IQ in terms of the WTAR task, pre-intervention mean of 90.5 (SD =13.19) vs. post-intervention control mean of 91 (SD =11.96). They did not differ significantly on the Letter_Numbering score for EM, pre-intervention mean of 9 (SD =2) vs. post-intervention control mean of 9.6 (SD =1.9). They differed slightly in WM on the WAIS-III task, pre-intervention mean of 29.8 (SD =8.31) vs. post-intervention control mean of 33.2 (SD =8.7). They differed slightly in Attention in each

Stroop task, Stroop_W, pre-intervention mean of 67.5 (SD =16.88) vs. post-intervention control mean of 68.7 (SD =17.01). Stroop_C, pre-intervention mean of 53.5 (SD =13.52) vs. post-intervention control mean of 52.7 (SD =12.72). Stroop_CW, pre-intervention mean of 32.3 (SD =11.12) vs. post-intervention control mean of 36.3 (SD =11.82).

Table 2.0**Descriptive statistics of Control Pre-Intervention variables**

	Mean (95% Confidence Intervals)	Std. Error Mean	Median	SD	Range
Letter_Num	9 (6.9-11.1)	.82	9	2	6-12
Matrix Patterns	17.2 (14.51-19.89)	1.19	17.50	3.77	9-23
WAIS_III	29.80 (23.85-35.75)	2.62	28	8.31	19-45
WTAR	90.5 (81.07-99.93)	4.17	86	13.19	73-113
Stroop_W	67.5 (55.42-79.58)	5.34	68	16.88	48-95
Stroop_C	53.5 (43.83-63.17)	4.28	51	13.52	29-73
Stroop_CW	32.3 (24.35-40.25)	3.52	36	11.12	10-46

Note. Stroop_W= Stroop Word; Stroop_C= Stroop Colour; Stroop_CW= Stroop Colour/Word; Letter_Num= Letter Number Sequence.

Table 2.1**Descriptive statistics of Control Post-Intervention variables**

	Mean (95% Confidence Intervals)	Std. Error Mean	Median	SD	Range
Letter_Num	9.6 (8.24-10.96)	.6	10	1.9	5-12
Matrix Patterns	18.5(14.56-22.44)	1.74	19	5.5	8-29
WAIS_III	33.20(26.95-39.45)	2.76	33.2	8.7	19-48
WTAR	91 (82.44-99.56)	3.78	90	11.96	78-115
Stroop_W	68.7 (56.53-80.87)	5.38	69	17.01	49-95
Stroop_C	52.7 (43.6-61.8)	4.02	55	12.72	32-70
Stroop_CW	36.3 (27.84-44.76)	3.74	38.5	11.82	11-50

Note. Stroop_W= Stroop Word; Stroop_C= Stroop Colour; Stroop_CW= Stroop Colour/Word; Letter_Num= Letter Number Sequence.

The two experimental groups represented in tables 3.1 and 3.2 differed slightly in terms of IQ, as estimated from performance on Matrix patterns task, pre-intervention mean of 13.17 (SD =5.98) vs. post-intervention control mean of 15 (SD =5.73), also differing significantly in

IQ on the WTAR task, pre-intervention mean of 87.5 (SD =13.46) vs. post-intervention control mean of 96.83 (SD =13.98). They differ significantly in terms of scores on the Letter_Numbering score for EM, pre-intervention mean of 9 (SD =2) vs. post-intervention control mean of 12.67 (SD =3.08). They differed significantly in WM on the WAIS-III task, pre-intervention mean of 26.83 (SD =9.68) vs. post-intervention control mean of 35.33 (SD =7.58). They differed significantly in Attention in each Stroop task, Stroop_W, pre-intervention mean of 65 (SD =14.28) vs. post-intervention control mean of 77.83 (SD =11.09). Stroop_C, pre-intervention mean of 56 (SD =11.08) vs. post-intervention control mean of 61.83 (SD =10.61). Stroop_CW, pre-intervention mean of 34.67 (SD =11.98) vs. post-intervention control mean of 40.33 (SD =12.16).

Table 3.1**Descriptive statistics of Experimental Pre-Intervention variables**

	Mean (95% Confidence Intervals)	Std. Error Mean	Median	SD	Range
Letter_Num	9 (6.9-11.1)	.82	9	2	6-12
Matrix Patterns	13.17 (6.89-19.44)	2.44	13	5.98	6-22
WAIS_III	26.83 (16.67-37)	3.95	23	9.68	18-40
WTAR	87.5 (73.38)	5.49	89	13.46	64-106
Stroop_W	65.67 (50.68-80-65)	5.83	64.5	14.28	50-91
Stroop_C	56 (44.37-67.63)	4.52	55	11.08	43-69
Stroop_CW	34.67(22.1-47.24)	4.89	31.5	11.98	25-57

Note. Stroop_W= Stroop Word; Stroop_C= Stroop Colour; Stroop_CW= Stroop Colour/Word; Letter_Num= Letter Number Sequence.

