An investigation into affect-related working memory for adolescents with dyslexia

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A Thesis Submitted to the Department of Educational Psychology, Inclusive and Special Education, Mary Immaculate College, In Partial Fulfilment of the Requirements For the Degree of Doctor of Educational and Child Psychology

Word Count for thesis: 31,000 (excluding tables and figures)

Word Count for empirical paper: 12,000 (excluding tables and figures)

Submitted to Mary Immaculate College, August 2021

Abstract

Title: An investigation into affect-related working memory for adolescents with dyslexia

Background Working memory and socio-emotional differences are often associated with the neurodiverse profile of dyslexia. However, it is not well understood how affect (i.e., feelings, emotion or mood) interacts with working memory processing among this population. Research suggests that affective information influences, and is influenced by, working memory, and that affective information is itself processed in working memory, with differences existing between populations. To date, research has not adequately accounted for the interaction of affect and working memory performance in this cohort.

Aims: This research sought to explore the affect-related working memory profiles of adolescents with dyslexia.

Sample(s): The participants for this study include adolescents with dyslexia aged 12-14 (n = 32), along with a control group matched for age and gender, but without a diagnosis or self-identified learning or developmental difficulty (n = 39).

Methods: This study adopted a post-positivist theoretical perspective and it was quasi-experimental in design. Participants completed online, computer-based, working memory tasks and also briefly self-rated their affective experiences. Participants were required to maintain an active representation of an image over a retention period, after which they made an affective or non-affective comparison judgement. While under working memory load, during this retention interval, they were required to perform an additional working memory task (N-back) with affective or non-affective literacy stimuli. Furthermore, cognitive emotional regulation strategies employed were recorded due to their capacity to interfere with affective representations.

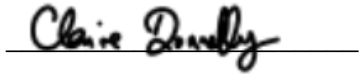
Results: Reaction times for maintenance tasks did not differ between groups, but reaction times for less affective words had quicker accurate response times. Adolescents with dyslexia

were less successful at maintaining affective information than their peers without dyslexia. Both groups displayed similar accuracy for maintaining less affectively-valent visual information, but this visual working memory task was more challenging for the dyslexia group when it required switching between different types of tasks. Catastrophising was a significant covariate for adolescents maintaining information, but it was positive re-focusing and reappraisal strategies that were reported more efficacious by the group with dyslexia. Both groups preferred the maintenance of affective information to brightness maintenance, but to a lesser extent for those with dyslexia.

Conclusions: This study gives educational psychologists a greater understanding of the complex cognitive underpinnings of dyslexia (Stothard et al., 2018; Elliott & Grigorenko, 2015), and illuminates the interaction between affect and working memory for this neurodiverse population.

Declaration

I hereby declare that, except where explicit attribution is made, the work presented in this thesis is my own.

Signature of Candidate: 

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Student Number: 09005128

Date: 04/05/2021

Wordcount: 30,734

Acknowledgement

There are many people I must acknowledge and sincerely thank for their positive influence along my journey to becoming an Educational and Child Psychologist. The list is too long for this brief acknowledgement section. However, I must acknowledge that I would not be nearing the end of this milestone, were it not for all those who helped in their own way. That said, I must mention a few.

Firstly, I would like to thank all of my family, my mam and dad, my two sisters, Sinead and Maria and brother in law, Htin. The interest you showed, support you gave, and general understanding has been amazing.

Secondly, I would like to thank my fiancé Aran who has shown tremendous patience, compassion, and encouragement over the past few years.

Thirdly, I would like to thank my friends who provided plenty distraction, laughs, and check-ins. You kept me going!

Fourthly, I would like to mention my DECPsy cohort. It has made this course possible to have such a talented and close group of individuals to share the successes and challenges along the way. The ‘quick’ phone calls and messages were often greatly appreciated.

Fifthly, I am sincerely grateful to my supervisors both on placement and of course Dr Therese Brophy and Dr Paul Mulcahy for supervising this research. Your expertise, guidance and general interest in this project made it what it is today.

I would finally like to thank the Dyslexia Association of Ireland, and all of the schools including their principals, teachers, and adolescents who took the interest and time to be part of this study. I am forever grateful.

Dedication

This thesis is dedicated to my parents for your love and support, encouragement, and belief in all things possible.

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List of Acronyms

ADHD	Attention Deficit Hyperactive Disorder
ANEW	Affective Norms for English Words
AWM	Affect-related Working Memory
CE	Central Executive
CERQ	Cognitive Emotional Regulation Questionnaire
CHC	Cattell-Horn-Carroll
DAI	Dyslexia Association Ireland
DLPFC	Dorsolateral Prefrontal Cortex
EI	Emotional Intelligence
EPSEN	Education for Persons with Special Educational Needs
ER	Emotional Regulation
FMRI	Functional Magnetic Resonance Imaging
IDA	International Dyslexia Association
NEPS	National Educational Psychological Service
PANAS	Positive and Negative Affect Scale
RT	Reaction Time
SENCO	Special Educational Needs Co-Ordinator
SERC	Special Education Review Committee
SLD	Specific Learning Difficulty
STM	Short Term Memory
TFD	Task Force for Dyslexia
WM	Working Memory
WMC	Working Memory Capacity

Chapter One: Introduction to the Thesis

This introduction provides an overview of key concepts and ideas which structure this thesis. It will begin with the rationale for selecting the topic. Secondly, the researcher's positionality in terms of personal interest and experience, along with practice-based factors are discussed. Thirdly, the constructs of Working Memory (WM) and Affect-Related Working Memory (AWM) are introduced. Fourthly, the epistemological and theoretical considerations which underpin this research are outlined, and then the overall structure of this thesis is delineated.

1.1 Thesis Rationale

The importance of working memory (WM) functioning and socio-emotional factors are frequently reported in the literature pertaining to learning (Gathercole & Alloway, 2004; Burden, 2008). The Report of the Task Force on Dyslexia (2001) lists working memory variance as one of the main characteristics of dyslexia and advises that non-linguistic factors such as 'emotional development' can impact on students' ability 'to cope with content and teaching methodologies' (Government of Ireland, 2001, p.77). The United Kingdom's Rose Report on dyslexia further describes the 'emotional obstacles' associated with dyslexia (Rose, 2009).

Working memory and socio-emotional factors, have until now been explored as siloed systems. For instance, Peng et al. (2018) conducted a meta-analysis which identified significant relationships between a student's working memory and their reading decoding and fluency. However, others have focused on the range of socio-emotional factors associated with dyslexia, including anxiety and resilience and their relationship with learning experiences and well-being (Badeley et al., 2013; Burden, 2008; Burton, 2004; Haft et al., 2016; Moran et al., 2016; Rose, 2009). These findings suggest that working memory and

socio-emotional factors are independently related to students' learning and literacy acquisition, but the relationship between all three variables is less developed.

Recent findings indicate a bi-directional causal relationship between socio-emotional factors and working memory (Mikels & Reuter-Lorenz, 2019; Schweizer et al., 2019), but it is unknown how affect and working memory interact simultaneously for this specific cohort. Growing research postulates that there is variance in how people store, encode and retrieve affect-related or emotive content in comparison to more affectively neutral content (Broome et al., 2012; Schweizer et al., 2019). It is unknown if emotional language and stimuli place additional demands on, or support the working memory of this neurodiverse population. Cognitive emotional regulation strategies may also play a role in the interaction between working memory and affect (Schweizer et al., 2019), but need further exploration, with mainly non-emotive self-regulation abilities in the form of planning, monitoring, and revising during learning experiences included in previous dyslexia specific research (Cutting et al., 2009; Kibby et al., 2004; Singer, 2008; Swanson, 1989).

1.2 Main Psychological Constructs

1.2.1 Working Memory (WM)

> Working memory refers to the system or systems that are assumed to be necessary in order to keep things in mind while performing complex tasks such as reasoning, comprehension and learning. (Baddeley, 2010, p. 1)

The conceptual model of working memory utilised, determines how the constructs of working memory are explored. Working memory can be conceptually understood as a general capacity, where attentional control is measured. (Turner and Engle, 1989). Working memory can also be conceptually understood by domain-specific aspects such as the phonological loop or visuospatial store (Daneman & Carpenter, 1980; Gray et al., 2019; Savage et al., 2006). The most influential WM model researched is the Baddeley and Hitch

Multicomponent Model of Working Memory (2003) which includes domain-specific elements including the central executive (CE), visuospatial sketchpad, the episodic buffer, and phonological loop (Gray et al., 2019; Savage et al., 2006). Baddeley added a component to his WM model known as a hedonic detector, to highlight the complex role emotion plays in WM, e.g., moods can influence working memory tasks (Baddeley et al., 2012; Fairfield et al., 2015).

1.2.2 Affect-Related Working Memory (AWM)

Mikels and Reuter-Lorenz (2019) posit that working memory and emotion are even more dynamic in their interactions than previously considered. While emotions and moods experienced can impact on working memory capacity, and working memory capacity can impact on emotions experienced, it is also plausible that the relationship is not always causal, but sometimes concurrent, i.e., emotions can be the information that is stored and processed by WM (Mikels & Reuter-Lorenz, 2019). Affect-related working memory is the storage and maintenance of affective information or experiences as mental representations within working memory, which are separate from less affective information and experiences (Mammarella et al., 2012; Mikels et al., 2005; Mikels et al., 2008; Mikels & Reuter-Lorenz, 2019; Mirabolfathi et al., 2020; Schweizer et al., 2019). According to this proposal, affective information is processed in a similarly specialised way to visuospatial or phonological information.

1.3 Researcher's Positionality

Professional experiences as a teacher and a trainee educational psychologist have highlighted the siloed nature in which socio-emotional factors and working memory are targeted, i.e., strategies and recommendations for socio-emotional factors and WM are kept separate. However, Aristotle once stated that 'the whole is greater than the sum of the parts'(Aristotle, ca. 1045 B.C.E./1981). Conceptualising affect and working memory

separately may not offer the same insight as when they are combined. To design the most effective interventions they may need to be explored together, especially given the possible relationship between affect-related working memory and higher order thought processes such as affective forecasting and decision making (Frank et al., 2020), emotional intelligence, goal directed learning and motivation (Mikels & Reuter-Lorenz, 2019).

1.4 Epistemological Considerations and Theoretical Perspective(s)

The researcher adopted a post-positivist paradigm to explore the reality of the interaction between working memory and emotion. Post-positivism ontology uses a rational and empirical approach, where the researcher can experiment and measure the probability rather than certainty of a general law (Panhwar et al., 2017; Philips & Burbules, 2000). This conceptual framework led the researcher to use a primarily quantitative, quasi-experimental research design, as participants were assigned to specific groups.

The researcher observes, and objectively measures the importance of working memory for affect but acknowledges that experimental observations cannot always capture a holistic, accurate and unbiased reading of a complex concept such as emotion (Mertens, 2015). Therefore, adolescents' own perception of affective versus cognitive working memory tasks was sought, in a single self-report item. This inclusion of a subjective self-report to supplement the primarily quantitative-based analysis provides an opportunity to begin merging diverse insights and perspectives (Johnson, 2009). This approach to merge insights and perspectives will enhance the understanding of how affect-related working memory experiences are understood for this neurodiverse population.

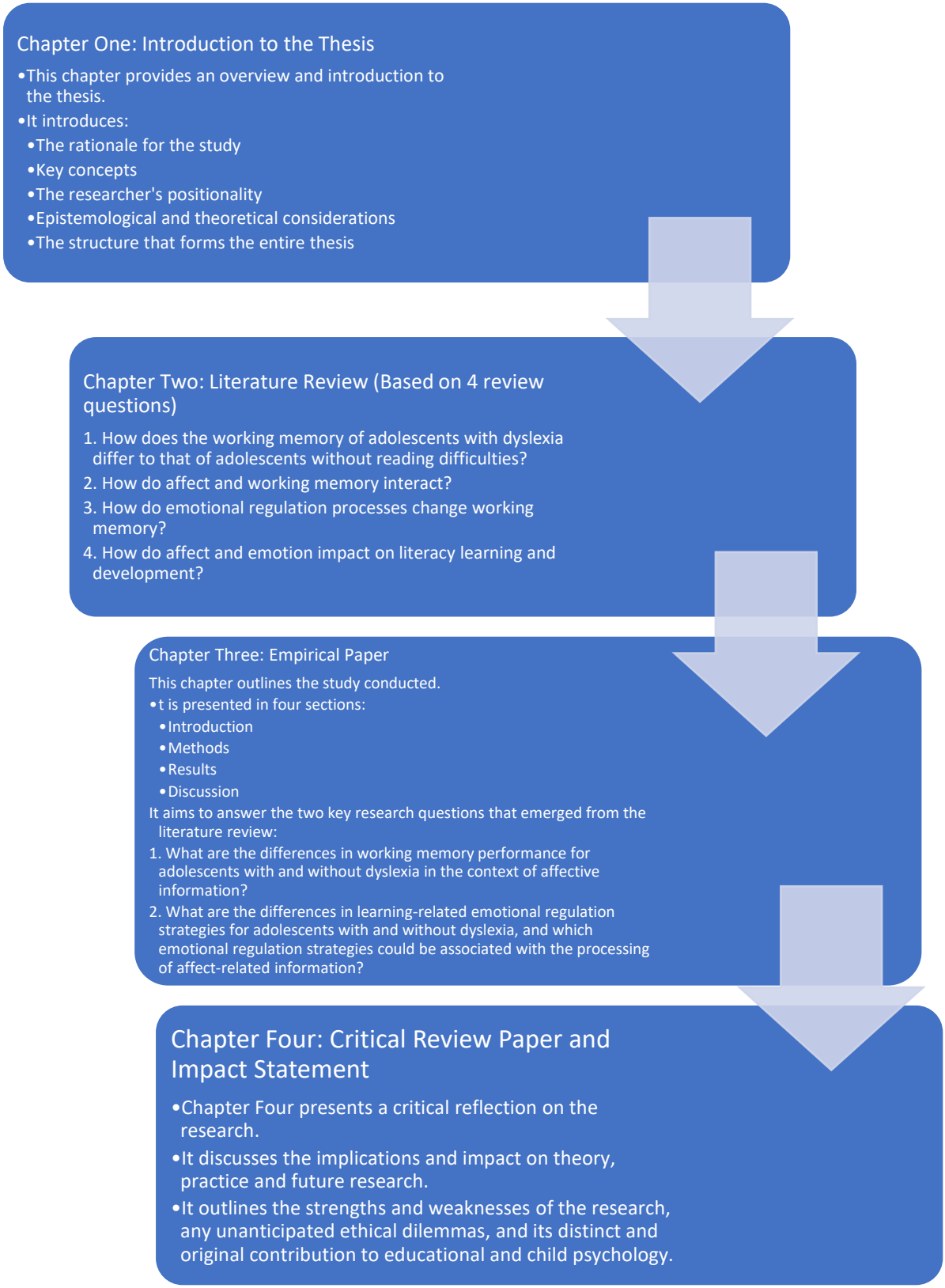
1.5 Structure of the Thesis

This introduction to the thesis precedes three further chapters. Chapter two details a literature review of working memory for adolescents with dyslexia, affect-related working memory, emotional regulation and working memory, and affect-related literacy learning.

Chapter three provides the empirical paper, which is an account of the research study intended for publication. Chapter four outlines a critical review including limitations and also a summary of the potential contribution of this research to educational psychology practice. See Figure 1 below for a visual overview of the thesis.

Figure 1

Overview of the Thesis



Chapter Two: Literature Review Paper

2.1 Introduction

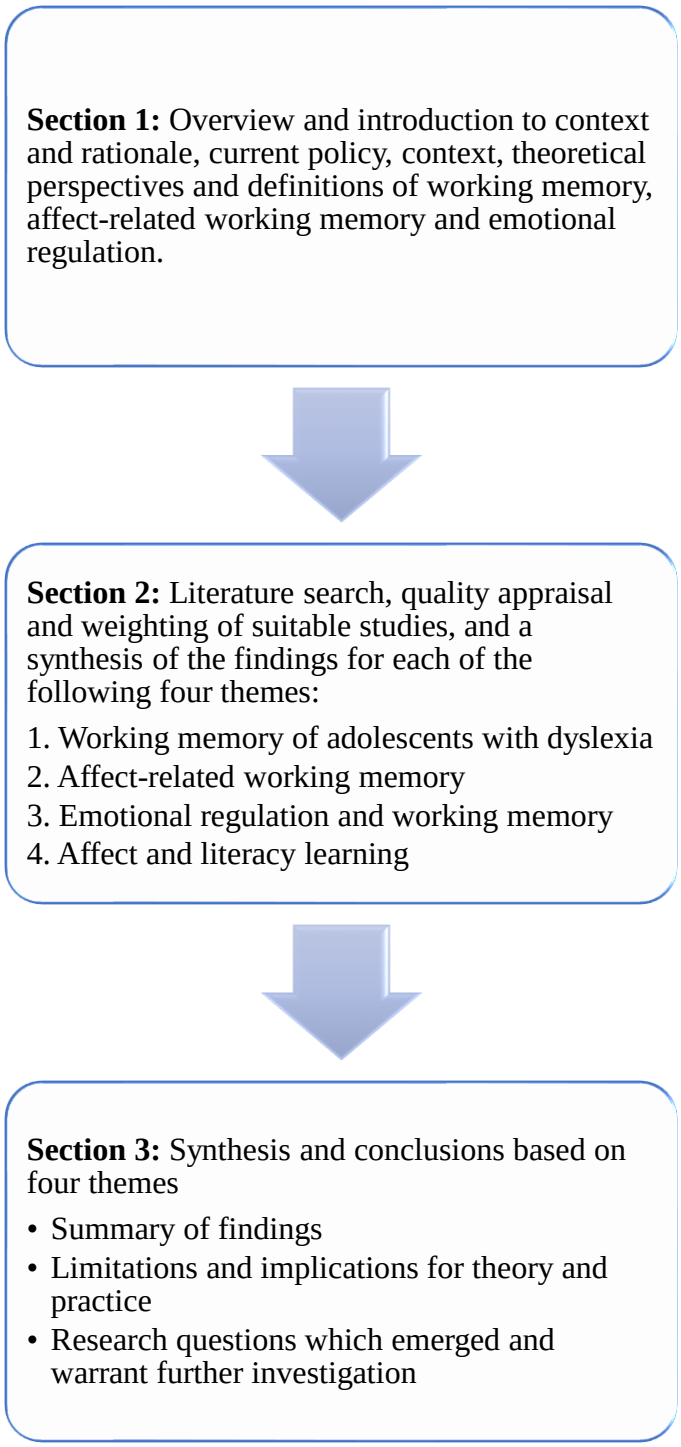
This literature review aims to explore the working memory profiles of adolescents with dyslexia, along with the role of affect or emotion on working memory processes. To begin, an overview of current policy and context in relation to dyslexia, along with theoretical perspectives and definitions of working memory, affect-related working memory and emotional regulation, will be examined. Following this introductory overview of key constructs and a scoping search of the key terms, it was apparent that these constructs have not yet been explored together, despite affect-related working memory being noted as a relevant area of research for neurodiverse groups (Broome et al., 2012). Therefore, an incorporation of methodological frameworks for narrative and thematic reviews (Enferm, 2007; Nicholson et al., 2016; Thomas & Harden, 2008) is utilised to capture, analyse and synthesise the information into four separate themes. These four themes aimed to answer the following:

- how does the working memory of adolescents with dyslexia differ to that of adolescents without reading difficulties?
- how do affect and working memory interact?
- how do emotional regulation processes change working memory?
- how do affect and emotion impact on literacy learning and development?

Each theme will begin with a literature search and screening process using the Horner et al. (2005) quality criteria framework. The articles will be examined and weighted based on criteria specific to answering each theme. A thorough appraisal and synthesis of the literature relating to these themes will follow, and will highlight some gaps in the literature for future research recommendations, along with some questions meriting further investigation.

Figure 2

Overview of Literature Review



2.2 Overview of Context

2.2.1 Dyslexia and Affect-related Working Memory Context

Adolescents with a specific learning difficulty (SLD), such as dyslexia, present with reading and spelling difficulties which are often but not always associated with deficits in working memory (Elliott & Grigorenko, 2015). Working memory and affect interact to influence one another, and there is a growing body of research to suggest that they are not fully dissociable; this shows that affective information is processed within working memory and indicates differences between people, including how they recall affective information in comparison to more neutral information (Frank et al., 2020; Mikels & Reuter-Lorenz, 2019; Schweizer et al., 2019). Affective and non-affective information processing in WM may exhibit differences , which may vary across people or groups. For some clinical populations that demonstrate difficulties in working memory, such as people diagnosed with schizophrenia, affect-related content is more difficult to sort, store and recall than neutral content (Mammarella et al., 2012). However, for other people, including ageing individuals who demonstrate difficultiesin working memory, their affect-related working memory is unimpaired and superior to cognitive working memory (Mikels et al., 2005). The nature of affect-related working memory and how it differentiates from cognitive working memory in dyslexia is unknown. It must be noted that the term cognitive working memory is being used in this paper as a linguistic convenience rather than a statement that emotion and cognition are entirely separable.