Table 3.2**Descriptive statistics of Experimental Post-Intervention variables**

	Mean (95% Confidence Intervals)	Std. Error Mean	Median	SD	Range
Letter_Num	12.67 (9.44-15.90)	1.26	11.5	3.08	10-17
Matrix Patterns	15(8.99-21.01)	2.34	14.5	5.73	8-23
WAIS_III	35.33(27.38-43.29)	3.1	37.5	7.58	22-42
WTAR	96.83 (82.16-111.50)	5.71	99	13.98	73- 115
Stroop_W	77.83 (66.2-89.47)	4.53	74	11.09	68-95
Stroop_C	61.83 (50.70-72-97)	4.33	59	10.61	49-80
Stroop_CW	40.33 (27.57-53.09)	4.96	34.5	12.16	31-59

Note. Stroop_W= Stroop Word; Stroop_C= Stroop Colour; Stroop_CW= Stroop Colour/
Word; Letter_Num= Letter Number Sequence.

Table 4 presents the results of the mixed analysis of covariance (ANCOVA) was conducted including one between-subjects variable, Group (Control and Experimental) and one within subjects variable (Pre and Post intervention) and one covariate (Gender), was run for each memory measure. Repeated measures ANCOVAs were run to determine if there was a significant difference amongst the five memory measures variables. Participants were divided into two groups, experimental(N=6) and control (N=10). The table clearly shows the that there was no significant difference between the CG and the EG post intervention.

There was no statistically significant difference in Letter_Number task, $F(1, 14) = 3.8$, $p = .073$. The effect size indicated a big difference within both groups ($\eta^2 = .23$). However, once gender was controlled for, $p = 1$, it was still not significant, therefore, it made no difference.

There was a statistically significant difference in WAIS_III, $F(1, 14) = 5.15$, $p = .02$. The effect size indicated a big difference within both groups ($\eta^2 = .42$). After gender was controlled for, $p = .21$, it became non significant.

There was a statistically significant difference in Matrix, $F(1, 14) = 39.81$, $p = .001$. The effect size indicated a large difference within both groups ($\eta^2 = .86$). After gender was controlled for, $p = .17$, therefore, it became insignificant.

There was no statistically significant difference in WTAR task, $F(1, 14) = 1.74$, $p = .32$. The effect size indicated a big difference within both groups ($\eta^2 = .47$). However, once gender was controlled for, $p = .65$, it was still not significant, therefore, it made no difference.

There was statistically significant difference in Stroop CW, $F(1, 14) = 21.13, p = .001$. The effect size indicated a large difference within both groups ($\eta^2 = .76$). After gender was controlled for, $p = .11$, therefore, it became insignificant.

Because, most of the ANCOVA results came back non-significant, we fail to reject the null hypothesis.

Table 4

Mixed analysis of covariance (ANCOVA * Gender)

	Experimental participants (N)	Control participants (N)	Statistics	P value	η^2
Mean age of participants	M= 87.5	M=110	Experimental: SD=13.46 Control: SD=13.19		
Groups	37.5%	62.25%	M= 25.44		
Gender (M;F)	3:3	5:5	M=8:8		

**EPISODIC
MEMORY TASK**

Letter_Number	6	10	F=3.8	P= 1	.23
Sequencing					

WORKING
MEMORY TASK

WAIS_III	6	10	F=5.15		.42
				P=.21	

IQ TASKS

Matrix	6	10	F=39.81		.86
				P=.17	

WTAR	6	10	F=1.74	P.65	.47
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ATTENTION
TASK

Stroop_CW	6	10	F=21.13		.76
				P=.11	

Discussion

This study failed to reject the null hypothesis. This study aimed to identify 1) whether 5 weeks of CRT would have an impact on a person's WM, EM, and Attention in individuals with possible/diagnosed dyslexia, and 2) whether gender played a role in how big the impact would be. A test of normality was performed on each scale; 1) WAIS III 2) Letter Number Sequencing 3) WTAR 4) Matrix and 5) Stroop_CW, both pre and post intervention, all of which came back as non-significant, which were all $<.05$, meaning the scales satisfied the assumption of the ANCOVA, showing that the sample was normally distributed. Using the five scales, results showed that, in this sample, the effect size obtained using the ANOVA, showed it was generally large. However, after the covariate gender was removed within the ANCOVA analysis, the results became non-significant.