2.2.2 Dyslexia, Socio-emotional Factors and Emotional Regulation Context

Adolescents who experience literacy difficulties can develop diverse socio-emotional profiles, resulting in differences in self-esteem, self-concept, resilience (Burden, 2008; Carawan et al., 2016; Haft et al., 2018; Harmon-Jones, 2012; Kalka & Lockiewicz, 2018; Long et al., 2007) and emotional regulation strategies (Boyes et al., 2020). There is an

association between a person's self-esteem and his/her ability to emotionally regulate, with those who are higher in self-esteem 'prolonging positive emotional responses' (Wood et al., 2003, as cited in Schmeichel et al., 2008, p. 1527). There is also a relationship between students' socio-emotional skills and reading abilities (Nachshon & Horowitz, 2019). The *My World Survey 2: National Study of Youth Mental Health in Ireland* indicated that the top three stressors in Irish adolescents' lives were reported to be school, exams and homework, and that protective factors such as resilience, self-esteem and optimism have decreased over the past number of years (Dooley et al., 2019). These socio-emotional factors may impact on the processing of affect-related information and experiences (Trilla et al., 2020). Overall, an individual's socio-emotional profile, including emotional regulation (ER) abilities and literacy experiences, are interconnected.

2.3 Policy and Context

There is an increased focus on youth mental health and well-being, both nationally and internationally (World Health Organisation, 2019). These developments for adolescents include the *National Well-being Policy Statement and Framework for Practice 2018-2023* (Government of Ireland, 2018) and the *Junior Cycle Wellbeing Programme* (NCCA, 2017), which aim to build resiliency and coping strategies to address distressing or unpleasant events. Irish policy and practice guidelines endeavour to meet the needs and rights of children with specific learning difficulties, including dyslexia (Government of Ireland, 2020; McPhillips et al., 2017). A specific learning difficulty is defined as a substantial area of need in an academic skill such as reading which is not pervasive across other aspects of learning (APA, n.d.a).The inclusive practices and best model of learning for students with dyslexia in Ireland (i.e., those used in reading schools and mainstream education) have frequently been discussed (Casserly, 2013; Casserly & Gildea, 2014; Nugent, 2008; O'Brien, 2019). Recent legislative movements have also renewed focus on best practice (Tiernan & Casserly, 2018),

including the introduction of the Task Force on Dyslexia (2001), the current New Model of Resourcing (DES, 2017), the National Literacy Strategy (DES, 2011; McPhillips et al., 2015), the Special Education Review Committee (SERC) (1993), *the Education Act* (1998) and the *Education of Persons with Special Educational Needs Act* (EPSEN) (2004). Individualised, inclusive and universally designed education is proposed through these policies and legislation by setting needs-based targets and devising student support plans (Learning Support Guidelines, 2000), involving students, parents and significant others in the process (Ball et al., 2011).

2.4 Dyslexia

2.4.1 Dyslexia Classification

Ball et al. (2011) report that, similar to international findings regarding comparably literate countries (countries with a similar percentage of literate people, with school enrolment and attendance data also considered; UNESCO, 2014), 7-10% of the Irish student population has dyslexia related difficulties. Dyslexia is now classified under the broader umbrella of a specific learning disorder (SLD), which includes disorders relating to reading, writing or mathematics, whereas it had previously been assigned its own specific diagnostic code (315.02) in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-V; APA, 2013; Lombardino & Gauger, 2014). O'Brien (2019) states that if 'difference' in learning is perceived as a disability for Irish students with dyslexia, inequality will continue. Therefore, this review will adopt the term 'specific learning difficulty' rather than 'disorder', but it will use the same acronym (i.e., SLD).

2.4.2 Dyslexia Definition

Dyslexia lacks a universally accepted definition, conceptualisation and operationalisation, and is often limited by 'binary adversarial positions' (Elliott, 2020, p. 561), meaning opposing perspectives on various aspects that 'define' dyslexia. It has been

defined by exclusionary factors (Vellutino, 1981), which refers to factors that must be absent, such as inadequate schooling and visual/hearing impairments, but it has also been defined from an inclusionary perspective (Elliott & Grigorenko, 2015). The Task Force for Dyslexia (2001, p. 68) included a list of possible indicators that adolescents with dyslexia may have, including those related to 'memorising, recalling names of words or objects, misuses or [mispronunciations of] words and self-confidence and image'. Elliott and Grigorenko (2015) list common inclusionary factors but acknowledge that not every factor must be included for a diagnosis:

> difficulties in phonological awareness, poor short-term (or, working) verbal memory, poor ordering and sequencing, weak spelling, clumsiness, a poor sense of rhythm, difficulty with rapid information processing, poor concentration, inconsistent hand preference, impaired verbal fluency, poor phonic skills, frequent letter reversals, poor capacity for mental calculation, difficulties with speech and language, low self-image, and anxiety when being asked to read aloud. (p. 13)

The Task Force for Dyslexia (2001) and the Rose Report in the UK (2009) highlighted a broader inclusive 'continuum' of need, emphasising the 'unexpectedness' of the difficulty. However, by moving to a broader inclusive model rather than the previous medical model, there are other gaps and contradictions regarding our understanding of it (McPhillips et al., 2015). Nonetheless, these gaps and contradictions, along with the lack of evidence, 'will not last forever' (Ramus, 2014, p. 3374, as cited in Elliott, 2020).

Some commentators consider the differentiation between a student with dyslexia and a 'struggling reader' to be arbitrary (Elliott & Gibbs, 2008). Elliott (2020) posits that using the term 'dyslexia' reflects vested interests favouring those who are socially privileged, with little empirical evidence for the ill-defined scientific construct that brings inequity and inequality to an inclusive learning environment. However, others advocate the use of the term

to influence government policy, legislation, lay perceptions, the provision of services and resourcing (Cameron & Billington, 2015; Cutting, 2014; Elliott & Gibbs, 2020; Ramus, 2014; Snowling, 2012).

Elliott (2020) advises that after that proliferation of research over the past 40 years, four common conceptions of individuals with dyslexia remain prevalent in the UK literature:

- those having word-level difficulty
- poor decoders (those who have difficulty applying knowledge of letter-sound relationships and patterns which result from phonological deficits)
- those unaffected by high-quality interventions
- those with a neurodiverse profile

In Ireland, the Dyslexia Association states that dyslexia is 'a specific learning difficulty affecting the acquisition of fluent and accurate reading and spelling skills, which occurs despite access to appropriate learning opportunities' (Dyslexia Association Ireland, 2020). This is in line with the International Dyslexia Association, which adds that it is neurobiological and unexpected compared to other cognitive abilities (IDA, 2018). A neurodiverse profile recognises and respects the neurological differences and diversity which exist within the continuum of 'dyslexia', and it respects the strengths and challenges involved. Cameron and Billington (2015) argue that students with dyslexia can grasp concepts, problem-solve, think critically and generate ideas similarly to typically developing students, but they may need more processing time. Some authors assert that dyslexia is not a clear-cut diagnostic category, but a 'holistic dimensional model of learning' (McPhillips et al., 2015, p. 32; Snowling & Melby Lervag, 2016). There are biological, cultural and environmental factors interacting at all ecological framework levels (Bell et al., 2011).

For this review, the author will adopt a synthesised definition of dyslexia as a *neurodiverse and multidimensional model of learning which impacts on the acquisition of*

fluent reading and spelling skills (e.g., word-level and decoding skills) to varying degrees on a continuum of need, and which is unexpected in the context of other cognitive abilities and/or strengths and learning opportunities. This continuum of strengths and need also includes variance in socio-emotional factors, including but not limited to anxiety, resilience, and self-esteem.

2.4.3 Assessing Dyslexia

The National Educational Psychological Service (NEPS) in Ireland endorses a three-staged approach to assessment, identification and programme planning for students with dyslexia to encapsulate the complexity of this learning difficulty (Tiernan & Casserly, 2018). The literature advocates a response-to-intervention approach (Fuchs & Fuchs, 2006) within a multi-tier system of supports and the patterning of strengths and weaknesses within the individual's profile (Fletcher & Miciak, 2017). However, the traditional discrepancy model of assessment remains prominent in Irish psychological services (Elliott, 2020; Nugent, 2008). The validity of the criteria within the ability achievement discrepancy model of assessment is queried (Maehler & Schuchardt, 2011). However, it is deemed unlikely that a false negative will be reported (Nugent, 2008). Best-practice psychological assessments of students with dyslexia assess academic needs using a person-centred approach to evaluate their unique strengths and needs, including their emotional and mental well-being profile (Long & McPolin, 2009).

The discrepancy model includes working memory tests, and adolescents' affective qualities are profiled separately when included. Schweizer et al. (2019) state that much of the stimuli used in traditional working memory tests, such as letters, numbers, or shapes, are affectively neutral, and interference is described as neutral and irrelevant information. It is questioned whether digit span tasks that measure working memory in cognitive assessments give an accurate measure of working memory (Rosen & Engle, 1997) or whether they can be

generalised to reading tasks (Elliot & Grigorenko, 2015; Swanson et al., 2009). One of the factors that may result in limited generalisability is the lack of accountability concerning affective content. Everyday affective information outside the laboratory setting can be influenced by the information's salience and the person's current goal states (Schweizer et al., 2019). The valanced world hypothesis acknowledges that what we perceive daily is never emotionally neutral but is primarily loaded or interpreted positively or negatively (Baddeley, 2007). Working memory and the role of affective content in WM may need more advanced assessment and intervention than viewing them as separate and non-interacting entities (Gray et al., 2019).

2.5 Working Memory

2.5.1 Working Memory Definition and Model

Working memory refers to the system(s) required to keep information in mind while completing other complex tasks, e.g., comprehension and reasoning (Baddeley, 2010). WM is similar to short-term memory (STM), as both store information, but it is distinguishable by the involvement of additional information processing during the storage of information. Therefore, WM assessments usually involve complex memory tasks such as counting or listening spans (Gathercole et al., 2006). The type of WM assessments used can focus on certain domains of WM or try to capture the general capacity of WM. This depends on the theoretical conceptualisation of WM. The most recent Baddeley and Hitch Working Memory Model (2000) theorises that WM comprises domain-specific systems, each processing different types of information. These domain-specific systems include the phonological loop, the visuospatial sketchpad, the central executive (which regulates and controls the processes) and the episodic buffer, which binds information across memory subsystems (Baddeley & Hitch, 2000).

2.5.2 Working memory and attention

Attentional deficits are associated with dyslexia (Facoetti et al., 2000; Vidyasagar & Pammer, 2010), and dyslexia and attention deficit hyperactive disorder (ADHD) can be comorbid (Gilger et al., 1992). Approximately 5% of children in the United States have both diagnoses, and some studies indicate that 25-40% who have one diagnosis meet the other criteria (McGrath et al., 2011). Working memory and attention are also closely related, with attention purported to be used in three separate ways with working memory; primarily as a resource for processing information, but also for memory maintenance and perceptual attention, and as attentional control (Oberauer, 2019).

2.5.3 Working Memory and Dyslexia

Working memory is the cognitive construct used to describe the process of sorting, storing and processing various types of content, including verbal and visual information, objects representations, semantic information and emotion (Mikels et al., 2005). Working memory is pivotal for reading and learning, as it connects the spoken and written word through phonological and visual-spatial processing of linguistic information (Elliott & Grigorenko, 2015) and is associated with the capacity for thinking and language processing (Baddeley, 2003).

Various tasks associated with working memory can present difficulty for students with dyslexia, including phonological working memory tasks (Giofre et al., 2017; Kibby, 2009), sequential order when recalling items (Hachmann et al., 2014), ‘noisy encoding’ (Palmer, 2000) and semantic tasks (Giofre et al., 2017; Kibby, 2009; Swanson, 2003). The central executive impacts WM processing for students with dyslexia when accessing speech-based information, during attentional process monitoring (Swanson et al., 2009) and inhibitory control (Swanson, 2003). Working memory differences between adolescents with and without dyslexia also influence the ability to integrate multiple-source information,

namely written text, pictures and video (Andresen et al., 2018). However, not all areas of cognitive functioning are impaired. Students with dyslexia can perform well in some academic and cognitive domains if the working memory demand is low, by utilising compensatory knowledge, environmental supports or different cognitive routes (Swanson et al., 2009).

2.5.4 Working Memory and Emotional Regulation

It is suggested that there is some overlap between emotional regulation, how we process emotions (see section 2.8 for a full definition) and affect related working memory (Schweizer et al., 2013). Working memory training, while previously focused on enhancing cognition, has recently shown an influence on emotional-regulation outcomes, highlighting a neural and cognitive overlap between cognitive and affective pathways (Barkus, 2020; Xiu et al., 2018).

2.6 Affect-related working memory

2.6.1 Emotion and Affect

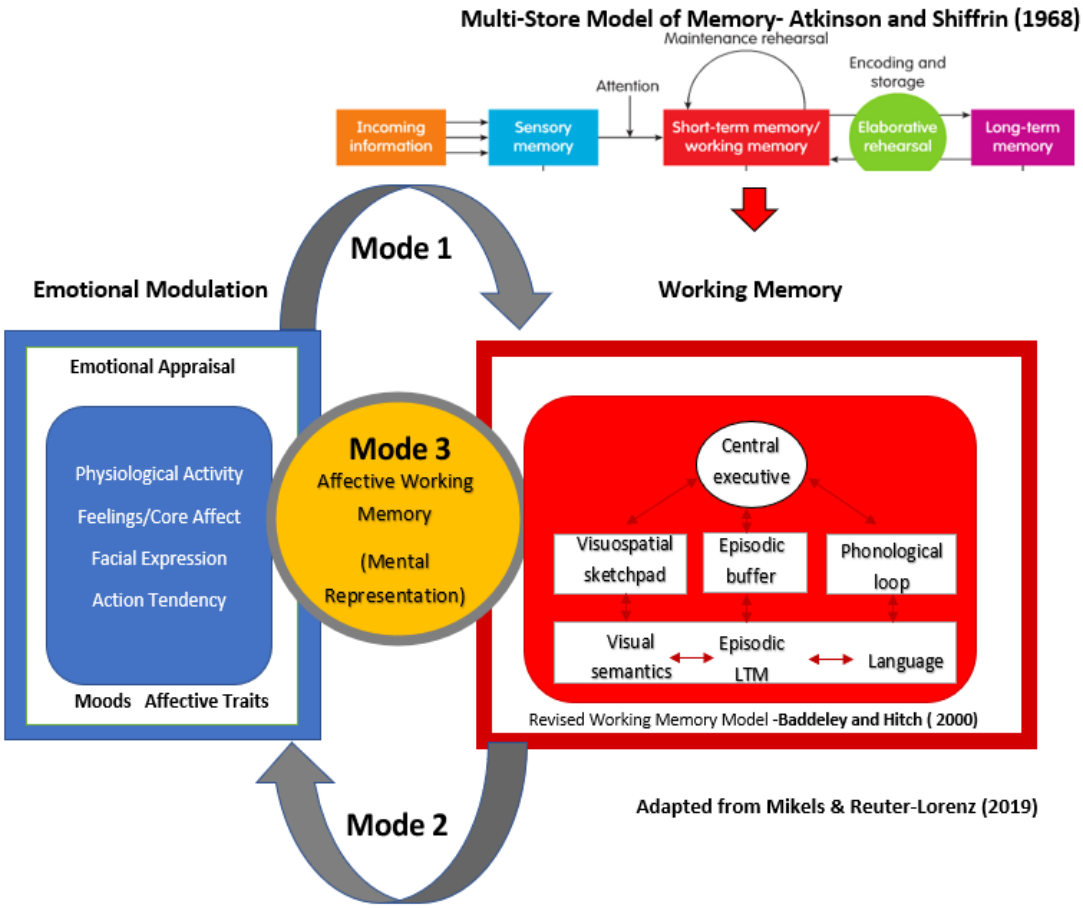
The American Psychological Association defines emotion as ‘a complex reaction pattern, involving experiential, behavioural and physiological elements’ (APA, n.d.b). The construct of ‘emotion’ used in this review primarily describes the first key element of this definition of emotion, namely the subjective feelings associated with stimuli or events rather than behaviours and physiological arousal. Affect is described as the experience of emotions or feelings which can be positive or negative, simple or complex, and it forms the traditional components of the mind together with cognition and conation (APA, n.d.a).

2.6.2 Affect-related Working Memory Model (Mikels & Reuter-Lorenz, 2019)

Mikels and Reuter-Lorenz (2019) posit that there are three modes in which affect and working memory interact. These are illustrated in Figure 3 and are detailed below.

Figure 3

The Hypothesised Interaction between the Working Memory and Emotional Modulation



Note: Mode 1 represents affect influencing working memory. Mode 2 represents working memory influencing affect. Mode 3 represents the affective mental representations mantained and processed within working memory.

Mode 1: Affective states (trait or acute) influence working memory processing (Baddeley, 2013; Moran; 2016; Schweizer et al., 2019). When applied to the context of specific learning difficulties (SLD), adolescents with SLD such as dyslexia showed more avoidance than vigilance with regard to reading stimuli, as demonstrated by a dot probe paradigm which assessed selective biases toward various threats (Haft et al., 2016). These

students with dyslexia used top-down processing and biases in information processing systems, particularly towards reading stimuli (Haft et al., 2016). This behaviour may suggest that affective qualities are hindering progress in academic attainment for students with dyslexia (Haft et al., 2016) and exacerbating executive functioning difficulties (Livingston, et al., 2018). Induced negative emotion has also been shown to impact on cognitive abilities such as phonological working memory performance (Fartoukh et al., 2014). However, positive emotion can also influence learning. Studies of Irish reading schools for children with dyslexia show the benefits of raised self-esteem on educational outcomes and describe the learning process as occurring in emotional channels, beginning with emotions and moving towards cognition (Casserly, 2013).

Mode 2: Working memory capacity can influence emotions experienced (Mikels & Reuter-Lorenz, 2019). Using functional neuroimaging, Zaehringer et al. (2018) reported that lower working memory capacity demanded increased cognitive resources to down-regulate emotional experiences. Furthermore, working memory has previously shown a negative correlation with emotional experiences, such as test anxiety experienced by students with dyslexia (Nelson et al., 2015).

Mode 3: Affective working memory: Feelings and emotions can be stored and maintained in working memory as mental representations, which are proposed to be differentiated from visuospatial or phonological representations (Mikels & Reuter-Lorenz, 2019, p. 543). Mirabolfathi et al. (2020) examined working memory function in Afghan adolescents who had experienced conflict-related trauma using a visual working memory task and found that affective distractors impaired performance most for adolescents who exhibited emotional disturbance symptoms. Processing affect-related stimuli shows greater use of the prefrontal cortex, amygdala and temporo-occipital cortex. (Schweizer et al., 2019)

The suppression of irrelevant information (inhibition) and the revising of current stimuli (updating) are pertinent to all types of memorising. Updating is a core feature of forgetting adverse emotional events, with some evidence suggesting that dysfunction in this process is associated with post-traumatic stress disorder symptoms (Nejati et al., 2018). Conversely, positive affect-related working memory is suggested to support decision-making, goal-directed behaviour and motivation by representing an emotion without ongoing immediate elicitors (Broome et al., 2012; Mikels & Reuter-Lorenz, 2019; Schweizer et al., 2019).

2.7 Early Adolescence

Early adolescence is a pivotal developmental stage between the ages of 12 and 14, when much physiological, psycho-social and cognitive change occurs (Malagoli & Carmen Usai, 2018; Oberst et al., 2017). Neuroimaging shows that the adolescent brain undergoes changes to the grey matter volume, sulcal depth and cortical thickness (Paulus et al., 2019). Early adolescence marks the beginning of Piaget's formal operational cognitive development stage, which relates to a change from concrete to more abstract ways of thinking, including the development of metacognition (Meschke et al., 2011; Piaget, 2003). Developments in the structure of brain regions and interconnections associated with emotion processing which occur during adolescence result in increased mood volatility, emotional arousal and impulsivity, along with a particular increase in reward-seeking and negative emotions (Malagoli & Carmen Usai, 2018; Meschke et al., 2011). There are also developments in executive functions such as planning, decision-making and flexible adaptation to various contexts (Malagoli & Carmen Usai, 2018). Furthermore, short-term memory and working memory skills begin as undifferentiated processes; however, they diverge toward the end of primary school (Savage et al., 2006). Individual differences in the brain's structural networks

during adolescence impact on adolescents' cognitive, behavioural and psychopathological processes (Juszczak, 1999; Paulus et al., 2019).

2.8 Emotional Regulation

Emotional regulation (ER) is defined as a process that can 'reduce, strengthen, or maintain the experience of either positive or negative emotions depending on the current needs or goals of an individual' (Gross, 2014, as cited in Kobylińska & Kusev, 2019, p. 2). These coping strategies are dependent on situational and dispositional characteristics (Kobylińska & Kusev, 2019). ER strategies can be adaptive, such as cognitive reappraisal, or maladaptive, such as situational avoidance or catastrophising (Leahy et al., 2011). In a study conducted by Jiboc (2019), children with an SLD reported positive ER strategies, including positive reassessment and refocusing, and acceptance combined with perspective-taking, but also some maladaptive mechanisms, such as rumination, catastrophising and self-blame. ER skills are integral to psychological well-being, adaptive functioning and the avoidance of psychopathologies (Fernandez et al., 2016; Gross et al., 2019).

Adolescence is a time when regulatory neural circuitry is developed; i.e., internal resources begin to manage ER strategies rather than being managed by the external sources common in childhood, such as parents (Young et al., 2019). The *National Well-being Policy Statement and Framework for Practice* (2018-2023) acknowledges that well-being does not involve the experiencing of no negative affect or stress, but rather involves showing resilience and regulation strategies when faced with challenging situations. A large Irish mental health study, *My World Survey 2* (2019), reported that 79% of adolescents have experienced at least one stressful life experience. However, it also stated a decrease in levels of resilience since the first survey involving adolescents, reporting that they coped well with problems, with lower levels of resilience reported on all subscales of resilience, decreasing from 49% to 42% (Dooley et al., 2019).

Svetaz et al.'s (2000) expansive longitudinal study of adolescents with learning disabilities found that those with learning difficulties experienced twice as much emotional distress as their peers. Adolescents with learning difficulties are thought to use passive non-productive coping strategies, such as ignoring problems with academic work (Firth et al., 2010) or experiencing higher rumination levels after a negative social encounter (Bonifacci et al., 2020). A study of online writing experiences noted that adolescents with dyslexia reported encounters of greater emotional intensity, receiving more negative feedback, and expressing stronger reactions compared to their peers (Reynolds & Wu, 2018). However, adolescents with dyslexia who have an understanding of their literacy difficulties and who employ effective regulatory and coping strategies (either implicitly or explicitly) tend to show greater resilience and positive emotional outcomes (Haft et al., 2016; Humphrey & Mullins, 2002; Livingston et al., 2018; Riddick, 2003; Riddick, 2010).

The neurodiverse movement focuses on building the capacity of students with dyslexia by focusing on strengths, such as ER strategies that are effective, and moving away from the traditional deficit and remedial focus (Rappolt-Sclichtmann et al., 2018). Coping strategies used can increase psychosocial adjustment and reduce the impact and stigma experienced when faced with challenges in learning (McNulty, 2016; Terras et al., 2009). Some productive strategies used by adolescents with dyslexia include focusing on the positives (Firth et al., 2010). However, Firth et al. (2010) caution that these positive strategies can lead to less energy being focused on academic work and focused more on areas where there are more favourable outcomes, such as sports.

2.9 Rationale for Literature Review

2.9.1 Gaining Further Insight into the Cognitive Underpinnings of Dyslexia

Stothard et al. (2018) and Elliott and Grigorenko (2015) suggest that the work of educational psychologists could benefit from greater appreciation of the complex

underpinnings of dyslexia. Many theories suggest various cognitive factors associated with dyslexia-related differences, such as difficulties with phonological awareness, rapid naming during information processing, working memory and the magnocellular deficiency (Fostik & Revah, 2018). A review of the multifaceted cognitive nature of dyslexia could support current understandings of the cognitive underpinnings of adolescents with dyslexia.

2.9.2 Supporting Educators' Conceptualisation of Dyslexia

Tiernan and Casserly (2017) contend that enhanced teacher expertise is required to fully implement the new resource model of allocation, as this model gives autonomy to schools in implementing and managing teaching support (DES, 2017) for students with dyslexia. Beck et al. (2017) highlighted the specific need for further post-primary provision and postgraduate training for post-primary teachers. Irish and UK teachers were surveyed to explore their conceptualisations of dyslexia, and their focus was primarily on behavioural aspects rather than biological, environmental or cognitive factors (Bell et al., 2011). A greater understanding of the cognitive factors associated with dyslexia has been shown to increase teachers' reported competence concerning teaching students with dyslexia (Knight, 2018). Interventions that focus on improving cognitive processing (i.e., those that prioritise phonological processing skills) are reported to be the most effective interventions for students with dyslexia (Knight, 2018; Rose, 2009; Snowling & Hulme, 2011). Therefore, reviewing affect-related working memory (AWM) literature could be useful in the consideration of how AWM could possibly be applicable to this clinical population (e.g., as a capacity-building intervention (Broome et al., 2012). Functional magnetic resonance imaging (FMRI) studies show different areas in the brain which are particularly observable when processing affective content in comparison to more neutral content (Schweizer et al., 2019). This may be useful if, for example, a deficit is evident in dorsolateral prefrontal executive functions, as it will not

impact on tasks if they can rely more on the orbitofrontal social and emotional processes (Schweizer et al., 2019).

2.9.3 Affect-related Working Memory Processing

To date, dyslexia research has not addressed the potential interaction of affective content and cognitive processing; for instance, by distinguishing between affect-related and non-affect-related stimuli (Gray et al., 2019; Maehler & Schechardt, 2016). Adolescents with a specific learning difficulty may be positively or negatively impacted by affective information and affective learning contexts. The way students manage and maintain emotions may lead them to compromise or compensate within learning experiences (Lee & Xue, 2018; Nachshon & Horowitz, 2019). Learning may be compensated by the emotional enhancement of memory theory, which posits that affect information is more easily remembered than neutral information (Hamann, 2001). However, learning for students with dyslexia may be compromised if they have ER difficulties. Difficulties in ER has been linked with an increased risk of internalising, externalising and peer relationship difficulties (Boyes et al., 2020). For the current study, the author conducted systematic review of affect-related working memory processing and emotional regulation in adolescents with dyslexia was carried out to facilitate an evidence-informed synthesis of the knowledge base connecting these domains. The following review questions informed the process and structure of this review.

2.10 Review Questions

1. How do affect and working memory interact in adolescents?
2. How do emotional regulation processes change working memory for adolescents?
3. How do affect and emotion impact literacy learning and development for adolescents?

2.11 Section 2: Narrative Review with Thematic Synthesis

In order to address these review questions, and to structure the review, the author used an amalgamation of methodological frameworks for narrative and thematic reviews (Enferm, 2007; Nicholson et al., 2016; Thomas & Harden, 2008). This review was divided into five phases, similar to that of Nicholson et al. (2016). These five phases were as follows:

1. Locating the key themes through scoping searches and then locating relevant studies through search strategies
2. Sampling – deciding the eligibility of studies based on quality appraisal techniques and inclusion and exclusion criteria
3. Critically evaluating the studies based on content related to each specific theme and categorically weighting them as sources of high or low relevance to the specific themes
4. Extracting data and converting it to tabular form
5. Description and synthesis of the findings

2.12 Phase 1 Overview: Locating the Studies

2.12.1 Preliminary Scoping Searches

Initial scoping searches were conducted in relation to dyslexia, working memory and emotion, considering their significance for learning and the well-being of adolescents with dyslexia. Scoping searches are vital for identifying and 'mapping' relevant literature in a chosen field (Arksey & O'Malley, 2005, p. 20). The initial searches alerted the author to the concepts of working memory and affect/emotion as prominent themes within the dyslexia literature, with little interaction evident between these key concepts. One article resulted from a scoping search of working memory, emotion and dyslexia, which did not report on this interaction or on the adolescent age group. In answering the research questions above, four relevant themes emerged: the working memory of adolescents with dyslexia; affect-related

working memory; ER processes and working memory; and the influence of affect or emotion influence on literacy learning. A literature search was conducted between June and August 2020, and it was continually refined and updated for each theme, using the electronic databases and search terms detailed in Table 1.

Table 1

Search Terms Used in Databases for the Four Themes

	Databases	**Search Terms**	**Participants**
Theme 1: The working memory of adolescents with dyslexia	Academic Search Complete, British Education Index, Education Full Text (H.W. Wilson), Education Source, ERIC, General Science Full Text (H.W. Wilson), MEDLINE, OmniFile Full Text Mega (H.W. Wilson), APA PsycArticles, APA PsycInfo, UK & Ireland Reference Centre, Readers' Guide Full Text Mega (H.W. Wilson)	SU (dyslexi* or reading difficulty or reading disorder or specific learning di* or sld) AND TI working memory	TX (adoles* or teenagers or young adults or teen or youth)
Theme 2: Affect-related working memory	Academic Search Complete, British Education Index, Education Source, ERIC, MEDLINE, APA PsycArticles, APA PsycInfo, UK & Ireland Reference Centre	TX (Working Memory AND Affect* OR Emotion OR mood OR Feeling*)	Neither age nor clinical population specified
Theme 3: Emotional regulation and working memory	APA PsycInfo, Academic Search Complete, British Education Index, Education Full Text (H.W. Wilson), Education Source, ERIC, General Science Full Text (H.W. Wilson), OmniFile Full Text Mega (H.W. Wilson), APA PsycArticles, UK & Ireland Reference Centre	TX (Emotional Regulation AND Dyslex* OR Working Memory)	Students with dyslexia, where possible, or all human populations
Theme 4: Affect and literacy learning	Academic Search Complete, Education Source, British Education Index, ERIC, APA PsycArticles, APA PsycInfo, UK & Ireland Reference Centre	TI (Literacy OR Word Reading) AND AB (Emotion* or affect*) AND SU (dyslex* or specific learning di* or sld OR reading di*)	All human populations

2.12.2 Phase 1: Locating the Studies

The initial searches resulted in access to a large number (Theme 1: 341, Theme 2: 865, Theme 3: 383, Theme 4: 894) of peer-reviewed and English-language articles within the last 20 years. Duplicate articles were removed, which reduced the number of articles (Theme 1: 157 articles, Theme 2: 412, Theme 3: 255, Theme 4: 550). Geographical and age considerations were taken into account when scanning the titles, as OECD countries may have a similar ethnographic population and similar orthographic languages. However, the filter was not placed on the articles, as it reduced the number of articles too significantly. The title and abstract were then screened, and 59 (Theme 1: 20, Theme 2: 10, Theme 3: 15, Theme 4: 14) chosen studies were read in full, after which 38 (Theme 1: 14, Theme 2: 5, Theme 3: 10, Theme 4:9) were excluded, reducing the relevant number of texts to six for Theme 1, five for Theme 2, five for Theme 3 and four for Theme 4. (See Appendix A for each theme's PRISMA flow diagram. These diagrams represent the process undertaken to locate studies.)

2.13 Phase 2: Sampling Studies and Deciding the Eligibility of Studies Based on Quality Appraisal Techniques and the Inclusion and Exclusion Criteria

2.13.1 Sampling

Phase two involved deciding on the eligibility of studies. Studies were evaluated based on inclusionary and exclusionary factors and their quality-indicating factors. Most studies included had adolescent participants, and a preference was given to studies pertaining to dyslexia. The studies included were empirical studies from an OECD country, were peer-reviewed and had been published in the last 10 years. The outcome measures of studies included working memory, socio-emotional factors or literacy factors. Studies were excluded if they included an adult or young child population (Basso et al., 2019; Evrard et al., 2011; Fischbach et al., 2014; Hendrichs & Buchranan, 2016; Maehler & Schuchardt, 2016; Wang & Gathercole, 2013). They were also excluded if the design was a review or purely qualitative

(Lee & Xue, 2018; Liu et al., 2020; Mikels & Reuter-Lorenz, 2019; Ribeiro et al., 2019; Savage et al., 2007; Schmeichel & Tang, 2015; Schweizer et al., 2019; Swanson et al., 2006) or were not from an OECD country (Swanson & Sache-Lee, 2001; Swanson et al., 2006). Studies were also excluded if they did not specifically measure AWM, WM, or ER (Artuso et al., 2020; Benevent et al., 2010; Dawes et al., 2015; Donolato et al., 2019; Fostick & Revah, 2018; Hitchcock & Westwell, 2017; Maehler & Schuchardt, 2011; Malstadt et al., 2012; Michaud Dumont et al., 2019; Moll et al., 2016; Music, 2014; Liu et al., 2020; Schuchardt et al., 2013; Wanteet et al., 2018). Please see Appendix B for a comprehensive table of inclusionary and exclusionary factors used. The quality-indicating factors, including validity, were decided using the Horner et al. (2005) Quality-indicating Framework (see Appendices C.1, C.2, C.3 and C.4 for a sample of this coding protocol for each theme). This quality-indicating framework and the inclusionary factors used were based on the conceptual model for this thesis, namely the framework concerning the interaction of affect and working memory proposed by Mikels and Reuter-Lorenz (2019). This interactive framework for WM and emotion shed light on how the core constructs may be envisaged to work on their own and synchronously.

2.14 Phase 3: Critically Evaluating the Studies

Studies chosen for the review were evaluated based on how relevant the content was to each specific theme, and they were categorically weighted as sources of high or low relevance to the specific research question. Appendix D presents details of how studies were rated for high or low relevance to the themes. The studies that were deemed eligible, along with their weightings, are included in a table at the start of each theme. The studies that were not included, and the rationales for exclusion, are detailed in Appendix E.

Table 2

Studies Deemed Eligible for Theme 1, and Their Weightings

Study Reference	Eligible Studies for Theme 1: The working memory of adolescents with dyslexia	Weighting
1	Gathercole, S. E., Alloway, T. P., Willis, C., & Adams, A. (2006). Working memory in children with reading disabilities. *Journal of Experimental Child Psychology*, *93*(3), 265-281. http://doi:10.1016/j.jecp.2005.08.003	Low
2	Gray, S., Fox, A. B., Green, S., Alt, M., Hogan, T. P., Petscher, Y., & Cowan, N. (2019). Working memory profiles of children with dyslexia, developmental language disorder, or both. *Journal of Speech, Language, and Hearing Research*, *62*(6), 1839-1858. http://doi:10.1044/2019_jslhr-l-18-0148	Low
3	Jeffries, S., & Everatt, J. (2004). Working memory: Its role in dyslexia and other specific learning difficulties. Dyslexia: *An International Journal of Research and Practice*, *10*(3), 196-214. http://doi-org.libraryproxy.mic.ul.ie/10.1002/dys.278	High
4	Kibby, M. Y., Marks, W., Morgan, S., & Long, C. J. (2004). Specific Impairment in Developmental Reading Disabilities: A Working Memory Approach. *Journal of Learning Disabilities*, *37*(4), 349-363. https://doi-org.libraryproxy.mic.ul.ie/10.1177/00222194040370040601	High
5	Menghini, D., Finzi, A., Carlesimo, G. A., & Vicari, S. (2011). Working memory impairment in children with developmental dyslexia: Is it just a phonological deficit? *Developmental Neuropsychology*, *36*(2), 199-213. http://doi:10.1080/87565641.2010.549868	High
6	Smith-Spark, J., & Fisk, J. (2007). Working memory functioning in developmental dyslexia. *Memory*, *15*(1), 34-56. https://doiorg.libraryproxy.mic.ul.ie/10.1080/09658210601043384	Low

2.15 Phase 4: Extracting the Data and Presenting it in Tabular Form

Table 3

Theme 1: The working memory of adolescents with dyslexia

Study Reference	Variables	Measures	Sample Population	Findings
Gathercole et al. (2006)	Working memory (complex memory tasks) reading, math abilities, fluid intelligence, verbal abilities, STM, phonological awareness	Wechsler Objective Reading Dimension (WORD), Wechsler Objective Numerical Dimensions (WOND), Wechsler Objective Language Dimensions (WOLD), Working Memory Test Battery for Children (WMTB-C) (Pickering & Gathercole, 2001), backward digit recall, counting recall, and listening recall, three measures of phonological STM from the WMTB-C, two measures of the visuospatial component: block recall, visual patterns test, Phonological Assessment Battery (Frederickson et al., 1997),	46 children (13 girls and 33 boys) with reading difficulties, 6-11 years Mean age: 9, UK study	Reading difficulty related to complex memory tasks, language and phonological awareness. IQ, language and phonological awareness was low for participants*.
Gray et al. (2019)	Working memory: central executive, phonological, visual-spatial and	13 working memory tasks from the Comprehensive Assessment Battery for Children-Working Memory (CABC-WM), CE tasks, N-back auditory and visual, number updating, short-term phonological memory tasks: short-term phonological memory tasks, digit span,	4 groups: Dyslexia, Developmental Language Disorder, Dyslexia, and Developmental	Working memory profile not synonymous with disability. Central executive ability dependent on WM capacity. WM updating predicted reading ability. Children with co-

	binding working memory tasks	non-word repetition, short-term visuospatial: location span, visual span, binding tasks: phonological binding tasks, visuospatial binding span, cross-modal binding	Language Disorder. Control group, 302 students in total, 2nd graders 7-9	morbidities more likely to have WM deficits.
Jeffries and Everatt (2004)	Phonological processing, visuo-spatial/motor co-ordination, executive/ inhibitory functioning	6 tasks from the Working Memory Test Battery for Children (WMTB-C) (Pickering & Gathercole, 2001) and Dyslexia Screening Test (Fawcett & Nicolson, 1996) and Bangor Dyslexia test (Miles, 1993), and Phonological Ability Battery (Frederickson et al., 1997).	Primary and post-primary students Mean age: 10.75, UK population, 3 groups: Students with dyslexia (21), students with dyslexia and other co-morbidities (26), control group (40)	Both groups with students who had dyslexia demonstrated impaired phonological loop measures. Dyslexia group was comparable to the control on visuo-spatial sketchpad measures and some visual-motor coordination tasks. Central executive and interference measures caused varied results. The dyslexia group showed particular difficulty with digit name processing.
Kibby et al. (2004)	Phonological loop, visual spatial sketch pad and central executive	Verbal WM: Memorising a list of words presented visually, and recalling in order	**3 groups:** 23 children with RD, 30 with ADHD, 30 with RD/ADHD, and 30 controls. UK study. Mean age: 9-13. Mean age: 11.	Differences evident in phonological loop (phonological store in particular), but not visual sketchpad or central executive functioning.

Menghini et al. (2011)	Working memory: Verbal span, visuospatial span, visual object span	Vicari's (2007) battery of tasks, including verbal, visual, spatial and visual object span tasks	Age range: 8-13. Italian students in primary and middle school	Dyslexia group demonstrated impairments in verbal, visuospatial and visual-object working memory.
Smith-Spark and Fisk (2007)	Verbal and visuospatial working memory	Simple verbal span: digit, letter and word span, Corsi block span, and three complex span measures (computation span, reading span and spatial working memory span) and two updating measures (consonant updating and spatial updating)	University students; mean age: 20.59, UK population, 2 groups: Students with dyslexia (22) and control (22)	Effects of dyslexia were still evident in adulthood. Difficulties with phonological, working memory WM and central executive. Novel spatial updating task proved more difficult for the dyslexia group initially.

Table 4

Studies Deemed Eligible for Theme 2, and Their Weightings

Study Reference	Eligible studies for Theme 2: Affect-related working memory	Weighting
1	Frank, C. C., Iordan, A. D., Ballouz, T. L., Mikels, J. A., & Reuter-Lorenz, P. A. (2020). Affective forecasting: A selective relationship with working memory for emotion. *Journal of Experimental Psychology*. *150*(1), 67-82. https://doi-org.libraryproxy.mic.ul.ie/10.1037/xge0000780	High
2	Gard, D. E., Cooper, S., Fisher, M., Genevsky, A., Mikels, J. A., & Vinogradov, S. (2011). Evidence for an emotion maintenance deficit in schizophrenia. *Psychiatry Research, 187*(1), 24-29. http://doi:10.1016/j.psychres.2010.12.018	Low
3	Mammarella, N., Fairfield, B., De Leonardis, V., Carretti, B., Borella, E., Frisullo, E., & Di Domenico, A. (2012). Is there an affective working memory deficit in patients with chronic schizophrenia? *Schizophrenia Research, 138*(1), 99-101. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.schres.2012.03.028	Low
4	Mikels, J. A., Larkin, G. R., Reuter-Lorenz, P. A., & Carstensen, L. L. (2005). Divergent trajectories in the aging mind: Changes in working memory for affective versus visual information with age. *Psychology and Aging, 20*(4), 542-553. https://doi-org.libraryproxy.mic.ul.ie/10.1037/0882-7974.20.4.542	High
5	Mikels, J. A., Reuter-Lorenz, P. A., Beyer, J. A., & Fredrickson, B. L. (2008). Emotion and working memory: Evidence for domain-specific processes for affective maintenance. *Emotion, 8*(2), 256-266. https://doi-org.libraryproxy.mic.ul.ie/10.1037/1528-3542.8.2.256	High
6	Mirabolfathi, V., Schweizer, S., Moradi, A., & Jobson, L. (2020). Affective working memory capacity in refugee adolescents. *Psychological Trauma*, Advance publication. http://doi:10.1037/tra0000552	Low

Table 5

Theme 2: Affect and working memory

Study Reference	Variables	Measures	Sample Population	Findings
Frank et al. (2020)	Affective working memory and affective forecasting, visual working memory, emotional regulation	Affect maintenance task, brightness maintenance task, affective forecasting task, Visual Imagery Questionnaire (VVIQ; Marks, 1973), Situational Test of Emotional Understanding, Positive and Negative Affect Scale (PANAS; Watson, et al., 1988), Emotion Regulation Questionnaire (ERQ)	66-85 undergraduate students per experiment. M:18.83 Michigan, America.	Affective working memory is suggested to be a separate subsystem of WM. Relationship between affective working memory and higher-order emotional processing and affective forecasting.
Gard et al. (2011)	Affective working memory of people with schizophrenia, motivation	Affect maintenance, emotion, in-the-moment emotion rating experience of pictures, brightness maintenance task, rating task, visual working memory task, Positive and Negative Syndrome Scale (PANSS), and Quality of Life Scale (QLS) motivation item	28 people with schizophrenia, 19 people without schizophrenia. Mean age: 44. America.	Normal in-the-moment emotional experience; however, emotion maintenance demonstrated a decrease in performance. Emotion maintenance deficit not evident for brightness performance. Negative emotion maintenance associated with motivation.