This is consistent with the results found by Dickinson and colleagues, (2010). It is similar in the fact that their participants also showed an improvement on the tasks at hand, however there were no generalisable results or improvements found, which is similar to the findings in this study. Although this study echoed the approaches drawn by McAvinue et al., (2013), in terms of the length of the CRT, the scales to be used and the 'Home-Based' therapy approach, which was supported within the rationale as being one of the more effective factors within this research, however the results did not echo their findings. As they found significant improvement in EM. However, the results were similar in the sense that WM was not improved, nor was there a difference between the CG and the EG in terms of improvement in the Letter Numbering task. Nor was there any improvement within Attention, which replicates the findings within this study.

As there have been no studies to date which have employed the use of gender as a covariate within their study, it is impossible to compare the results. However, within this study, it showed that once gender was removed, the significant difference decreased within all scales.

This shows that gender may in fact play a part within learning difficulties and outcomes. Therefore, in the future, this may be a domain which could be looked into further. Therefore, if gender can have such an effect on the results, the effect of individual differences should also be looked into, such as age, education, location in which the program is being completed in, as they may also play a role in terms of the progress, as is explained within the Torgesen et al., (1999) study. IQ should also be looked into, as the results within this study were insignificant once gender was taken out, however, it was seen to be significant beforehand, this shows that it could affect the study, in terms of who may need more resources and time when it comes to CRT, which may depend on the level of education one may have (Fisher et al., 2009).

There were a few limitations present within this study, which may have affected the outcome significantly. 1) It was not always possible to tell how much time and effort and individual from the experimental group was putting into their training. As it was a 'home-based' therapy, it was not easy to control for this. Some participants did acknowledge the fact that more time could have been spent on doing some of the tasks. 2) Participants also reported favouring the easier tasks over the harder more stressful ones. This is a limitation as although they were getting trained, they were not making much progress as they chose to stick to the easier tasks so that they may complete the tasks much faster and experience less stress and difficulties. This defeated the purpose of the tasks set for them.

Strengths of this study was that 1) the inclusiveness of the dyslexic control group meant that results could be compared to give a better idea of the actual effect size, meaning less chance of gaining biased results. 2) Games were used instead of the traditional class-room techniques used to improve learning. This meant participants were more likely to stay engaged in the program than drop out. 3) Another strength of this study was the fact that the researcher contacted the participants through email every week to check up on their progress and to answer/resolve any problems they may be experiencing. This meant that any

misunderstandings or problems were quick to be resolved, meaning that any inconveniences could be resolved. Participants were also quick to give feedback using this technique.

It is shown that within McAvinue et al., (2013) that those of whom spent more time using the program, the less they improved. However, this was found to be caused by the psychological stress during the training. However, once duration of the study was reduced, the significant result of the study also dropped. Therefore, it is not enough to say that in order to gain better and significant scores within the study, training time should be increased or decreased, instead, stress levels should be tackled. An initiative should be put in place in order for participants to unload their stress so that it may not affect the scores gained. A way to tackle this in the future would be to provide them with a therapist which they could see whenever they wished to. Or set them physical tasks such as exercising or extra-curricular hobbies in which they may relieve their stress.

Although this study was un-successful in accepting the hypothesis, there is reason to believe it could be due to the small number of participants gathered within the EG(N=6). Most other studies performed had many participants such as Hargreaves et al., (2015) had 48 participants in total. Therefore, it goes without saying, that in order to find a large effect size and for the study to be significant, the sample size should also be large.

The implications of this study, although mentioned in the rationale that the CRT program could be used within the comfort of people's homes and schools. This would allow for disadvantaged kids to be given a chance to catch up with their peers. However, since the null hypothesis could not be rejected, others could use this study to learn from and recreate this study, with maybe better results from a wider population so that results can be generalizable. As it is a computer-based program, it would also mean that it could be a cheaper method of therapy over others.

Conclusion

Although this study failed to reject the null hypothesis, there is still potential to gain significant results which show that this therapy could in fact be very beneficial to those in need of it. This study can be used as a learning curve for future studies to realise what needs to be done in order to find significant results and use the program to their and others advantage. If the right conditions are met in the future studies, there is potential for this study to make a difference in individuals with dyslexia, as it has with individuals of other Working, and Episodic Memory, and Attention.