Mammarella et al. (2012)	Working memory for affective and neutral words	Operation working memory span test with affective and neutral words	22 adults with schizophrenia, and 22 adults without schizophrenia	People with schizophrenia had more intrusion errors, recalled off-goal information and had poorer long-term WM. Attention control deficit for affective content impact recalling ability.
Mikels et al. (2005)	Affective working memory of young adults and older adults	Affect maintenance and brightness maintenance tasks	20 adults aged between 64-80, and 20 adults aged between 18-28. America	Working memory for affective content was superior to visual information. Older participants displayed better recall for positive rather than negative emotion trials.
Mikels et al. (2008)	Affective working memory	Affect maintenance task, brightness maintenance task, with cognitive and affective interference tasks, counting task and visual search task	64 participants. Mean age: 19.47. America	Suggests AWM to be a domain-specific subsystem of WM for affective memoranda. Valence of maintained emotion-effected performance. Emotion regulation altered emotion intensity experienced but supported brightness maintenance. Cognitive tasks facilitated emotion maintenance.

Mirabolfathi et al. (2020)	Anxiety, depression, working memory with affective and neutral distractors	Children's Depression Scale (CDS) (Lang & Tisher, 2004), Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988), visual working memory capacity paradigm with affective and neutral distractors	47 adolescents attending a vocational training centre near Tehran, aged 13-19 years; M = 5.49	Affective contexts changed cognitive functioning. WM capacity lower when affective distractors rather than neutral distractors were used for adolescents who had experienced high PTSD.

Table 6

Studies Deemed Eligible for Theme 3, and Their Weightings

Study Reference	Eligible Studies for Theme 3: Emotional regulation and working memory	Weighting
1	Garrison, K. E., & Schmeichel, B. J. (2020). Getting over it: Working memory capacity and affective responses to stressful events in daily life. *Emotion*. Advance online publication. https://doi.org/10.1037/emo0000755	High
2	Malagoli, C., & Usai, M. C. (2018). WM in adolescence: What is the relationship with emotional regulation and behavioral outcomes? *Frontiers in Psychology*, *9:* 844. http://doi:10.3389/fpsyg.2018.00844	High
3	Pe, M. L., Raes, F., & Kuppens, P. (2013). The cognitive building blocks of emotion regulation: Ability to update working memory moderates the efficacy of rumination and reappraisal on emotion. *PLoS ONE*, *8*(7). https://doi-org.libraryproxy.mic.ul.ie/10.1371/journal.pone.0069071	High
4	Schmeichel, B. J., & Demaree, H. A. (2010). Working memory capacity and spontaneous emotion regulation: High capacity predicts self-enhancement in response to negative feedback. *Emotion*, *10*(5), 739-744. http://doi:10.1037/a0019355	Low
5	Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology*, *95*(6), 1526–1540. https://doiorg.libraryproxy.mic.ul.ie/10.1037/a0013345	High

Table 7

Theme 3: Emotional regulation and working memory

Study Reference	Variables	Measures	Sample Population	Findings
Garrrison and Schmeichel (2020)	Working memory capacity (WMC) for emotional and neutral words, affect, momentary affect, the occurrence of stressful events, and responses to those events, personality characteristics	2 WMC tasks-Operation span task (OSPAN) (Turner & Engle, 1989) using emotional words and emotionally neutral words. Experience sampling 5x per day for 6 days measuring affect and stressful events experienced. Personality questionnaires to assess individual differences in behavioural inhibition and behavioural activation system (BIS/BAS) sensitivity (Carver & White, 1994), approach and avoidance temperament (AATQ) (Elliot & Thrash, 2010), trait positive and negative affect (Watson & Clark, 1999), trait self-control (Tangney, Baumeister, & Boone, 2004) and trait anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983).	92 participants (age M = 18.68, SD = 1.16; 73.9% female). America	Stressful events related to higher momentary negative affect, but less so among participants higher in WMC. WMC plays a role in emotion regulation.

Malagoli and Carmen Usai (2018)	Working memory and emotional regulation	Symmetry span task (Kane et al., 2004). Reading span task (Daneman and Carpenter, 1980), Mr. Cucumber (Case, 1985); Youth Self Report (YSR, 11-18 years) (Achenbach & Rescorla, 2001); Difficulties ER Scale (DERS, Gratz, & Roemer, 2004; Italian version by Giromini et al., 2012)	227 typically developing adolescents aged between 14-19	This study showed a significant relationship between self-reported difficulties in ER and WM, while no significant contribution of the predictors considered was evident in the externalising or internalising symptoms, adding knowledge about how behavioural and emotional self-reported outcomes may relate to these processes.
Pe et al. (2013)	Working memory, rumination, reappraisal of emotional experiences	Emotional n-back using words and deciding whether they had a similar valence, Positive and Negative Affect Schedule (PANAS), Emotion Regulation Questionnaire (ERQ), Ruminative Response Style Questionnaire (RRS). Study 2: repeated assessment of emotions using a slider scale, repeated assessment of rumination and reappraisal, emotional n-back, affective interference resolution task	221 1st-year undergraduates in study 1 (184 women). Mean age: 18.47. 95 1st-year undergraduates in study 2. Australia	Greater updating skills in WM affect rumination and reappraisal when regulating high-arousal negative emotions. People with higher WMC experienced less elevated high-arousal negative emotions when ruminating or reappraising. Updating could be fundamental for ER.

Schmeichel and Demaree (2010)	Working memory, spontaneous emotional regulation, self-enhancement, and affect	Positive and Negative Affectivity Schedules (PANAS) (Watson, Clark, & Tellegen, 1988), operation span task (OSPAN) (Turner & Engle, 1989), Over-claiming questionnaire (OCQ) (Paulhus et al., 2003)	102 undergraduate students (age not specified). America.	Higher WMC predicted more self-enhancement and less negative affect following negative feedback. Cognitive capacity may facilitate the spontaneous self-regulation of emotion.
Schmeichel et al. (2008)	Working memory capacity, self-regulation of emotional expression and emotional experience	The Berkeley Expressivity Questionnaire (BEQ) (Gross & John, 1995, 1997), OSPAN task (Turner & Engle, 1989), UWIST Mood Adjective Checklist (Matthews, Jones, & Chamberlain, 1990), facial expressions for supressing and expressing emotion experienced during emotive film and marked 1-100. Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988). Behavioral Inhibition Scale (BIS) and Behavioral Activation Scale (Carver & White, 1994), n-back task for verbal and spatial stimuli, Discrete Emotions Questionnaire (borrowed from Gross & Levenson, 1995).	45, 50, 71, and 63 undergraduate students completed 4 different experimental tasks. M:19.09. America	Better suppression of positive and negative emotion evident in people with higher WMC. Appraised information in an unemotive way People with higher WMC experienced and expressed less emotional reactions to stimuli.

Table 8

Studies Deemed Eligible for Theme 4, and Their Weightings

Study Reference	Eligible Studies for Theme 4: Affect and literacy learning	Weighting
1	Fairfield, B., Mammarella, N., Di Domenico, A., & Palumbo, R. (2015). Running with emotion: When affective content hampers working memory performance. *International Journal of Psychology*, *50*(2), 161-164. https://doi-org.libraryproxy.mic.ul.ie/10.1002/ijop.12101	High
2	Grimm, S., Weigand, A., Kazzer, P., Jacobs, A. M., & Bajbouj, M. (2012). Neural mechanisms underlying the integration of emotion and working memory. *NeuroImage*, *61*(4), 1188–1194. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.neuroimage.2012.04.004	High
3	Perry, C., Willison, A. T., Walker, M. K., Nankivell, M. C., Lawrence, L. M., & Thomas, A. (2019). Working memory load affects early affective responses to concrete and abstract words differently: Evidence from ERPs. *Cognitive, Affective & Behavioral Neuroscience*, *19*(2), 377–391. https://doi-org.libraryproxy.mic.ul.ie/10.3758/s13415-018-00686-9	Low
4	Rączy, K., & Orzechowski, J. (2019). When working memory is in a mood: Combined effects of induced affect and processing of emotional words. Current Psychology: *A Journal for Diverse Perspectives on Diverse Psychological Issues*. Advanced online publication. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s12144-019-00208-x	High

Table 9

Theme 4: Affect and Literacy Learning

Study Reference	Variables	Measures	Sample Population	Findings
Fairfield et al. (2015)	Working memory for positive, negative and neutral words, current mood	Positive and Negative Affective Scale (PANAS) (Watson, Clark, & Tellegen, 1988), running memory task (Broadway & Engle, 2010; Mammarella & Fairfield, 2006).	40 adults (18-29 years old, mean age: 22). Italy	Valence did not affect performance with shorter lists, whereas participants did better with longer lists that were neutral, if emotional words preceded neutral words.
Grimm et al. (2012)	Verbal working memory, affective words, mood and arousal	Multidimensional Mood Questionnaire (MDBF) (Steyer et al., 1997). Intelligence was assessed using a word recognition test (WST) (Schmidt & Metzler, 1992), which is functionally equivalent to the widely used NART test	20 males (18-28 years old, mean age: 23). Germany	Word valence has no impact on performance in the verbal working memory task. Emotion leads to an increase of activation in cognition-related lateral prefrontal regions, whereas cognitive effort yields enhanced deactivation in emotion-related cortical midline regions. The stronger dorsolateral prefrontal recruitment during emotional stimuli may reflect an arousal effect or higher cognitive effort due to interference with emotion.

		(Nelson & O'Connell, 1978), FMRI.		
Perry et al. (2019)	Early posterior negativity working memory, alpha desynchronisation	Silent reading task using abstract and concrete words of negative and neutral valence and a dual phonological working memory task to manipulate memory load	Twenty-four 20-30-year-old students/ people known to experimenter. Australia	Abstract but not concrete words elicited early posterior negativity, which may have affected downstream processing. Negative concrete words, unlike negative abstract words, appeared to be significantly affected by the memory load manipulation. Processing of negative concrete words is more affected than negative abstract words by working memory and attentional demands. EPN of words depend on semantic representations and competing cognitive processes. Memory and attention can affect the processing of the semantic features of words.
Rączy and Orzechowski (2019)	Mood, working memory, literacy emotional and neutral content	Cyberball paradigm (Williams et al., 2000) with three different intensities, to manipulate mood, mood questionnaire, working memory n-back test, including 2-back, 3-back, and 4-back, with positive, negative and neutral loads.	90 undergraduate students (29 male). Mean age: 21. Poland	There is a relationship between emotional content and accuracy and reaction times (RT) in a 2-back task. There is a relationship between mood and WM performance accuracy. Participants demonstrated faster reactions to negative words. Participants were more accurate when they were in a positive mood, but positive words interfered with their accuracy. The type of load (high/low) of n-back affected mood. Combining mood and emotional content did not heighten individual responses. N-back task might distract from mood.

2.16 Phase 5: Description of the Findings

2.16.1 Theme 1: Working Memory of Adolescents with Dyslexia

2.16.1.1 Working Memory Development. Working memory difficulties are evident up until adulthood (Smith-Spark & Fisk, 2007). There are differences between primary and post-primary students, as developmental changes cause some working memory deficits to become apparent and others to go away (Jeffries & Everatt, 2004). Young children may have a less developed memory span (Kibby et al., 2004). Typically developing children with lower working memory scores in First Grade can have similar WM profiles to their peers with higher WM by Third Grade (Nicolaou al., 2018). Of note, a percentage of typically developing children will score in the lowest WM group regardless of age (Archibald & Gathercole, 2006; Gray et al., 2019).

2.16.1.2 Working Memory and Learning with a Reading Difficulty. Working memory can predict reading attainment and constrains the learning of new knowledge and skills due to reading difficulties (Gathercole et al., 2006; Swanson & Sachse-Lee, 2001). The severity of reading difficulties is significantly associated with complex memory, language and phonological awareness abilities (Gathercole et al., 2006). However, students' working memory profiles are not entirely synonymous with their reading difficulty, with WM profiles intersecting rather than overlapping, i.e., each WM profile shares similarities and differences with others who have dyslexia (Gray et al., 2019). Studies in this review noted differences in the phonological loop, visual-spatial abilities and central executive abilities.

2.16.1.1 Phonological Loop. Compared to skilled readers, students with dyslexia display difficulties with the phonological loop tasks (Jeffries & Everatt, 2004; Kibby, 2004; Smith-Spark & Fisk, 2007). Some of the measures used include complex span tasks (e.g., digit recall) and are linked with attentional processes and short-term memory storage (Jeffries & Everatt, 2004; Morris, 1996;). Studies with older students noted less impaired phonological

skills, although this may be the result of intensive phonological remediation interventions (Gathercole et al., 2006). The phonological loop deficit is one of the main dyslexia theories, but it cannot capture all of the differences in working memory functioning. The verbal WM deficit alone, or when taken as secondary to problems with phonological processing and the expression of a dysfunctional articulatory loop (Jeffries & Everatt, 2004; Kibby et al., 2004), does not explain some variance in the visuospatial sketchpad (Menghini et al., 2011).

2.16.1.2 Visuospatial Sketchpad. Some studies have documented few difficulties in WM visual-spatial tasks (Kibby, 2004; Jeffries & Everatt, 2004), and others report that difficulties are evident, but to a lesser extent than the phonological domain. Smith-Spark and Fisk (2007) and Menghini et al. (2011) argue that the difficulties are comparable to phonological processing deficits. This visuospatial processing difficulty is linked with the reduced visual processing hypothesis (Stein & Walsh, 1997). The type of visual-spatial tasks involved can explain some variance (e.g., differences evident in the spatial working memory tasks but not the block span; Smith-Spark & Fisk, 2007). Visual deficits found could be compounded by verbal commands (Jeffries & Everatt, 2004) or co-morbid diagnoses not mentioned, such as ADHD, known for attention and central executive difficulties causing extra demands on more complex spatial arrays (Smith- Spark & Fisk, 2007). The primary deficit may not be with the visuospatial sketchpad, as the central executive has a role in encoding the stimuli (Menghini et al., 2011).

2.16.1.3 Central Executive. Some students with dyslexia demonstrate difficulties in the central executive system independent of the phonological or visuospatial domain. However, measures used cannot always reliably distinguish between central executive functions (Jeffries & Everatt, 2004; Smith-Spark & Fisk, 2007). Working memory deficits for students with dyslexia are particularly evident in certain contexts where greater demands are placed on executive resources (Smith-Spark & Fisk, 2007). Students with reading difficulties

who had high central executive functioning were comparable to peers who had no reading difficulty for verbal and visuospatial WM measures (Swanson & Sachse-Lee, 2001). Students with dyslexia are often able to perform tasks that involve assessing the sub-components of working memory on their own, but when multiple processes are combined, the dual-task conditions become problematic (Kibby et al., 2004). This is linked with evidence supporting higher levels of interference and the episodic buffer's questioned role (Jeffries & Everatt, 2004). Children with RD are more susceptible to interference and diminished inhibition, finding it challenging to prevent unnecessary information from entering specific WM domains (Chaippe et al., 2000; Swanson & Sachse-Lee, 2001). Low cognitive load tasks concerning working memory allow for conscious processing, increasing automation and fluency skills that students with dyslexia find difficult when presented with a higher load and increased updating tasks (Menghini et al., 2011). Novel tasks can also cause difficulty for students with dyslexia (Gray et al., 2019; Smith-Spark & Fisk, 2007). Novel task difficulty is linked with the cerebellar deficit hypothesis (e.g., impaired automaticity of skills such as information processing) (Elliott & Grigorenko, 2015) and the control, coordination and integration of information (Nicolson et al., 2001; Swanson & Sachse-Lee, 2001). The challenges experienced regarding updating tasks impact on learning, planning and problem-solving in all situations (Smith-Spark & Fisk, 2007). Some other executive functioning tasks prove particularly difficult, including sequencing, which may be related to the cerebellum, frontal lobes or premotor temporal sequencing (Menghini et al., 2011). Gray et al. (2019) report that the maintenance of an active memory composed of auditory or visual information is more difficult for children with dyslexia than for their peers without dyslexia. Children with lower executive processing scores use more capacity to reduce interference during tasks (Swanson & Sachse-Lee, 2001). This competition for limited resources is described in the resource interaction approach (Daneman & Carpenter, 1980; Engle et al., 1992).

2.16.2 Theme 2: Affect and Working Memory

2.16.2.1 The Mechanics of Affective Working Memory. Everyday working memory governs problem-solving using rules, facts, details and goals, and this problem-solving also includes capturing and maintaining the emotional intensity, valence and reward value of the memoranda used to make decisions (Mikels et al., 2005; Mikels et al., 2008). Working memory models may need to be reconceptualised to include affect as a conceptually distinct form of working memory processing (Mikels et al., 2008). Maintaining affective information is purported to depend on specific domain processes within working memory (Frank et al., 2020; Gard et al., 2011; Mikels et al., 2005; Mikels et al., 2008). The interference evident from ER interval tasks during affect maintenance indicates shared underlying mechanisms between AWM and the affective task of down-regulation, unlike that of the visual search (Mikels et al., 2008). Which specific domain of working memory AWM may theoretically situate is questioned, but Mikels et al. (2008) suggest the role of a mediating episodic buffer or a specialised episodic buffer for emotion.

2.16.2.2 AWM is Fundamental for Higher-order Emotion Processing. Working memory for emotional intensity judgements rather than visual-spatial judgements (like brightness intensity) is considered to be suggestive of higher-order emotion processing, such as the predictive ability of affectively forecasting emotions (Frank et al., 2020). The maintenance of negative emotional experiences was also associated with motivation, suggesting links to goal-directed behaviour by avoiding undesired outcomes and guiding actions toward chosen goals (Gard et al., 2011).

Frank et al. (2020) did not find associations between AWM and trait or ability emotional intelligence, which was inconsistent with other research findings (Dunn et al., 2007; Hoerger et al., 2012). However, study limitations did note methodological differences, with measures employed for EI being based on understanding rather than managing emotions

(Frank et al., 2020). Gard et al. (2020) reported no difference in their sample population with 'in-the-moment' experience ratings of emotional intensity, but they reported a significant difference when this emotion required processing and maintenance. While no direct relationships between AWM and ER or cognitive appraisal were evident, Frank et al. (2020) recommended further research to investigate the relationship between these constructs. Adaptively maintaining affect provides a way to regulate emotions (Gross, 1998b; Thompson, 1994, as cited in Mikels et al., 2008). Conversely, inhibitory control processes that are weaker may allow further interference during the maintenance of affective memoranda, and AWM processes that are dysfunctional may link with rumination behaviours that predict mental difficulties such as depression (Mikels et al., 2008).

2.16.2.3 Socio-emotional Influence on Working Memory. A person's socio-emotional development stage can influence his/her biases and perceptions of emotions, as posited via the socioemotional selectivity theory (Mikels et al., 2005). Older adults who demonstrated a decline in cognitive working memory maintained their working memory for affect, particularly with positively valenced stimuli, compared to younger adults (Mikels et al., 2005). Populations that demonstrate the preservation of working memory functioning for affect could encode information emotionally during everyday psychological functioning to improve cognitive representations (Gard et al., 2011; Mikels et al., 2005).

2.16.2.4 Factors that Can Influence AWM. Several combined factors intertwine to influence affective working memory. A person's affective state, for instance, can influence his/her judgement and bias his/her perception of affective stimuli (Mikels et al., 2008). Affective information, meanwhile, can increase the likelihood of forgetfulness for specific populations with a deficit in working memory (Mammarella et al., 2012). In addition, people with schizophrenia who have lower working memory capacity (WMC) and difficulties regarding attentional control (similar to people with dyslexia) demonstrate increased intrusion

errors (especially for positive emotions) and recall more off-goal information, in particular for affective content (negative words) (Mammarella et al., 2012). A person's cognition may naturally modulate his/her affect, depending on how many attentional resources are available, and deep concentration on a task can also reduce affect reactions (Mikels et al., 2008). Interestingly, the type of context in which working memory is assessed (e.g., affective or neutral contexts) can also influence adolescents' performance (Mirabolfathi et al., 2020). In particular, adolescents can be sensitive to highly negative social experiences, and such experiences can demonstrate adverse effects on working memory capacity, particularly when adolescents are exposed to affective distractors (Mirabolfathi et al., 2020).

2.16.3 Theme 3: Emotional Regulation and Working Memory

2.17.3.1 Working Memory and Emotional Regulation are Related. ER 'influences the experience, expression, or duration of an emotional response' (Schmeichel et al., 2008, p. 1526). Difficulties experienced with regard to emotionally regulating are suggested to be significantly related to working memory, and they may explain some individual differences in WM (Malagoli & Carmen Usai, 2018; Schmeichel et al., 2008). Working memory may also influence ER processes by modulating or interfering with ER (Malagoli & Carmen Usai, 2018; Schmeichel et al., 2008). Schmeichel et al. (2008) contend that WM does alter expressive suppression more than a person's disposition.

2.16.3.2 Working Memory Performance and Affect. Students with higher WMC have a less affective response when processing emotional stimuli and spontaneously engage in ER (Garrison & Schmeichel, 2020; Malagoli & Carmen Usai, 2018; Schmeichel & Demaree, 2010). They express and experience less emotion, and they more effectively adopt neutral appraisals for affective content (Schmeichel et al., 2008). Participants with higher WMC do experience similar stressful events in daily life; however, they experience a less negative affect afterwards compared to participants with lower WMC, even when controlling

for trait-negative affect and anxiety (Garrison & Schmeichel, 2020). WMC is related to prolonged negative affect, especially if participants use rumination or mixed coping strategies (Garrison & Schmeichel, 2020). Participants with lower WMC have experienced higher negative affect after receiving negative feedback compared to no feedback (Schmeichel & Demaree, 2010).

2.16.3.3 Disentangling WM and ER from other Processes and the Role of Updating.

Cognitive regulation and ER strategies are difficult to disentangle, as they can be automatic or deliberate processes utilising top-down or bottom-up processing (Malagoli & Carmen Usai, 2018). A combination of executive processes may be involved, but updating affective information in WM is fundamental to the efficacy of ER attempts, especially when reappraising high-arousal negative emotions (Pe et al., 2013). Updating affective information moderates the impact of rumination and reappraisal for high-arousal emotions such as anxiety, but not low arousal (e.g., sadness or positive emotions, such as happiness) (Pe et al., 2013). Emotional N-back results did not show a correlation with trait questionnaires for ER; however, questionnaires do not measure strategies as experienced in everyday life (Pe et al., 2013). Lindsey et al. (2013) completed a meta-analysis on n-back tasks such as those used in the Pe et al. (2013) study and defined them as tasks which require participants to respond if the current stimulus matches a stimulus presented n stimuli previous. Lindsey et al. (2013) noted that non-verbal n-back tasks (e.g. using word like stimuli instead of digit recall) have higher correlations to other complex working memory tasks, therefore they may be a more valid measure of WM. Furthermore, given word-level reading is a particular area of need for learners with dyslexia (Fletcher & Miciak, 2017), and given the differences noted between literacy which is affective and neutral for those without dyslexia, this may require further investigation with learners who have literacy difficulties.

2.16.3.4 WM and Emotional Elicitations Experienced Require for Future Research.

Working memory supports emotional elicitations experienced (Malagoli & Carmen Usai, 2018). WM capacity may not be associated with the emotional expression or experience when viewing emotive stimuli if the regulation of emotions is not involved, but it might influence emotional experience and facial expression when processing, suppressing and appraising emotional stimuli (Schmeichel et al., 2008). Adolescents' ability to experience and to process emotions are separate (Malagoli & Carmen Usai, 2018). Further research is advocated for the relationship between ER and WM in emotionally charged situations and contexts (Schmeichel & Demaree, 2010), as ER may be fundamental in processes such as decision-making, goal-directed behaviour and controlling impulses (Malagoli & Carmen Usai, 2018).

2.16.4 Theme 4: Affect and Literacy Learning

2.16.4.1 Emotional Content may be Prioritised or Inhibited within Affective Literacy.

Emotive content plays a role in how semantic representations are interpreted (Perry et al., 2019), and may alter the speed and accuracy of working memory (Raczy & Orzechowski, 2019). Grimm et al. (2012) contend that emotive content may not inhibit accuracy but could impede processing efficiency. Fairfield et al. (2015), meanwhile, suggest that emotive content in cognitive tasks may deplete WM performance further if operating within a limited-resource model (Fairfield et al., 2015). Perry et al. (2019) argue that the effect is dependent on the WM load and the time of processing (i.e., during the early posterior negativity window or downstream processing) and that during a high-load WM condition, emotional content may be privileged and prioritised over neutral content (Perry et al., 2019).

2.16.4.2 The Effect of Mood and Context on Affective Literacy.

A student's mood and context (e.g., after social exclusion) may alter how affective literacy (positively and negatively valenced literacy) is processed (Raczy & Orzechowski, 2019). Raczy and

Orzechowski (2019) add that if mood and stimuli are not congruent (e.g., positive moods with negative stimuli), WM performance can decrease.

2.16.4.3 Working Memory Load, Abstract/Concrete and Positioning During Affective Literacy. Fairfield et al. (2015) posit that the task's difficulty determines the resources available and the effort to process valenced stimuli. If too much information is processed simultaneously, affective literacy may be compromised (Raczy & Orzechowski, 2019). Fairfield et al. (2015) report that neutral words were more accessible to recall than valenced words when the lists were longer and the type of valence did not influence this difficulty. However, Perry et al. (2019) posit that negative abstract words may attract additional attentional resources, making them easier to be processed (Perry et al., 2019). Memory load in the early posterior negativity window impacted neutral abstract words' processing, but not that of negative abstract words (Perry et al., 2019). Negative abstract words appeared to access attentional resources quickly and were resistant to high-load WM later in the process compared to neutral abstract words (Perry et al., 2019). This difference may be explained due to variations in how abstract or concrete words were and how much of a cognitive load there was (Perry et al., 2019). Negative concrete words were disadvantaged compared to neutral concrete words in high-memory load situations; however, the reverse was true in low-load conditions (Perry et al., 2019). A high phonological working memory load modulates early posterior negativity and affects the processing of negative concrete words (e.g., ‘venom’ and ‘hijackers’) more than negative abstract words e.g., ‘misery’ and ‘jealousy’ (Perry et al., 2019).

2.16.4.4 Valence and Affect Literacy. There was also a discrepancy between reports indicating that valence caused a quicker response. Raczy and Orzechowski (2019) report quicker responses from negatively loaded words, while Grimm et al. (2012) report that positive words had faster response times. Grimm et al. (2012) followed this with FMRI data

which showed an increase of neural recruitment in the bilateral dorsolateral prefrontal cortex (DLPFC), with more recruitment extending the response time, which could be due to an arousal effect or greater cognitive effort employed due to interference from emotional content (Grimm et al., 2012).

2.17 Phase 6: Synthesis of Findings for Each Theme

2.17.1 Theme 1: The Working Memory of Adolescents with Dyslexia

Working memory differences are typically noted in the cognitive profile of students with dyslexia (Jeffries & Everatt, 2004). However, the exact WM profile is not always synonymous with the learning difficulty (Gray et al., 2019). This variance of ability in WM subsystems (e.g., phonological processing, visuospatial skills and central executive skills) can present to different extents.

Differences were evident in the phonological loop but were reduced for adolescents (Jeffries & Everatt, 2004; Kibby et al., 2004; Smith-Spark & Fisk, 2007). Visuospatial differences ranged from studies where none were evident (Kibby, 2004; Jeffries & Everatt, 2004) to those with indications of some difficulty (Smith-Spark & Fisk, 2007) or difficulties comparable to phonological deficits experienced (Smith-Spark & Fisk, 2007). Menghini et al. (2011) state that central executive functions may confound visuospatial effects.

Although it has been challenging to differentiate between CE functions, all studies mentioned the effects of attentional resources (Jeffries & Everatt, 2004; Smith-Spark & Fisk, 2007; Kibby et al., 2004; Menghini et al., 2011; Gray et al., 2019). The central executive was particularly important when tasks were novel, when WM load was high and during dual-task conditions. The executive component remains pivotal in the model of WM, as controlled attention is significantly related to growth in reading fluency and comprehension (Swanson & Olga, 2007).

2.17.2 Theme 2: The Interaction between Affect and Working Memory: Affective Working Memory

The interaction between affect and working memory is theoretically relevant for WM, but also pragmatically, as it is suggested to be a core mental ability that aids higher-order emotion processing (Frank et al., 2020). Previous research documented affect as an additional demand and strain on WM (Mammarella et al., 2012; Mirabolfathi et al., 2020), but in some situations, as a positive compensatory support (Mikels et al., 2005). Schweizer et al. (2019) suggest that AWM may impact decision-making and predict mental health difficulties, such as rumination, as well as acting as a potential transdiagnostic mechanism. AWM is also suggested to relate to everyday functioning thoughts, goals, motivations, judgements and problem-solving (Broome et al., 2012; Mikels et al., 2008; Mikels et al., 2019; Schweizer et al., 2019).

Schweizer et al. (2019) and Mikels et al. (2019) define AWM as the 'maintenance of a mental representation' that is affective, amid competing demands for task-relevant content and task-irrelevant distractions. The AWM construct is quickly gaining attention, and its complex nature, along with the interplay between the working memory and affect systems, have led to some interpretations which consider the role that affective distractors (Mirabolfathi et al., 2020) and affective content (Mammarella et al., 2012) play in this process. The biopsychosocial system in which it sits cannot be ignored, and the context in which the learning is situated can influence the affective experience, subject to the individual (Mirabolfathi et al., 2020). For example, students with dyslexia demonstrate lower performance when completing tasks perceived as 'scholastic' (Andresen et al., 2018). However, school contexts and tasks may not serve as affective contexts or contents, depending on various factors, such as self-esteem, self-concept, attribution style and

resilience (Burden, 2008). A participant's age can also change the emotional relevance, and Schweizer et al. (2019) report that adolescence may be more affected by rewarding stimuli.

2.17.3 Theme 3: Emotional Regulation and Working Memory

WM is associated with ER, but most ER studies were experimenter-guided tests of ER, such as cognitive reappraisal and expressive suppression (McRae et al., 2012; Schmeichel et al., 2008). However, Garrison and Schmeichel's (2020) study was not experimenter-guided, where participants followed the rules and demand characteristics, but instead used daily observations and reporting from participants instead, and these reports showed a relationship with WM.

Participants who are higher in WM capacity tend to show less negative affect for daily stressors (Garrison & Schmeichel, 2020). Higher WMC is related to enhanced 'expressive suppression, cognitive reappraisal, self-enhancement following negative feedback and coping with daily life stressors' (Schmeichel & Tang, 2014, p. 96). WM capacity is associated with the ability to filter distractions during encoding (Malagoli & Carmen Usai, 2018), and affective updating ability is predictive of down-regulation high-arousal negative states, but not low-arousal affective states (Pe et al., 2013; Schweizer et al., 2019). It is difficult to disentangle WM and ER processes; for example, inhibitory control regulates the recall of emotional events, and mild negative affect enhances inhibitory control (Tang & Schmeichel, 2014). Negative emotions reduce updating ability, and positive emotions improve switching, but they can also increase distractibility, depending on a student's motivation (Schmeichel & Tang, 2014). Specific ER strategies, such as reappraisal ability and frequency, have also shown a positive association with WMC in neutral and emotional contexts and well-being (McRae et al., 2012).

2.17.4 Theme 4: Emotive Content in Literacy Learning

The impact of emotional literacy on WM depends on many compounding factors, such as context, mood, WM load and word type (concrete/abstract) (Aoki et al., 2011; Erk et al., 2007; Fairfield et al., 2015; Gray et al., 2002; Grimm et al., 2012; Perry et al., 2019; Raczy & Orzechowski, 2019). Emotional literacy can create vivid memories or prompt a process of adaptively ignoring emotional stimuli (Dietrich et al., 2001; Malagoli & Carmen Usai, 2018; Mitchell & Phillips, 2007). Raczy and Orzechowski (2019) report slower responses for negative literacy, similar to Kensinger and Corkin (2003); however, Grimm et al. (2012) have reported faster responses to negative stimuli. While Perry et al. (2019) have indicated advantages to WM when emotive content is included, Fairfield et al. (2015) suggest that emotion impacts literacy learning if operating within a limited-resource model.

The emotional enhancement of memory theory reports emotionally arousing events easier to encode and recall due to basolateral amygdala activation improving hippocampal consolidation (Cahill & McGaugh, 1998; McGaugh, 2004, as cited in Mammarella et al., 2014). Perry et al. (2019) note that negative information was easier to recall for participants. However, the emotional impairment hypothesis posits that emotional content can affect attentional control and information maintained in WM. Garrison and Schmeichel (2019) found a reduction in WMC for emotional words compared to neutral words, which was similar to the findings of Mammarella et al. (2014), who reported that longer lists in the case of high WM load were easier to recall if neutral.

Grimm et al. (2012) conducted the only study that used FMRI evidence, which showed greater activation in the DLPFC. This could mean higher arousal or higher cognitive effort due to interference from the emotional content. Previous FMRI evidence of emotional literacy on working memory-related brain areas such as the dorsolateral prefrontal cortex (DLPFC) showed reduced WM (Perlstein et al., 2002), no effect on WM (Dóhnel et al., 2008) or increased activation during WM tasks (Neta & Whalen, 2011). This complexity in

processing affective stimuli can provide varying results based on the tasks and sample populations involved (Raczy & Orzechowski, 2019).

2.18 Limitations of the Review

The variation in theoretical conceptualisations of WM, and sample populations, which are not screened for co-occurring developmental challenges, leads to complex patterns of working memory results (Savage et al., 2006). Few studies in this review focused specifically on the adolescent age group. This developmental stage is important, as some WM difficulties can be overcome by this stage, and others become apparent (Jeffries & Everatt, 2004). Working memory findings for students with reading difficulties are complicated to interpret due to the variance in working memory tasks and procedures (Savage et al., 2006). Maintaining information in WM involves various functions, including inhibition, updating, WM capacity, binding and other functions; therefore, the measurement of WM is complex, and no task currently accounts for all WM functions (Mammarella et al., 2014). Affective working memory studies in this review have primarily included American adult populations, and this construct is still in its infantile stage of development. Themes 2 to 4 of the review focused on populations without reading difficulties due to a paucity of research pertaining to students with dyslexia in those specific areas.

2.19 Implications for Theory and Practice

There is a dearth of research which incorporates adolescence as a specific age group in dyslexia and WM studies. However, it is a developmental period of change in emotion (Malagoli & Carmen Usai, 2018) and working memory (Jeffries & Everatt, 2004; Rose & Rouhani, 2012). Rose and Rouhani (2012) assert that future research should focus on the developmental stage of adolescence when studying dyslexia, as it is not just an extension of childhood literacy difficulties, and different factors influence reading, such as vocabulary.

This is an age group which is particularly sensitive to negative social events (Mirabolfathi et al., 2020) and which could be impacted by frustrations with learning.

Previous research on AWM has alluded to it being associated with higher-order emotional processing, such as goal-directed learning and motivation (Gard et al., 2011; Mikels et al., 2005; Schweizer et al., 2019) and affective forecasting (Frank et al., 2020). AWM's relationship with emotional intelligence is the subject of ongoing debate, with some believing it is related (Dunn et al., 2007) and others not endorsing that relationship (Frank et al., 2020). Indeed, Schweizer et al. (2019) posit that AWM could contribute to a transdiagnostic indication of mental health. ER is hypothesised to be involved in AWM (Mirabolfathi et al., 2020), showing interference during AWM tasks (Mikels et al., 2008). Although Frank et al. (2020) did not find an association between AWM and ER, they suggest that further research is required with regard to ER and emotional intelligence, due to methodological limitations. Similarly, Gard et al. (2011) report that an 'in-the-moment' experience of emotion and understanding of that emotion can be very different from a person's ability to process and maintain the emotion. Similarly, Schneider and McGrew (2018) report that emotional intelligence is a broad tentative ability within the Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities which is described as perception and knowledge of emotion, in addition to the management and utilisation of emotion. While adolescents with dyslexia may be competent in the first two abilities (perceiving and understanding emotions), managing and utilising emotions are also distinct abilities of emotional intelligence, areas which are relatively unknown. Adolescents with dyslexia have shown variance in socio-emotional factors such as self-esteem, resilience and anxiety (Burden, 2008; Burton, 2004). Therefore, future research specifically measuring AWM for adolescents with dyslexia and ER strategies used could shed further light on socio-emotional processes and development for this neurodiverse population.

Further research is needed to delineate the differences between affective working memory and working memory processes, investigating their interaction with ER (i.e., determining which ER strategies are separate and which overlap with AWM) (Mikels et al., 2019; Garrison & Schmeichel, 2020). In particular, the interplay between affect and executive resources requires further investigation in clinical populations (Schweizer et al., 2019). A recent meta-analytic study of WM and learning disabilities observed that further research is required to understand the nature of WM and to gain a better understanding of its relationship with learning (Peng & Fuchs, 2016). More research would advance the knowledge base on general working memory capacity and specific domains pertinent to students with dyslexia, and it could add to the clinician's knowledge (i.e., that of educational psychologists) when testing the working memory of a student with reading difficulties. Additionally, Mikels et al. (2005) and Gard et al. (2005) suggest that encoding information using affect-related working memory could suit certain neurodiverse populations. Swanson et al.'s (2009) metanalysis posits that students with dyslexia perform well in academic domains that have fewer demands on working memory functioning. This could support teachers' awareness of working memory loads and how to effectively manage these WM loads in school, which, in turn, could support effective teaching and learning practices (Gathercole et al., 2006).

2.20 Conclusion

Reading difficulties cannot be explained or confined to one sub-system of working memory, and the neurodiverse profile for each individual sits within a biopsychosocial model of learning (George & Engle,1980). Despite a proliferation of research on the relationship between WM and reading difficulty, the pattern of results has varied based on measures used. The most frequently used working memory measures in studies of students with reading difficulties are complex span tasks. They are criticised on various theoretical grounds,

including the lack of developmental evidence of their reliability, predictive validity and ecological validity, along with the requirement of storage and non-shallow processing for these complex span tasks (Savage et al., 2006).

The use of various measures in extant research between all three constructs of WM, AWM and ER makes it difficult to draw definite conclusions, but it yields converging evidence of similarity between the constructs of WM, AWM and ER (Schmeichel & Tang, 2014). This gives confidence regarding the relationship between these concepts and suggests further latent factors that link the constructs; simple bivariate relationships may not explain the relationship fully (Schmeichel & Tang, 2014). Nonetheless, ER is suggested to influence how affect is processed (i.e., how it is appraised, how long it is experienced and responses to it) (Garrison & Schmeichel, 2020; Schmeichel et al., 2008). However, it may be dependent on the type of processing, whether deliberately using an individual's working memory capacity (Schmeichel & Demaree, 2010) or an automatic affective response (Malagoli & Carmen Usai, 2018). It may also be dependent on the type of emotions (Pe et al., 2013) and the context (Schmeichel & Demaree, 2010). Similarly, the working memory profiles reviewed in this study also depend on different factors, and reports vary.

A selective meta-analysis of working memory in students with reading difficulties highlights problems they face with accessing resources from the phonological and executive systems (Swanson et al., 2009). This does not include all areas (e.g., oral language comprehension and spontaneous speech within the phonological loop may not be impaired) (Swanson et al., 2009). The visual brain areas are recruited more for affective than for neutral information (Schweizer et al., 2019), which may support some students with dyslexia. Most WM tests are devoid of emotional information, which could alter working memory capacity (Schweizer et al., 2019). Working memory tests used such as the digit span involve sorting and recalling numbers, information which could be described as neutral and questionable in

terms of their ability to accurately measure WM as a complete construct (Rosen & Engle, 1997).

This review highlights the debate relating to high working memory load and emotion. It raises the concern that affective information (including affective literacy) may cause more strain within the resource interaction approach (Danneman & Carpenter, 1980; Engle et al., 1992) but at times supports the enhancement of memory (Hamann, 2001). This interaction between a high working memory load and emotion is still unknown for adolescents with dyslexia. This is an area for future research as affect may lessen or increase this WM load for these students.

This literature review drew together four themes central to the exploration of the role of AWM in adolescents with dyslexia. These themes related to the functioning of working memory and affect in adolescents with dyslexia. Following this review, there is a need to further clarify the interaction between WM and AWM, the role ER plays in this interaction and how relevant these processes are for adolescents with dyslexia. The following research questions are suggested.