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Appendix

1) Information Letter/ Consent Form

Information on the study “Impact of CRT on the working memory, episodic memory and attention on an individual with possible dyslexia”.

NOTE: This study would be best suited for individuals living in Dublin, as training will be conducted in the National College of Ireland (NCI), unless commuting is not a problem.

Firstly, I would like to thank you for taking interest in my study. Below I will be explaining what this study involves, what I am looking to gain out of it (results wise) and what you as a potential participant may be required to do if you so wish to take part in this study.

Cognitive Remediation Therapy (CRT) programme has been shown successful in improving the working memory, attention memory, cognitive functioning and episodic memory in adults with ADHD and schizophrenia. Since working memory is so important for dyslexia and since this working memory training programme has been successfully employed in multiple populations, it is worth investigating whether this particular programme will also help people with dyslexia to overcome their working memory problems and improve on reading skills.

This study is examining individuals with diagnosed dyslexia or possible dyslexia over the course of five weeks. Participants will first be required to do a pre-test at week 0, which will assess participants reading abilities, IQ, verbal working memory and executive functioning such as attention. Participants will then be randomly assigned to either a control group or an experimental group. The control group will be required to continue with their daily routine as per normal. The experimental group will be trained in the CRT programme on a computer or a laptop. They will be required to do this independently for 40 minutes a day, five days a week. As you will be doing the tasks on your own, you have complete freedom over where and when you choose to do them. The computer programme will provide you with feedback regarding your progress. At week 5, participants from the control group and the experimental group will be asked to take a post-test. It will be the same as the pre-test.

Participants from the control group will be given the chance to participate in the CRT programme if they wish to do so, after week 5.

If you would like more information regarding this study, please do not hesitate to contact me through the dyslexia-crt@outlook.com email address

If you wish to participate in this study, also please let me know. I will need approximately 40 participants in order to conduct this study, therefore, if you know of anyone suitable, please let them know.

Please sign below to show that you understand the terms and conditions and agree to take part in the study.

2)

CALLING ALL STUDENTS WITH DYSLEXIA

Would you like to take part in a study
which aims to find out if training your
memory helps with dyslexia
symptoms?



PLEASE CONTACT
DYSLEXIA-CRT@OUTLOOK.COM

3) WRITTEN DEBRIEFING FORM

CRT STUDY, NCI

Thank you for participating in this study! We hope you enjoyed the experience. This form provides background about our research to help you learn more about why we are doing this study. Please feel free to ask any questions or to comment on any aspect of the study.

You have just participated in a research study conducted by Aqsa Anjum.

X16317603@student.nirl.ie. Please note that even though you as an individual will be kept anonymous, the data that you will have submitted may be disseminated for publishing or advertising purposes.

This study is to see if there will be an increase in the working memory, episodic memory and attention in individuals with possible dyslexia.

As you know, your participation in this study is voluntary. If you so wish, you may withdraw after reading this debriefing form, at which point all records of your participation will be destroyed. You will not be penalized if you withdraw.

You may keep a copy of this debriefing for your records.

If you have questions now about the research, please ask. If you have questions later, please e-mail Aqsa Anjum at x16317603@student.ncirl.ie. If, as a result of your participation in this study, you experienced any adverse reaction, please contact the NCI College ON 1850 221

If you wish to avail of any other issues such as mental health issues or need non-judge mental support, then below are a list of numbers you can avail of;