2.21 Research Questions

1. What are the differences in working memory performance for adolescents with and without dyslexia in the context of affective information?
2. What are the differences in learning-related emotional regulation strategies for adolescents with and without dyslexia when they experience difficulty with learning, and which emotional regulation strategies could be associated with the processing of affect-related information?

Chapter Three: Empirical Paper

3.1 Introduction

Dyslexia is conatively loaded; its definition is driven by competing conceptions, shifting diagnostic criteria and many interest groups (Cameron & Billington, 2017). Despite a proliferation of research, dyslexia is still lacking a conclusive consensus and scientific evidence to incorporate all factors for this heterogeneous population (Elliott, 2020). Some query the need for differentiation from other students who struggle with reading. The Rose Report in the UK (2009) and more recent reviews (Elliott & Grigorenko, 2014; Gibbs & Elliott, 2020)acknowledge the ongoing dyslexia debate and advise that this deliberation should give rise to further professional expertise and effective interventions. A review of the dyslexia reports from north and south Ireland note the evolving understanding of dyslexia from a previous medical model to a more inclusive 'continuum of need', but one which still includes many gaps and contradictions (McPhillips et al., 2015, p. 32).

A synthesised definition of dyslexia from leading authors and dyslexia agencies is adopted for this study: 'a neurodiverse and multidimensional model of learning, which impacts on the acquisition of fluent reading and spelling skills (e.g., word level and decoding) to varying amounts on a continuum of need. This difficulty is unexpected amongst other cognitive abilities, and/or strengths, and learning opportunities. This continuum of strengths and need also includes variance in socio-emotional factors, including but not limited to anxiety, resilience and self-esteem'.

This neurodiverse profile of dyslexia highlights differences and relative strengths that students bring to their learning experiences (Armstrong, 2010; Elliott, 2020). There is a dearth of strengths-focused literature building on known capacity (Rappolt-Schlichtmann et al., 2018). However, it is recognised that some students with dyslexia have shown positive variance in socio-emotional factors (e.g., resilience and self-esteem), and this capacity for

emotional processing has served as an important protective factor in learning (Burden, 2008; Burton, 2007; Ghisi et al., 2016; Hellendoorn & Ruijssenaars, 2000; Patael et al., 2018; Riddick, 2003). This variance may be greater than expected, given the incidence of a perceived decrease in resilience according to the general adolescent Irish population (Dooley et al., 2019). Imaging studies suggest the existence of structural differences in the brain that appear to correlate with a degree of resilience and reading proficiency in individuals with dyslexia (Patael et al., 2018). Haft et al. (2016) propose a cognitive and socio-emotional resilience framework for students with reading difficulties, stating that despite an increased risk of difficulty in cognitive and socio-emotional outcomes, good functional outcomes are possible, such as positive psychosocial adjustment and reading proficiency. In considering how socio-emotional resilience may be fostered, it is important to explore affect among adolescents with dyslexia.

3.1.1 Affect and Adolescents with Dyslexia

Barrett and Moreau (2009) argue that all of our experiences are embedded in affect, shaping our attitudes and beliefs, influencing our consciousness and learning. Participants can show differences between identifying 'in-the-moment feelings' and the ability to process and maintain the feelings (Gard et al., 2011), and socio-emotional difficulties can influence the processing of affective information (Trilla et al., 2020). Adolescents with dyslexia reported secondary emotional difficulties and distress, particularly in the first six years of schooling, as students grapple with academic self-esteem and learn to distinguish their learning difficulty from their self-concept (Ingesson, 2007). A 20-year longitudinal study identified effective coping strategies as significant predictors of success in people with learning difficulties (Goldberg et al., 2013). If students with dyslexia can re-frame negative feelings about their specific learning difficulty, success is more likely. It is noteworthy that a large Irish youth mental health survey (*My World Survey-2*) has shown a worrying decrease in all

adolescents' reports of coping effectively with their problems (Dooley et al., 2019). Therefore, the types of coping strategies or cognitive-emotional regulation strategies used can highlight positive strategies used when psychosocially adjusting to literacy challenges (McNulty, 2016; Terras et al., 2009). In addition to the role that affect and socio-emotional factors play, the cognitive factors within Haft et al.'s (2016) framework must also be considered. It is well-established that working memory is a primary area of cognitive difference within this neurodiverse population (Elliott & Grigorenko, 2015; Peng et al., 2018; Swanson et al., 2009).

3.1.2 The Working Memory of Adolescents with Dyslexia

Working memory (WM) is a cognitive ability that predicts academic success (Alloway, 2009; Gray et al., 2019), reading decoding/fluency and comprehension abilities (Peng et al., 2018). The Baddeley and Hitch Multicomponent Model of Working Memory (2003) identifies domain-specific elements of WM. These domains have shown functional differences in dyslexia populations and to varying extents (Elliott & Grigorenko, 2015). Students with dyslexia have predominantly demonstrated the most difficulty in tasks associated with the phonological loop (Jeffries & Everatt, 2004; Kibby, 2004; Smith-Spark & Fisk, 2007; Stanovich & Siegel, 1994), but to a lesser extent in adolescence (Gathercole et al., 2006). Giofré et al. (2019) have reported that dyslexia working memory profiles consistently include visual processing difficulties, and only sometimes phonological difficulties. Smith-Spark and Fisk (2007), in addition to Menghini et al. (2011), report that their students have a comparable level of difficulty in tasks associated with the phonological loop and visuospatial sketchpad. However, others argue that this is due to interference from verbal commands (Jeffries & Everatt, 2004) or that the central executive plays a role in visual-spatial difficulties (Menghini et al., 2011).

Nonetheless, a selective meta-analysis highlights the broad agreement that the central executive (CE) is implicated in acquiring literacy skills, including reading (Swanson & Olga, 2007). Many studies suggest the CE also plays a pivotal role for other WM sub-components, but the key processes of CE (i.e., attention, updating, inhibition or maintenance) can be difficult to compartmentalise (Everatt, 2004; Gray et al., 2019; Jeffries & Everatt, 2004; Kibby et al., 2004; Menghini et al., 2011; Patael et al., 2018; Smith-Spark & Fisk, 2007; Swanson & Sachse Lee, 2001). Students with and without reading difficulties demonstrate similar WM abilities when matched for these key processes of attention, updating, inhibition and maintenance (Swanson & Sachse-Lee, 2001). Gray et al. (2019) argue that CE updating is particularly important for students with dyslexia. Updating abilities involve more than maintenance alone, and they include dynamically manipulating WM (Iuculano et al., 2011). Students with dyslexia can often perform well on sub-components of working memory which allow for conscious processing, but when they are combined within dual-task conditions, performance typically decreases (Kibby et al., 2004; Wang & Gathercole, 2013). Furthermore, interference from other stimuli increases (Chaippe et al., 2000; Swanson & Sachse-Lee, 2001). Therefore, the central executive component of WM is pertinent for reading and influential for other sub-components of WM. Some tasks have been demonstrated to be more taxing for students with dyslexia. The maintenance of information, in dual-task conditions, where some content requires dynamic manipulation is an area of particular difficulty for students with dyslexia (Kibby et al., 2004). While a broad range of working memory elements has been investigated in the dyslexia literature, the assessment of working memory in practice is not as extensive.

3.1.2 Assessing the Working Memory of Adolescents with Dyslexia

Irish psychological services frequently employ a traditional discrepancy-style assessment model for dyslexia, one which incorporates working memory sub-tests (Elliott,

2020; Nugent, 2008) in combination with other elements, such as a response-to-intervention approach and the patterning of strengths and weaknesses in multi-tier systems of support (Miciak & Fletcher, 2020). Working memory assessments may be limited or nuanced by our preconceived understanding of working memory and its interaction with emotion. Schweizer et al. (2019) report that working memory assessments lack affective information and are created and tested within emotionally neutral lab settings, with limited generalisability to real-world settings. Mirabolfathi et al. (2020) state that the environmental contingencies and distractors in real life could impact on affect-related working memory, as affective information is an important source of attentional salience. Hence, WM sensitivity to affective information is essential for dynamically updating goals. WM assessments such as the digit span task include recalling and sorting numbers, and they could be described as affectively neutral, while their accuracy at measuring WM as a complete construct is questioned (Rosen & Engle, 1997), in addition to how it generalises to other tasks (Swanson et al., 2009; Elliot & Grigorenko, 2015).

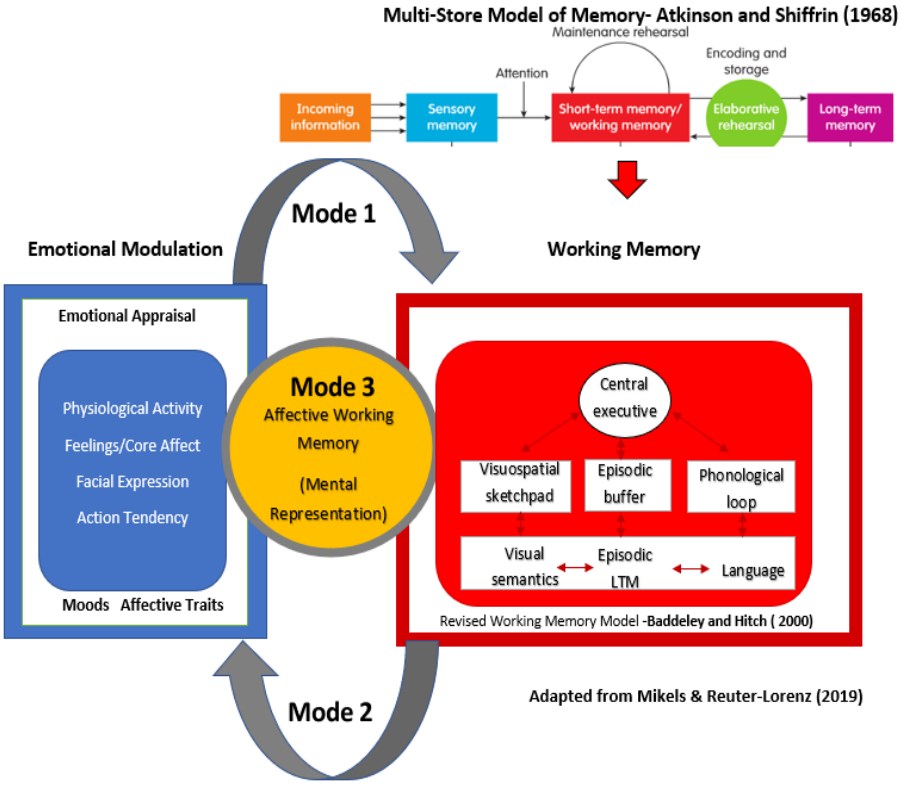
Even extant working memory tests used in the literature are questioned in relation to their theoretical basis and variance in reliability and predictive validity, as well as the ecological validity arising from the use of storage and non-shallow processing tasks (Savage et al., 2006). The wide variance in WM abilities found in dyslexia literature may be influenced by particular WM assessments used and participants recruited (i.e., if students with dyslexia chosen have notably lower working memory, and the control group chosen has significantly higher working memory scores) (Gathercole, 2006). Gray et al. (2019) argue that the WM profile is not synonymous with the learning difficulty, and students without any reading difficulties can be in the lowest working memory group. Therefore, it is vital that population samples are representative and generalisable rather than obtaining participants with extremes of working memory capacity.

3.1.3 The Interaction between Working Memory and Affect

It is evident that working memory and socio-emotional profiles of students with dyslexia have been well-researched, but to date, they have remained isolated from each other within the literature. There is growing attention in the literature on the interaction between working memory and affect (Schweizer et al., 2019). Mikels and Reuter-Lorenz (2019) proposed affective working memory (AWM) as an integrative model and detailed three modes by which working memory and emotion interact.

Figure 1

The Hypothesised Interaction between Working Memory and Emotional Modulation



Note. Mode 1 represents affect influencing working memory. Mode 2 represents working memory influencing affect. Mode 3 represents the affective mental representations mantained and processed within working memory.

Similar to Mode 1, Baddeley et al. (2012) acknowledged that emotion impacted on cognition. They proposed a hedonic detection system, concerning the degree of association with pleasure, within the WM model. Via the hedonic judgment of images, words and faces were given lower hedonic ratings by participants when they were in a negative mood (Baddeley et al., 2012). Induced negative emotion has also been shown to impact on cognitive abilities such as phonological working memory performance (Fartoukh et al., 2014).

Conversely, working memory capacity has also been reported to impact emotions by supporting successful down-regulation (Zaehringer et al., 2018), which links with Mode 2 of Mikels and Reuter-Lorenz's model (2019). Nelson et al. (2015) report working memory to be negatively correlated with, and a significant predictor of, test anxiety experienced by students with dyslexia.

The third mode posits that affective content is processed and held as 'mental representations' in the working memory system, but in a separate sub-system to the phonological loop or visuospatial sketchpad (Mikels & Reuter-Lorenz, 2019; Schweizer et al., 2019). For some populations that demonstrate a difficulty in working memory, such as people diagnosed with schizophrenia, affect-related content is more difficult to sort, store and recall than neutral content (Mammarella et al., 2012). However, for other people, including ageing individuals who demonstrate difficulties in working memory, their affect-related working memory is unimpaired and superior to cognitive working memory (Mikels et al., 2005). It is not known how adolescents with dyslexia sort, store and recall affective stimuli.

3.1.4 Emotional Regulation and Working Memory

Emotional regulation (ER) is defined as a process that can 'reduce, strengthen, or maintain the experience of either positive or negative emotions depending on the current needs or goals of an individual' (Gross, 2014, as cited in Kobylińska & Kusev, 2019, p. 2). It is

difficult to disentangle ER processes and working memory; for example, inhibitory control regulates the recall of emotional events, and mild negative affect enhances inhibitory control (Tang & Schmeichel, 2014). Negative emotions reduce updating ability, and positive emotions improve switching, but they can also increase distractibility, depending on a student's motivation (Schmeichel & Tang, 2014). Emotional regulation and working memory can be interdependent. Some ER strategies, such as reappraisal ability, are associated with working memory capacity in neutral and emotional contexts (McRae et al., 2012). Likewise, working memory capacity can modulate or interfere with ER processes (Malagoli & Carmen Usai, 2018; Schmeichel et al., 2008). Participants who have higher WM abilities have previously exhibited less negative affect after receiving negative feedback, suggesting greater adaptive ER (Garrison & Schmeichel, 2020; Malagoli & Carmen Usai, 2018; Schmeichel & Demaree, 2010).

The relationship between ER and affect-related working memory has also specifically been investigated, with some finding a relationship (Dunn et al., 2007), and others not finding a direct relationship but suggesting further investigation due to methodological limitations (Frank et al., 2020). Both ER and AWM are posited as being fundamental to higher-order emotion processing, such as motivation and goal-directed behaviours (Frank et al., 2020; Gard et al., 2011; Schweizer et al., 2019). Therefore, the interaction and conceptual clarity between ER and affect-related memory requires further investigation in emotionally charged situations (Schmeichel & Demaree, 2010), such as when experiencing difficulty learning.

In consideration of this interaction between ER processing and working memory, McGrew and Schneider (2018) propose that ER and emotion processing may form part of emotional intelligence (EI), a tentative broad cognitive ability contained within Cattell-Horn-Carroll's (CHC) Theory of Intelligence. The CHC Theory suggests four abilities: emotion perception, emotion knowledge, emotion management and emotion utilisation (e.g.,

adaptively using emotion to facilitate reasoning). Therefore, the interaction between ER, emotion processing and working memory could be assumed to play a pivotal role in emotional intelligence, and hence a role in an individual's overall cognitive abilities. While these theoretical considerations may influence our understanding of this interaction, there are also pragmatic considerations, such as the effect of affect on literacy-related tasks. This is pertinent given the literacy-based continuum of need associated with adolescents with dyslexia.

3.1.5 Working Memory and Affect-related Literacy

'Affect-related literacy' is a phenomenon that explains an 'ability to identify, understand, interpret, create, communicate and compute, using printed and written materials' (OECD, 2009, p. 7), which induces a somatic, emotive response (Amsler, 2001). The response to positively and negatively valenced text is dependent on the context, working memory load, word type (concrete or abstract) and the student's mood (Aoki et al., 2011; Erk et al., 2007; Gray et al., 2002; Grimm et al., 2012; Mammarella et al., 2014; Perry et al., 2019; Raczy & Orzechowski, 2019). Affect-related literacy can support vivid memories through higher arousal or can cause interference when the person tries to ignore incoming stimuli (Dietrich et al., 2001; Grimm et al., 2012; Malagoli & Carmen Usai, 2018; Mitchell & Phillips, 2007). The effects of emotional literacy are thought to impact on learning if operating within a limited-resource model (Mammarella et al., 2012), and students with dyslexia may have a domain-general WM difficulty (Swanson & Sachse-Lee, 2001; Daneman & Carpenter, 1980; Engle et al., 1992). However, literacy learning with emotive content can also support learning success (Perry et al., 2019), especially if emotional processing and attentional processing are unimpaired (Mitchell & Greening, 2012). Students with dyslexia show variance in attentional processes for reading stimuli, sometimes showing more avoidance than vigilance and using top-down processing and biases in information

processing compared to students without dyslexia (Haft et al., 2016). However, the emotional enhancement theories hypothesise that memories may be encoded and recalled more easily due to basolateral amygdala activation improving hippocampal consolidation (Cahill & McGaugh, 1998; McGaugh, 2004, as cited in Fairfield et al., 2015). The processing of emotive literacy in comparison to less affective literacy for students with dyslexia is unknown. Understanding how students with dyslexia process affective stimuli and emotive literacy has implications for theory, but also for practice concerning assessment and intervention.

3.1.6 Rationale for the Current Research

Elliott and Grigorenko (2015) posit that knowledge of cognitive factors to date does not greatly impact interventions that are popularised and empirically supported, except for factors such as phonological or phonemic awareness. However, interventions that focus on improving cognitive processing (i.e., phonological awareness) have also proven to be those most effective for students with dyslexia (Knight, 2018; Rose, 2009; Snowling & Hulme, 2012). While a large amount of research has been conducted into the cognitive factors relating to dyslexia, there is still a lack of a universally accepted definition, conceptualisation and operationalising of dyslexia (Elliott, 2020). Affect-related working memory has not yet been investigated for these students, and it could provide a broader picture of cognitive factors that interact and form their working memory profile, which would have important implications for the assessment and intervention strategies for students with dyslexia.

There is some evidence of overlap between the constructs of working memory and affect-related working memory (Mikels et al., 2005; Mikels et al., 2008), working memory and ER (Schmeichel & Tang, 2014), and affect-related working memory and ER (Dunn et al., 2007). Further investigation is required to conceptually differentiate between these three constructs and to better understand the interaction (Garrison & Schmeichel, 2020; Mikels et

al., 2019), in particular for neurodiverse populations (Schweizer et al., 2019), such as adolescents with specific learning difficulties (e.g., dyslexia) (Nachson & Horrowitz-Kraus, 2018).

3.1.7 Aim of the Research

This research aims to ascertain whether adolescents with dyslexia maintain affective information differently to less affective information and determine whether this is unique to adolescents without dyslexia. This would give a greater understanding of the complex cognitive underpinnings of dyslexia (Stothard et al., 2018).

3.1.8 Research Questions

1. What are the differences in working memory performance for adolescents with and without dyslexia in the context of affective information?
2. What are the differences in learning-related emotional regulation strategies for adolescents with and without dyslexia, and which emotional regulation strategies could be associated in the processing of affect-related information?

3.2 Methodology

3.2.1 Research Design

3.2.1.1 Paradigm and Philosophical Assumptions. This study adopted a post-positivist theoretical perspective to address the aforementioned research questions. The working memory tasks were constructed based on Daneman and Carpenter's (1980) idea of WM as processing and storing information. However, it conceptually replicated most of the design from Experiment 2 of Mikels et al.'s (2008) study, which compared performance for affectively and affectively neutral stimuli in WM maintenance tasks. The modification involved introducing a language-related component, as this is the specific area of difference for students with dyslexia. ER strategies were measured using the Cognitive Emotional Regulation Questionnaire (CERQ) (Garnefski & Kraaij, 2006). ER's role in affect-related

WM required further investigation regarding its shared or separate role in the recall of affective information and events (Mikels et al., 2019; Schweizer et al., 2019). There were three independent variables, with two levels each: adolescents with and without a diagnosis of dyslexia; maintenance tasks that were affective or non-affective; and interval tasks that were affective or non-affective. There were two dependent variables: reaction time (RT) and concordance with norms, and particular ER strategies as covariates. Concordance with normed data is used to analyse data such as affect, which is subjective in nature, and so its level of accuracy cannot be determined.

3.2.2 Power Analysis

As there was no previous research investigating the interaction of a dyslexia diagnosis and affect-related working memory performance, and as affect-related working memory was a within-subjects factor, power was determined separately for each main effect, and the larger of the two minimum sample sizes was chosen. Firstly, the a priori sample size was calculated using G*Power (Version 3.1.9.2; Faul et al., 2007) before recruiting participants. This criterion was based on similar effects from previous affect-related working memory research (Mikels et al., 2008). The sample size was calculated using ANOVA statistical analysis, which involved the desired power level ($\beta = 0.95$), an alpha (α) of 0.05 and the desired effect size (i.e., > 0.35). The G*Power analysis indicated that a minimum sample size of 38 would provide sufficient power to detect a difference in WM performance for affective and affectively-neutral content. Secondly, a meta-analysis of working memory studies of children with and without reading difficulties was analysed; it had a mean effect size of -.89 (SD = 1.03), with the average mean total of participants being 62.43 (Swanson et al., 2009). The larger of the two minimum sample sizes (62) was subsequently chosen for this study. The stopping criteria for recruitment were when the minimum sample size for both the dyslexia

and control group was met and when the groups were adequately matched for sex, age and socio-economic status (based on area, not individual status).

3.2.3 Participants

Eighty participants were initially recruited. Exclusionary criteria were then applied (i.e., self-declared reading difficulties among those in the control group or visual impairments that would interfere with performance; incomplete experiments; data loss due to technical issues; or difficulty with the methodology experienced by a participant). There were 71 remaining participants (36 males and 35 females), consisting of 32 adolescents with dyslexia and 39 adolescents without dyslexia.

3.2.4 Sampling Method

Ball et al. (2011) report that the incidence of dyslexia among the Irish student population is approximately 10%. The design was quasi-experimental due to its purposive nature, and using purposive and convenience sampling, participants were recruited from Irish post-primary schools and the Dyslexia Association of Ireland. All participants were required to be an early adolescent, between the ages of 12-14 (Malagoli & Carmen Usai, 2018). This stage of development brings about increased mood volatility, emotional arousal and reward-seeking emotions (Malagoli & Carmen Usai, 2018; Meschke et al., 2011). It also includes developments in executive functioning, planning, decision-making and flexibility in adapting to contexts (Malagoli & Carmen Usai, 2018). Adolescence is also the stage at which working memory and short-term memory skills begin to diverge (Savage et al., 2006).

All participants' diagnoses of dyslexia or the absence of dyslexia/reading difficulties were confirmed by parents, the special educational needs co-ordinator (SENCO) within the school or organisation and the participant. Considerable weighting and predictive value were given to self-reporting of the possible diagnosis of dyslexia for those who were in the control group (Deacon et al., 2012; Leavett et al., 2014; Tamboer & Vorst, 2015).

3.2.5 Assignment to Groups

There were two groups. The first group consisted of participants who had a diagnosis of dyslexia and no co-morbid diagnoses. This increased the clarity and purity of working memory patterns (Savage et al., 2006), reducing additive WM deficits (Maehler & Schuchardt, 2016) and additional attentional deficit demands, which impact CE task performance (Jeffries & Everatt, 2004). The second group was a control group. The participants were selected based on being of a similar age and having a similar group gender ratio to the adolescents with dyslexia (Jeffries & Everatt, 2004). They were required to disclose whether they had experienced reading difficulties before participating, and they did not participate if they self-identified as having reading difficulties. Participants of both groups with a history of medical eye disease or a visual impairment that would have impacted their performance during the brightness tasks were also excluded (Talepasand et al., 2018). Participants were asked to verify the absence of these prior to participation.

3.2.6 Demographic Information

Initially, three adolescents participated in a pilot study (one male and two females, with a mean age of 12) (SD = 2.57). They were recruited using convenience sampling due to recruitment challenges and they completed all tasks on their own computers at home. These students did not have a specific learning difficulty, and their data was not included in the study, but instead, their experimental experiences were used to troubleshoot any technical or engagement difficulties while undertaking the experiment. While not including adolescents with dyslexia may be a limitation for troubleshooting dyslexia specific engagement difficulties, the pilot did highlight a technical difficulty with one part of the experiment, the need for a demonstration video as well as instructions, and software compatibility difficulties. Following this, each of the 104 post-primary schools listed on the Department of Education and Skills Statistics Section for Dublin 2019/2020 (DES, 2020) were invited to participate in

the research study. A further five convenience-sampled post-primary schools and the Dyslexia Association of Ireland were invited to participate. Four post-primary schools (two urban; two rural) and some students who attended the Dyslexia Association agreed to participate in this project. This included two co-educational schools, an all-male and an all-female school, including lower, middle, and higher socio-economic areas, with a total of 35 males and 36 females. Participants' ages ranged from 12 to 14 years. Six of these participants (3 male and 3 female) completed the experiment at home instead of a school setting but followed the same experimental procedure.

3.2.7 Apparatus

Participants' own laptops were used to present stimuli and for the purpose of data acquisition. PsychoPy V.3.0 software (Pierce et al., 2019) was used to design working memory tasks, and the Pavlovia online platform hosted and ran the experiment.

3.2.8 Stimuli

3.2.8.1 Maintenance tasks stimuli. Maintenance tasks followed the procedure of Mikels et al. (2008), and performance scores for emotion and brightness intensity were established to determine whether there was interference to intensity maintenance from the interval tasks. Mikels et al. (2008) provided the normative emotional intensity ratings used in the present study for the International Affective Picture System (IAPS) (Lang et al., 1997). Normative intensity ratings for these images were used to provide a baseline distribution score for measuring this subjective construct. Normative intensity ratings were obtained from 120 participants who gave subjective impressions of the intensity of the feelings they experienced when viewing the image (Mikels et al., 2008). Mikels et al. (2008) also gathered subjective norms for the brightness images, similarly to the affective intensity ratings. However, the brightness intensity for this study was measured using the image processing toolkit in Matlab (Matlab, 2010) to gain the actual brightness intensity data rather than

normed perceptions of brightness. Luminance scores were computed via a series of transformations to account for the spectral sensitivity of human vision and the non-linearity of luminance perception (Marques, 2011).

Both positively and negatively valenced images (*n* = 20) and neutral images (n = 20) from the IAPS (Lang et al., 1997) were selected. The positive and negative images had similar intensity ratings (2.63-4.55), but they differed in pleasure ratings (i.e., negatively valanced images were rated between 1.45- 4.59, while positively valenced images had a pleasure rating of between 5.00-8.34). A paired-samples t-test and additional descriptive analyses were conducted to investigate whether there was sufficient variance in intensities between paired images for both the affect and brightness maintenance tasks. This study's overall affect intensity varied from 2.63 to 4.55, and the overall brightness intensity varied from -8.98 to 40.66. The affect intensity ratings were less varied than those of Mikels et al.'s (2008) study; whose affect intensity range was 2.2-6.1 (*M* = 4.07, *SD* = 1.01). This study had larger variance of brightness intensity ratings between image pairs than those reported in Mikels et al. (2008), whose brightness intensity range was 2.04-7.13. This range was required to ensure age-appropriate images were used, and was also recommended in previous literature.

3.2.8.2 Retention Interval Stimuli. Affective and neutral words were selected from *The Affective Norms for English Words* (ANEW), to be used as N-back stimuli. The list was ordered by valence ratings and then split into three sections. The first section had words with negatively valenced words. The second had neutral valenced words, and the third had positively valenced words. Age-appropriate words were selected from the second section to form the neutral valence word group (Range = 4.61-6.59), and from the positive valence (Range = 6.68-8.72) and negative valence (Range = 1.61-3.64) word groups to form the affective word group. Affective and neutral word groups were matched based on word length

and syllables. Sequences of words in the N-back task were kept simple, mainly limited to one- or two-syllable words, as word length affects processing in students with dyslexia (Kibby et al., 2004). The font Comic Sans was used to make reading tasks more accessible for participants (British Dyslexia Association, n.d.).

3.2.8.3 Cognitive Emotional Regulation Questionnaire. The CERQ questionnaire is reported to have good factorial and construct validity, in addition to good discriminative properties, with most of the subscales being above .70 and many of the scales having above .80 internal consistency (Garnefski et al., 2002). The Cognitive Emotional Regulation Questionnaire, short version (CERQ-short), has strong empirical support in relation to its ability to capture cognitive strategies and individuals' styles of response to stressful events, and it is particularly suited to research with time and space constraints, in comparison to the longer version (Garnefski & Kraaij, 2006). The Cronbach alpha of the CERQ-short is lower than that of the extended version. However, it includes a range from its lowest subscale (self-blame) reporting ($\alpha = 0.68$) and its highest subscales (positive re-appraisal and catastrophising) reporting ($\alpha = 0.81$). The internal consistency for the rumination subscale is $\alpha = 0.79$. It is deemed suitable for clinical and non-clinical populations (Feliu-Soler et al., 2017).

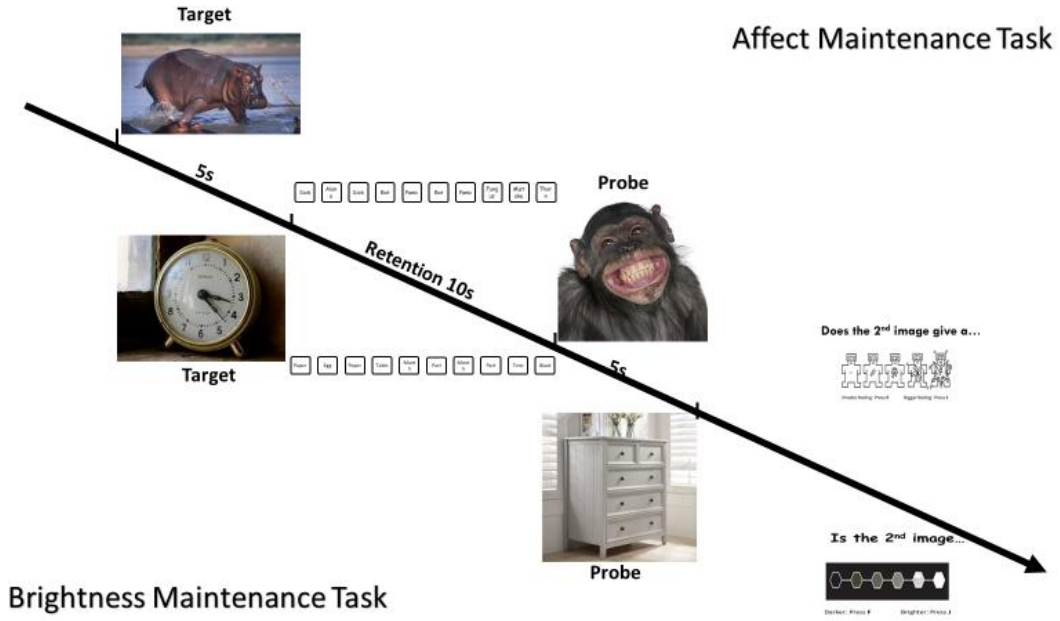
3.2.9 Procedural Design

Tasks were firstly piloted with non-participating adolescents, as per Section 2.3.4 of the PSI code of ethics, which states that pilot studies should be carried out to consider the use of new procedures or techniques and any risk entailed before being used on a broader scale (PSI, 2011). During the experiment, participants entered demographic information regarding gender, and they subsequently received a pre-screening demonstration of tasks before beginning the experiment. This multi-media demonstration (audio-visual) was shown to ensure that participants were comfortable with the intensity of tasks and understood the

procedures. Multi-media environments (if not surpassing the limitations of information processing systems) can increase learning for students with dyslexia (Andresen et al., 2018). This pre-screening was followed by a trial run of each maintenance task (which includes a 10-word N-back cycle during the retention period), as students with dyslexia demonstrate less difficulty in WM when tasks are not novel (Kimmpa et al., 2018; Rasamimanana et al., 2020). Graphics were added beside textual instructions during the experiment, as this is a recognised effective pedagogical supplement for students with dyslexia (Smith et al., 2019). Task parameters for both maintenance tasks were identical: image A was shown on screen for five seconds, followed by a retention interval (10.5s), which included a cross (0.5s) and then 10 words, each remaining on the screen for one second. A prompt followed the second image, one which suggested a response via a keypress, to signal whether the second image was judged to be of greater or less intensity than the first. Of note, participants were presented with affective or brightness judgement tasks as two separate blocks phases (i.e., all brightness judgement tasks were placed together in one block, and likewise, all affective judgement tasks were in a separate block; see Figure 2, below).

Figure 2

Graphical representation of a sample affective and brightness trial used in the experiment



Note. Each trial included a target image, followed by a retention interval task for 10s, followed by a probe image. Participants had to then determine whether the intensity of the affective reaction or perception of brightness to the probe were greater or less than those of the target image. These images were not used in the study; they are sample images (used to protect IAPS copyright).

3.2.9.1 Between and Within Subject Factors. The overall design was a mixed-factor design, maintenance task type was the within-subject factor, with two levels (affect and brightness). The congruence between the maintenance task type was a between-subject factor, with two levels (congruent and incongruent); i.e., affect maintenance or brightness maintenance tasks were congruent or incongruent with affective or neutral interference tasks, depending on their group. Congruency was a between-subject factor used to prevent the fatigue effect of multiple trials (Mikels et al., 2008). See Table 1, below, with a visual representation of congruent and incongruent trial sequence.

Table 1

Congruent and Incongruent Trial Matrix

	Affect Maintenance	Brightness Maintenance
Congruent N-back	Affective N-back	Non-affective N-back
Incongruent N-back	Non-affective N-back	Affective N-back

Note. This matrix shows what a congruent and incongruent trial sequence would look like, e.g., affect maintenance with a congruent N-back includes an affective N-back task, whereas with an incongruent task includes a non-affective N-back.

3.2.9.2 Intensity Maintenance Tasks. The maintenance tasks required participants to view an image and remember the feeling evoked or brightness experienced over an interval, then compare its affective intensity or luminosity to that of a post-interval second image. Affect maintenance tasks demonstrate test-retest reliability similarly to other WM tasks, albeit with greater reliability for higher performers (Broome et al., 2012). Brightness maintenance tasks were found to be a suitable comparable measure of WM, intended to be a 'non-affective' control condition. Brightness maintenance is more reliable when easier comparison images are used (Broome et al., 2012); therefore, greater variance in intensity differences between pairs was allowed for brightness maintenance intensities in this study. There is some evidence of a relationship between emotion and brightness maintenance, but also data to suggest that these maintenance processes are separate domain-specific mechanisms of WM (Broome et al., 2012), e.g., Mikels et al. (2008) found a double disassociation using interference methodologies between cognitive and affective WM tasks.

3.2.9.3 N-Back Interference Tasks. The interference tasks took place within the maintenance retention intervals (10.5 seconds) and involved N-back computer tasks using *The Affective Norms for English Words* (ANEW) (Bradley & Lang, 1999). The inclusion of

interference tasks during the retention interval was necessary to ensure other verbal or visual memory strategies were not used (Mikels et al., 2008). The N-back interference tasks used neutral linguistic information during one of the maintenance intervals (affect or brightness maintenance) and affective (i.e. both positive and negative) linguistic information for the other maintenance interval. Both reaction time and accuracy for the linguistic information were measured (Rączy & Orzechowski, 2019). The mean accuracy across all trials was calculated, and a 'no response' or incorrect response was recorded as incorrect (Pe et al., 2013). While Mikels et al. (2008) focused primarily on concordance scores without consideration of response times, the present study did record response times as well as concordance. Response times in WM studies (including studies with emotional stimuli) can explain more meaningful WM variance than concordance can (Hur et al., 2017; Meule, 2017). Previous WM studies report its predictive value in measuring literacy competency for students with reading difficulties (Savage et al., 2006). A mean correlation of 0.27 is reported between N-back working memory tasks and other putative measures of WM, including the OSPAN (Schmeichel et al., 2008).

3.2.9.4 Emotional Regulation Covariates. Jiboc (2019) reports positive refocusing, rumination and catastrophising as the main cognitive emotional regulation strategies which are reported to be significantly different for early adolescents with dyslexia compared to their peers. This study found a similar reported difference in positive refocusing strategies, but also positive reappraisal strategies (see section 3.3.1 below for further details). However, based on previous theoretical findings and the findings within this current study, only those particular ER strategies (positive refocusing, positive reappraisal, rumination and catastrophising) will be included as covariates, not all nine ER subscales. Kahan et al. (2014) argue that adjusting the covariates to include those that are known prognostic covariates substantially increases the power of the analysis.

3.2.9.5 Participants' Perspectives. Following the brightness and affect maintenance tasks, participants self-rated their experiences of maintaining emotion and brightness, and they selected the tasks that they found easier to maintain.

3.2.10 Ethical Challenges

Mary Immaculate College, Limerick granted ethical approval for this study. The study followed the PSI code of Ethics. Townsend (2020) cautions that there are extra ethical challenges conducting research during a global pandemic such as ensuring the research does not add additional stress to participants. Informed consent was obtained, and the software, launch platform and data retention were GDPR-compliant. Participants could withdraw participation at any stage of the project. Please see chapter four and Appendix F (ethics certificate) for further ethical challenges.

3.3 Results

3.3.1 Cognitive emotional regulation strategies

An independent samples t-test was conducted to analyse ER strategies differences between the dyslexia and control group. A significant difference was recorded between groups, with adolescents with dyslexia reporting the use of increased positive re-focusing strategies, t (60.075) =2.185, p = 0.033, d = 0.62, and positive reappraisal strategies, t (66) =2.556, p = 0.013, d = 0.52. There was no significant difference between the criterion and the experimental/control group for the subscales of acceptance, t (66) = 1.540, p = 0.128, rumination, t (66) = -.814, p = 0.418, self-blame, t (66) = -.681, p = 0.498, catastrophising, t (66) = -.304, p = 0.762, other blame, t (66) = 1.606, p = 0.113, re-focus on planning, t (66) = .291, p = 0.772, or putting into perspective, t (66) = -1.119, p = .267. Adolescents with dyslexia used additional positive re-focusing strategies and positive reappraisal strategies in comparison to peers without dyslexia. Therefore, these two strategies (positive reappraisal and positive re-focusing) along with additional strategies noted in the literature (rumination

and catastrophizing) (Jiboc, 2019) will be included as covariates to understand the role they play in processing affective or less affective information.

3.3.2. Preliminary Check for Order Effects

Each participant completed two phases of the maintenance task (one each of brightness and affective maintenance), with order of maintenance tasks counterbalanced 50/50 among the entire sample. Preliminary checks were first completed to analyse if the phases in which tasks were presented impacted the results, i.e. the order of tasks-whether they were in the first or second phase. A four-way interaction was also conducted to investigate the order in which the maintenance tasks were presented (brightness first or affective first) the phase of the task (first or second), the congruency of maintenance and N-back tasks (congruent or incongruent), and grouping (dyslexia or control group). This four-way interaction was non-significant, i.e. p = >.05. This lack of effect was expected given that tasks were counter-balanced. The subsequent analyses were conducted with the assumption that the main interaction effect of interest (the interaction of maintenance task performance, maintenance/interval task congruence, and group) did not interact with the order in which the maintenance tasks were completed (i.e. if the brightness maintenance or affective maintenance task came first). Therefore, phase was removed from the subsequent analyses. However, some lower-order effects and interactions with task sequence were noted and are listed in Appendix M.

3.3.3 Concordance and accuracy for affective and brightness maintenance tasks

3.3.3.1 Maintenance tasks and groups. A three-way mixed ANOVA was conducted to determine whether there was an interaction of maintenance task type (i.e. brightness or affective maintenance), congruency between maintenance and N-back task, and dyslexia grouping. This interaction was non-significant, $F(1, 64) = 1.140$, $p > .05$, partial $\eta 2 = 0.017$, i.e., the maintenance task accuracy or concordance with normed data did not differ based on

the interference during interval tasks or by dyslexia grouping. There were also no significant two-way interactions ($p > .05$). See Table 2 and Figure 3 below.