Niteline: 01 883 5400

Aware: 1800 80 48 48

Dyslexia Association of Ireland: 01 877 6001

Please sign below to show that you have understood,

Thank you,

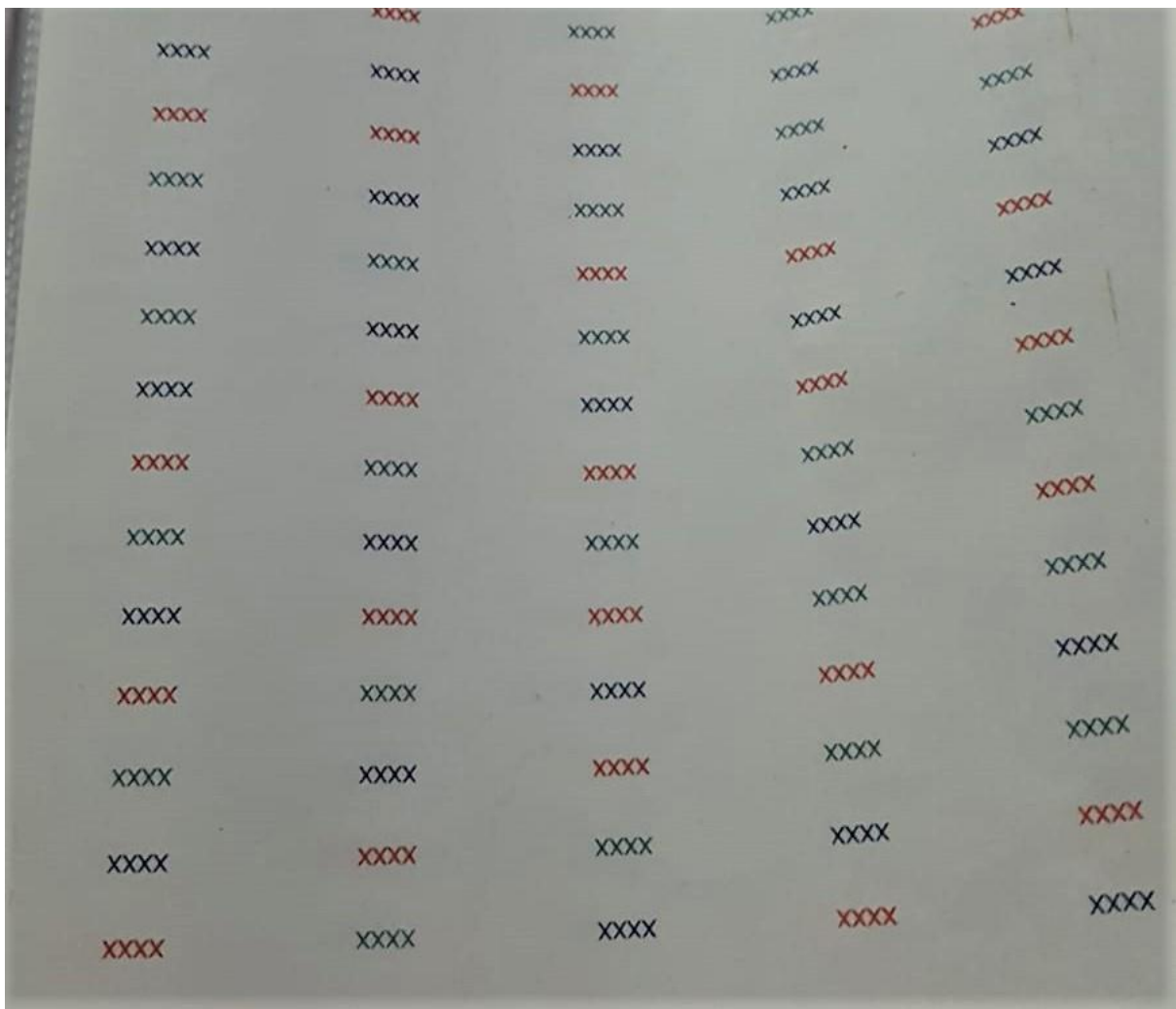
Name:

Date:

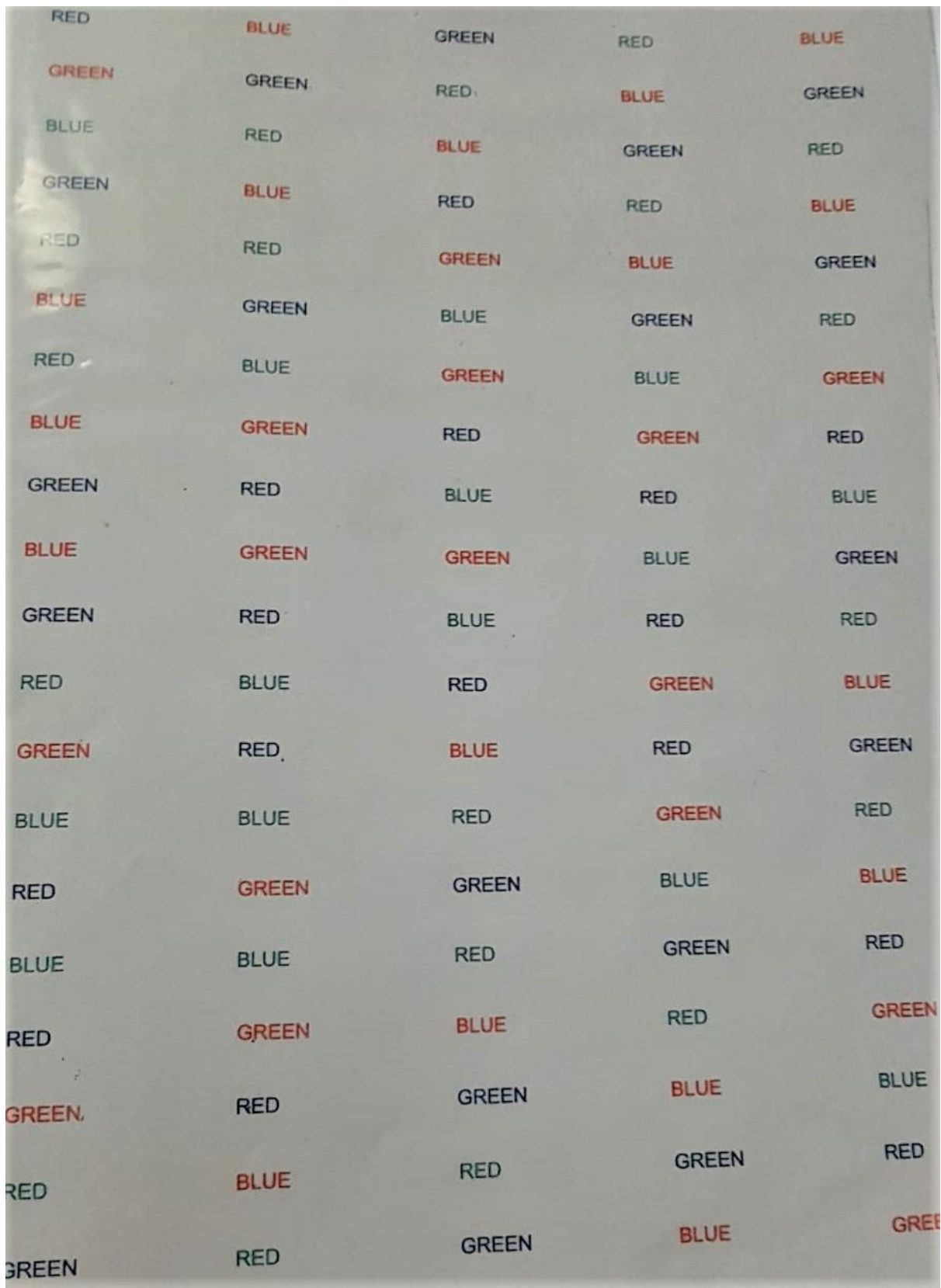
4) Stroop W

RED	BLUE	GREEN	RED	BLUE
GREEN	GREEN	RED	BLUE	GREEN
BLUE	RED	BLUE	GREEN	RED
GREEN	BLUE	RED	RED	BLUE
RED	RED	GREEN	BLUE	GREEN
BLUE	GREEN	BLUE	GREEN	RED
RED	BLUE	GREEN	BLUE	GREEN
BLUE	GREEN	RED	GREEN	RED
GREEN	RED	BLUE	RED	BLUE
BLUE	GREEN	GREEN	BLUE	GREEN
GREEN	RED	BLUE	RED	RED
RED	BLUE	RED	GREEN	BLUE
GREEN	RED	BLUE	RED	GREEN
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	GREEN	BLUE	BLUE
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	BLUE	RED	GREEN
GREEN	RED	GREEN	BLUE	BLUE
RED	BLUE	RED	GREEN	RED
GREEN	RED	GREEN	BLUE	GREEN

Stroop C





Stroop CW




5) WAIS III Vocabulary Pronunciation Task

2. Vocabulary

REVERSE RULE
 score of 0 or 1 on item 4 or 5, administer items 1-3 in reverse sequence until two consecutive perfect scores are obtained.

DISCONTINUE RULE
 0 consecutive scores of 0.

SCORING RULE
 All items 0, 1, or 2 pts.


Item	Response	Score (0, 1, or 2)
1. Bed		
2. Ship		
3. Penny		
START → 4. Winter		
5. Breakfast		
6. Repair		
7. Assemble		

2. Vocabulary *(continued)*


Item	Response
8. Yesterday	
9. Terminate	
10. Consume	
11. Sentence	
12. Confide	
13. Remorse	
14. Ponder	
15. Compassion	
16. Tranquil	
17. Sanctuary	
18. Designate	
19. Reluctant	
20. Colony	
21. Generate	
22. Ballad	
23. Pout	
24. Plagiarize	
25. Diverse	
26. Evolve	
27. Tangible	
28. Fortitude	
29. Epic	
30. Audacious	
31. Ominous	
32. Encumber	
33. Tirade	

6) Letter Numbering Sequence

13. Letter-Number Sequencing



DISCONTINUE RULE
After failure on all 3 trials of an item.



SCORING RULE
0 or 1 pt. for each response.
Item score = Trial 1 + Trial 2 + Trial 3

	Trial	Item/Response	Trial Score (0 or 1)	Item Score (0, 1, 2, or 3)
START →	1	L-2 (2-L)		
	2	6-P (6-P)		
	3	B-5 (5-B)		
	1	F-7-L (7-F-L)		
	2	R-4-D (4-D-R)		
	3	H-1-8 (1-8-H)		
	1	T-9-A-3 (3-9-A-T)		
	2	V-1-J-5 (1-5-J-V)		
	3	7-N-4-L (4-7-L-N)		
	1	8-D-6-G-1 (1-6-8-D-G)		
	2	K-2-C-7-S (2-7-C-K-S)		
	3	5-P-3-Y-9 (3-5-9-P-Y)		
	1	M-4-E-7-Q-2 (2-4-7-E-M-Q)		
	2	W-8-H-5-F-3 (3-5-8-F-H-W)		
	3	6-G-9-A-2-S (2-6-9-A-G-S)		
	1	R-3-B-4-Z-1-C (1-3-4-B-C-R-Z)		
	2	5-T-9-J-2-X-7 (2-5-7-9-J-T-X)		
	3	E-1-H-8-R-4-D (1-4-8-D-E-H-R)		
	1	5-H-9-S-2-N-6-A (2-5-6-9-A-H-N-S)		
	2	D-1-R-9-B-4-K-3 (1-3-4-9-B-D-K-R)		
	3	7-M-2-T-6-F-1-Z (1-2-6-7-F-M-T-Z)		
Total Raw Score (Maximum = 21)				

7) Matrix

7. Matrix Reasoning

U **REVERSE RULE**
 Score of 0 on Item 1 or 5; administer Items 1-3 in reverse sequence until two consecutive perfect scores are obtained.
*Note: Correct response appears in **bold italic**. Administer Sample Items A-C to all examinees.*

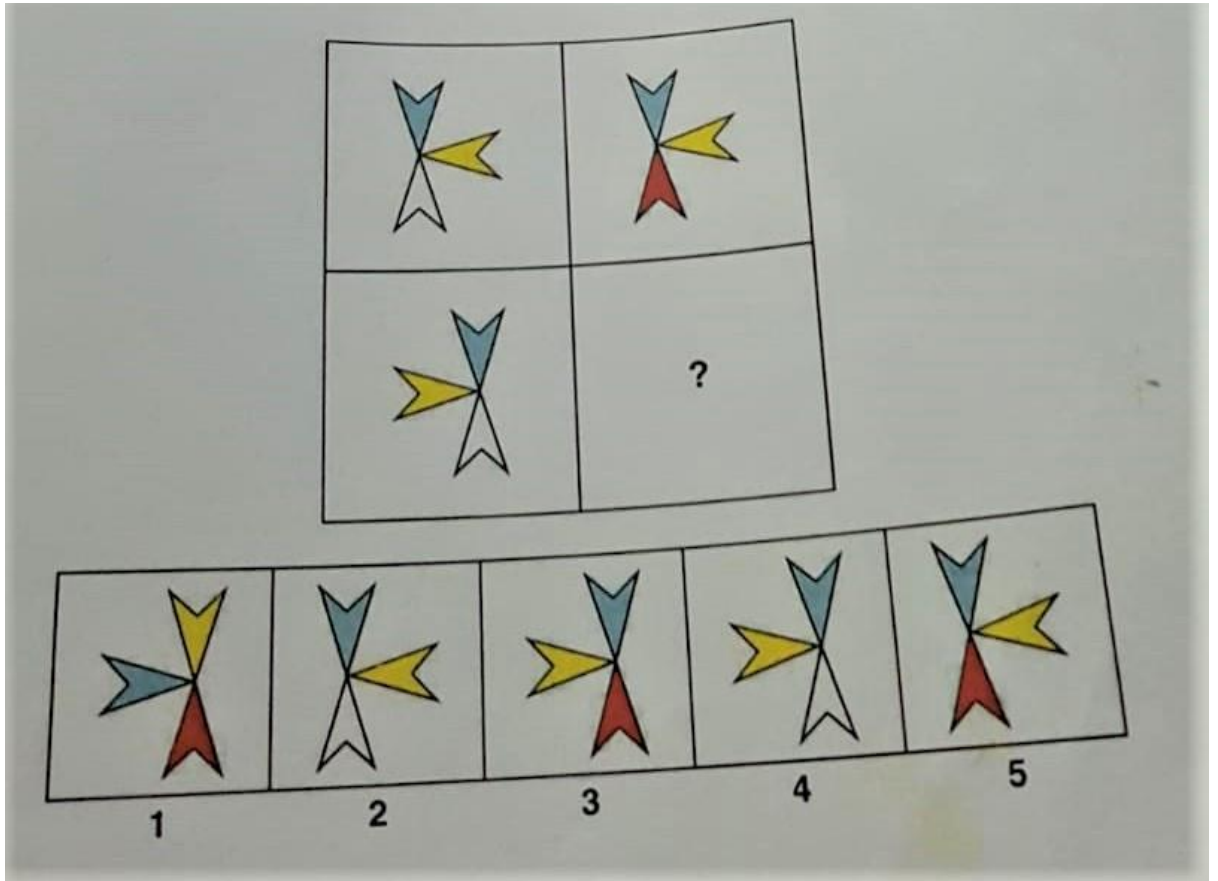
DISCONTINUE RULE
 3 consecutive scores of 0 or 1 scores of 0 on 5 consecutive items.

SCORING RULE
 All items: 0 or 1 pt. for each response. Do not score Sample Items A-C.

Item	Response Options (Circle one)						Score (0 or 1)
A.	1	2	3	4	5	DK	
B.	1	2	3	4	5	DK	
C.	1	2	3	4	5	DK	
1.	1	2	3	4	5	DK	
2.	1	2	3	4	5	DK	
3.	1	2	3	4	5	DK	
4.	1	2	3	4	5	DK	
5.	1	2	3	4	5	DK	
6.	1	2	3	4	5	DK	
7.	1	2	3	4	5	DK	
8.	1	2	3	4	5	DK	
9.	1	2	3	4	5	DK	
10.	1	2	3	4	5	DK	
11.	1	2	3	4	5	DK	
12.	1	2	3	4	5	DK	

Item	Response Options (Circle one)						Score (0 or 1)
13.	1	2	3	4	5	DK	
14.	1	2	3	4	5	DK	
15.	1	2	3	4	5	DK	
16.	1	2	3	4	5	DK	
17.	1	2	3	4	5	DK	
18.	1	2	3	4	5	DK	
19.	1	2	3	4	5	DK	
20.	1	2	3	4	5	DK	
21.	1	2	3	4	5	DK	
22.	1	2	3	4	5	DK	
23.	1	2	3	4	5	DK	
24.	1	2	3	4	5	DK	
25.	1	2	3	4	5	DK	
26.	1	2	3	4	5	DK	

Total Raw Score
(Maximum = 26)



8) WTAR

wtar[™] WORD CARD

ECHSLER[®] TEST OF ADULT READING[™]

1. again
2. address
3. cough
4. preview
5. although
6. most
7. excitement
8. know
9. plumb
10. decorate
11. fierce
12. knead
13. aisle
14. vengeance
15. prestigious
16. wreath
17. gnat
18. amphitheatre
19. lieu
20. grotesque
21. iridescent
22. ballet
23. equestrian
24. porpoise
25. aesthetic
26. conscientious
27. homily
28. malady
29. subtle
30. fecund
31. palatable
32. menagerie
33. obfuscate
34. liaison
35. exigency
36. xenophobia
37. ogre
38. scurrilous
39. ethereal
40. paradigm
41. perspicuity
42. plethora
43. lugubrious
44. treatise
45. dilettante
46. vertiginous
47. ubiquitous
48. hyperbole
49. insouciant
50. hegemony

9) Permission from Dyslexia Association of Ireland

 **Dyslexia Association** <info@dyslexia.ie>
To: aqsaanjum6@yahoo.com

 Oct 1 at 4:59 PM

Hi Aqsa,

Can I ask you to provide us with proof of ethical approval from your college?

Once we have that we can post your request on our social media. I hope the info below helps.

+++++

DAI receives a very large number of requests from students conducting research. Unfortunately, we do not have the capacity to get involved in such projects to any great extent. We refer all students to our website, www.dyslexia.ie, in the first instance, as this contains a large amount of information on dyslexia. We can also offer the following:

1. We will share requests for research participants on our Facebook page, once we have seen proof of ethical approval for the project
2. We will respond to a small number of specific questions by email
3. We have a drop-in service at our office on Talbot Street, Dublin 1, on Wednesday afternoons between 3 pm and 4 pm. Students are welcome to avail of this service.

Kind Regards,

Jenny Byrne

Information Team | Dyslexia Association of Ireland

5th Floor | Block B | Joyce's Court | Talbot St | Dublin 1 | (01) 877 6001 | info@dyslexia.ie