Table 2

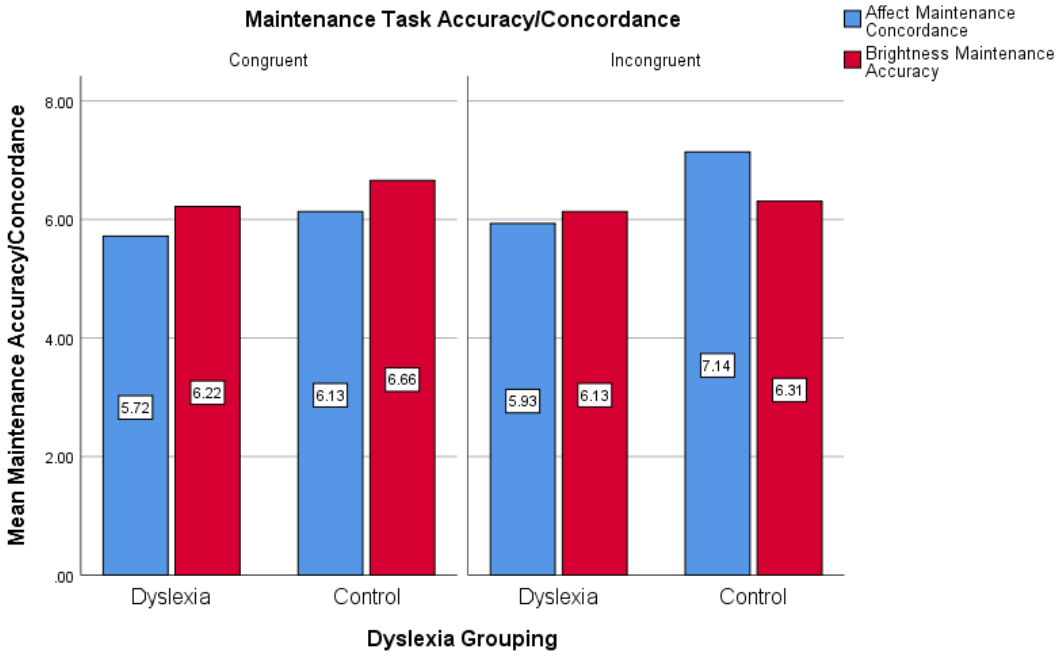
Maintenance Accuracy/Concordance

	Dyslexia Group	**Control Group**
Affective maintenance/ Congruent N-back	(*M* = 5.71, *SD* = 1.36)	(*M* = 6.13, *SD* = 1.45)
Affective maintenance/ Incongruent N-back	(*M* = 5.93, *SD* = 1.38)	(*M* = 7.14, *SD* = 1.83)
Brightness Maintenance/ Congruent N-back	(*M* = 6.21, *SD* = 1.54)	(*M* = 6.66, *SD* = 1.41)
Brightness maintenance/ Incongruent N-back	(*M* = 6.13, *SD* = 1.64)	(*M* = 6.30, *SD* = 1.02)

Note. This figure shows N-back accuracy differences by group when congruent or incongruent with maintenance tasks.

Figure 3

Maintenance Task Accuracy/Concordance

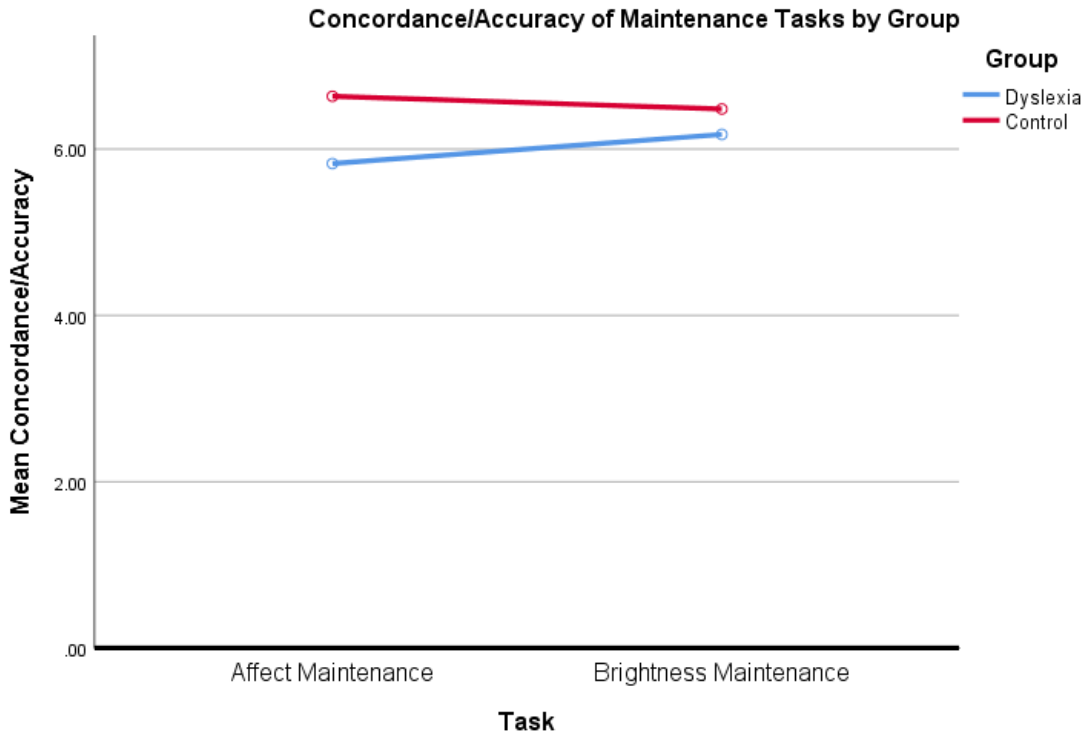


Note. This figure shows maintenance task accuracy/concordance by dyslexia grouping and congruency with the N-back task.

The three-way ANOVA did report a main effect for the dyslexia grouping, $F(1,64) = 4.663$, $p = .035$, partial $\eta 2 = .068$. This result and Figure 2 below indicate that the control group had overall higher concordance/accuracy scores than the dyslexia group, in both the maintenance tasks regardless of congruence with interval task. The control group had higher affect maintenance concordance ($M = 6.62$, $SD = 1.70$) than the dyslexia group ($M = 5.82$, $SD = 1.36$) and higher brightness maintenance accuracy ($M = 6.49$, $SD = 1.23$) than the dyslexia group ($M = 6.17$, $SD = 1.56$). See Figure 4 below.

Figure 4

Group Concordance/Accuracy of Maintenance Tasks



Note. This figure shows group differences on affect maintenance concordance and brightness maintenance accuracy.

Given the main effect between the two groups and the focus of the research, further analysis was conducted to investigate this group difference. This research aims to analyse performance differences between the types of tasks and the performance differences between the groups on each maintenance task. The mixed ANOVA already noted a lack of group difference between the maintenance tasks (i.e. the dyslexia group scored similarly on the affective and brightness maintenance tasks, and likewise the control group scored similarly on both maintenance tasks). Therefore, this follow-up analysis did not compare group differences again across the maintenance tasks but instead analysed the differences between the groups within each maintenance task (i.e. group differences for affective and brightness maintenance separately).

A one-way ANOVA found a significant difference between the affect maintenance concordance of the dyslexia group (M = 5.8226, SD = 1.357) in comparison to the control group (M = 6.6216, SD = 1.701), $F(1,67) = 4.457$, $p = .039$, partial $\eta 2 = .063$. The control group was significantly more concordant at maintaining affective information.

A second one-way ANOVA reported no significant difference in brightness maintenance accuracy between the dyslexia group (M = 6.1774, SD = 1.562) and the control group (M = 6.486, SD = 1.233), F(1,67) = 0.831, p > .05, partial $\eta 2 = .012$. Therefore, both groups were comparable on this visual task.

Previous studies hypothesised that ER strategies could be involved in working memory processing (Dunn et al., 2007; Frank et al., 2020; Schweizer et al., 2019). Therefore, the main mixed ANOVA analysing the interaction of maintenance task type (affective and brightness maintenance), congruency, and dyslexia grouping was repeated with the addition to the four chosen covariates (i.e. an ANCOVA was conducted), but the three-way interaction was still non-significant, $F(1, 60) = 1.632$, $p > .025$, partial $\eta 2 = 0.013$. Of note, there was a significant main effect for catastrophising $F(1,60) = 6.51$, $p = .013$, partial $\eta 2 = .098$. Therefore, catastrophizing, but not the other ER strategies ($p > .025$), may be associated with how information is maintained.

To analyse this main effect further, two simple linear regression analyses were conducted to analyse if the catastrophising subscale explained some of the variance in affective or brightness maintenance tasks. Catastrophising explained some variation of affective information (affect maintenance), $F(1, 67) = 8.036$, $p = .006$, $R^2 = .109$, but not visual information (i.e. brightness maintenance), $F(1, 67) = 1.099$, $p > .05$, $R^2 = .016$.

3.3.3.2 Accuracy of Retention Interval N-back Tasks. Mikels et al. (2008) study analysed the accuracy of one of their interval tasks (visual search). This study also measured accuracy of the interval task but used word stimuli instead of the visual search. There was no

significant interaction between N-back tasks, dyslexia grouping, and congruency, i.e. accuracy did not differ when considering the congruency of tasks and groups, F (1, 63) = .650, p > .05, partial η2 = .010. However, there was a main effect reported for N-back task type, F (1, 63) = 5.569, p = .021, partial η2 = .081. There was greater N-back accuracy for neutral words (M = 2.5336, SD =.49124) as opposed to affective words (M = 2.4343, SD =.51480).

While a main effect of task type indicated that participants were overall less accurate for affective N-back words, a lack of three or two-way interactions indicated that this effect did not differ between participants with or without dyslexia, and was irrespective of the congruence of N-back words with the content of the maintenance tasks. See Table 3 and Figure 5 below for further information on N-back accuracy results.

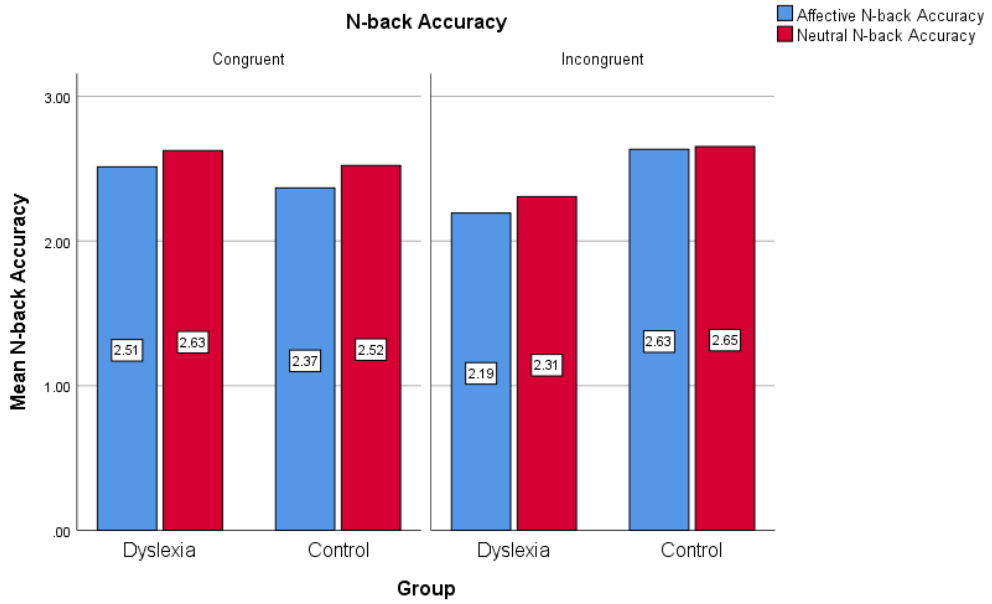
Table 3

N-back Accuracy

	Dyslexia Group	**Control Group**
Affective N-back/ Congruent Maintenance	(M = 2.51, SD =.38)	(M = 2.37, SD = .68)
Affective N-back/ Incongruent Maintenance	(M = 2.19, SD = .54)	(M = 2.63, SD = .30)
Neutral N-back/ Congruent Maintenance	(M = 2.63, SD = .40)	(M = 2.52, SD = .58)
Neutral N-back/ Incongruent maintenance	(M = 2.30, SD = .60)	(M = 2.65, SD = .31)

Figure 5

N-back Accuracy



Note. This figure shows N-back accuracy differences by group when congruent or incongruent with maintenance tasks.

The four ER strategies were included in the mixed ANOVA to conduct an ANCOVA, however this resulted in all non-significant effects including for N-back task-type $F(1, 59) = .001$, $p > .025$, partial $\eta 2 < .001$. There was no association between ER strategies and N-back task accuracy.

3.3.4 Reaction Time Data

3.3.4.1 Testing Reaction Time Data for Normality. Assumption tests were first conducted to test the normality of reaction time data distribution for both the N-back and maintenance tasks, as reaction time distributions tend to be skewed by more long responses than short responses (Whelan, 2008; Fernandez & Vadillo, 2020). Kolmogorov-Smirnov tests indicated that reaction times for the first round of N-back tasks were normally distributed, $D(672) = .034$, $p > .05$; however, the other three distributions were significantly non-normal (reaction times for second round of N-back tasks: $D(672) = .040$, $p = .013$; reaction time for

first round of maintenance tasks: $D(672) = .270$, $p < .001$; and reaction time for second round of maintenance tasks: $D(672) = .174$, $p < .001$).This non-normality was confirmed by inspection of histograms and Q-Q plots.

As standard normality tests are known to produce Type-1 errors in large samples and this study containing hundreds of RTs, the normality tests were confirmed by obtaining standardised skewness scores. These standardised skewness scores were obtained by dividing the skewness by its standard error, and results were compared to cut-off criteria for statistical significance with alpha of 0.05 (Field, 2018). These scores showed the same pattern of non-normality.

A Box Cox transformation was conducted to normalise the skewness and distribution of data (Box & Cox, 1964). RT's were transformed for analysis by using the anti-logs of the mean log-transformed RT's for each 'condition-by-group' combination (Box & Cox, 1964). Raw reaction times were transformed using the natural logarithm transformation. Then for each factorial combination, the mean log-RT was computed, and then the anti-log of this value was obtained for final analysis. Anti-logs (exponents) were used instead of log-transformed scores so that the variables could be more easily interpreted as the same scale as raw scores. In other words, they can be interpreted as response times instead of log response times. This procedure applies to all RTs used for analysis throughout the study. One data point (1.3% of the overall dataset), which was an outlier, i.e. two standard deviations beyond the mean of reaction times, was removed (Whelan, 2008).

3.3.4.2 Reaction Times for Maintenance Tasks. A three-way mixed ANOVA with maintenance task type as a within subjects factor, and congruence and group as between subjects factors found no significant three-way interaction between maintenance task type (affective or brightness), the congruency of the maintenance and N-back task, and dyslexia grouping, $F(1, 63) = .107$, $p > .05$, partial $\eta 2 = .002$**.** For the dyslexia and control groups, RT

performance on both the affective and brightness maintenance tasks was not affected by the interval task's congruence, i.e. there was no difference in the amount of interference between the maintenance and interval tasks for affective and less affective material. There were no two-way interactions or main effects, $p > .05$. See Table 4 and Figure 6 below.

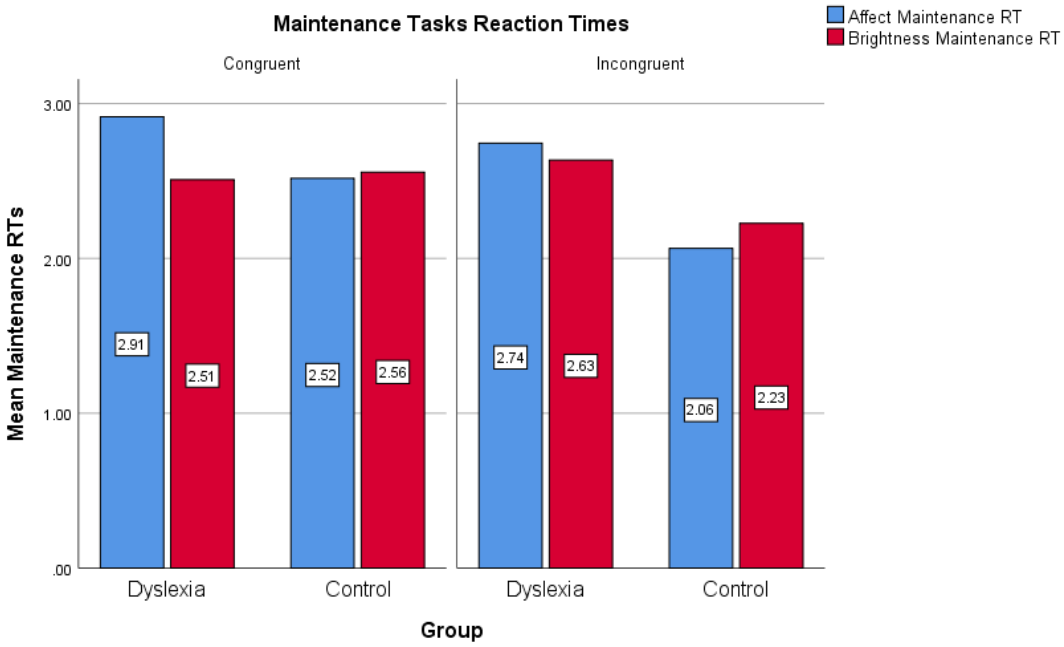
Table 4

Maintenance Task Reaction Time

	Dyslexia Group	**Control Group**
Affective maintenance/ Congruent N-back	(*M* = 2.91, *SD* = 1.40)	(*M* = 2.51, *SD* = 1.30)
Affective maintenance/ Incongruent N-back	(*M* = 2.74, *SD* = 1.36)	(*M* = 2.06, *SD* = .80)
Brightness Maintenance/ Congruent N-back	(*M* = 2.50, *SD* = 1.18)	(*M* = 2.55, *SD* = 1.35)
Brightness maintenance/ Incongruent N-back	(*M* = 2.63, *SD* = 1.33)	(*M* = 2.22, *SD* = 1.02)

Figure 6

Maintenance Tasks Reaction Times



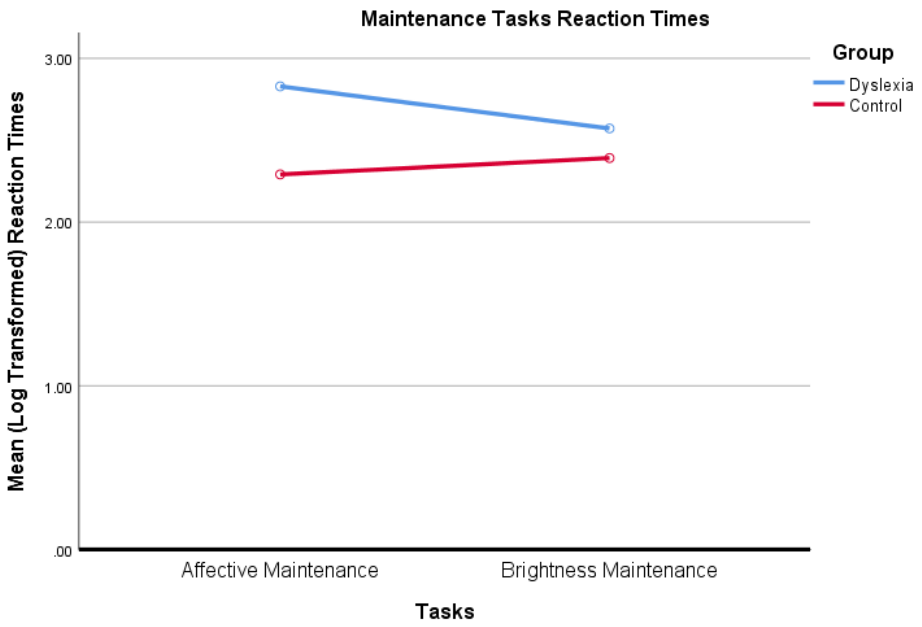
Note. This figure shows maintenance task reaction times by group and when they are congruent or incongruent with N-back tasks.

The four ER strategies were included in the mixed ANOVA, to analyse the potential role ER may play in the reaction time for affect related working memory processes. This ANCOVA found no interaction effects, all *p's* > .025. Therefore, ER strategies were not associated with the reaction time for maintenance tasks.

Similar to maintenance accuracy/concordance, a simple main effects analysis was conducted to analyse any group differences for the reaction times of maintenance tasks. Two one-way ANOVAs reported no significant effect between maintenance task type (i.e. brightness or affective) and dyslexia grouping, both *p* > .025. Therefore, there was no significant group differences in reaction times for either task. See Figure 7 below for visual on maintenance task reaction times.

Figure 7

Maintenance Reaction Times by Group



Note. This figure shows maintenance task reaction times by group.

3.3.4.3 Reaction Time of Retention Interval N-back Tasks. Reaction times were also measured for N-back interval tasks similar to Mikels et al. (2008). However, this study included the addition of the dyslexia grouping variable. A three-way mixed ANOVA with N-back task type as a within subjects factor, and congruence and group as between subjects factors found no significant three-way interaction between N-back task type (affective or neutral), the congruency of the maintenance and N-back task, and dyslexia grouping, $F(1, 63) = 1.978$, $p > .05$, partial $\eta 2 = .030$. There was no two-way interactions, $p > .05$, however, there was a main effect of task type (affective versus neutral), $F(1, 63) = 7.569$, $p = .008$, partial $\eta 2 = .107$. There was quicker accurate reaction times for neutral words ($M = .5650$, $SD = .07439$) in comparison to affective words ($M = .5884$, $SD = .07507$). Although the valence of words affected the reaction time, a comparison of these RTs and congruency of task for the dyslexia and control cohort showed similar responses, i.e. both were quicker responding correctly to neutral words. See Table 5 and Figure 8 below.

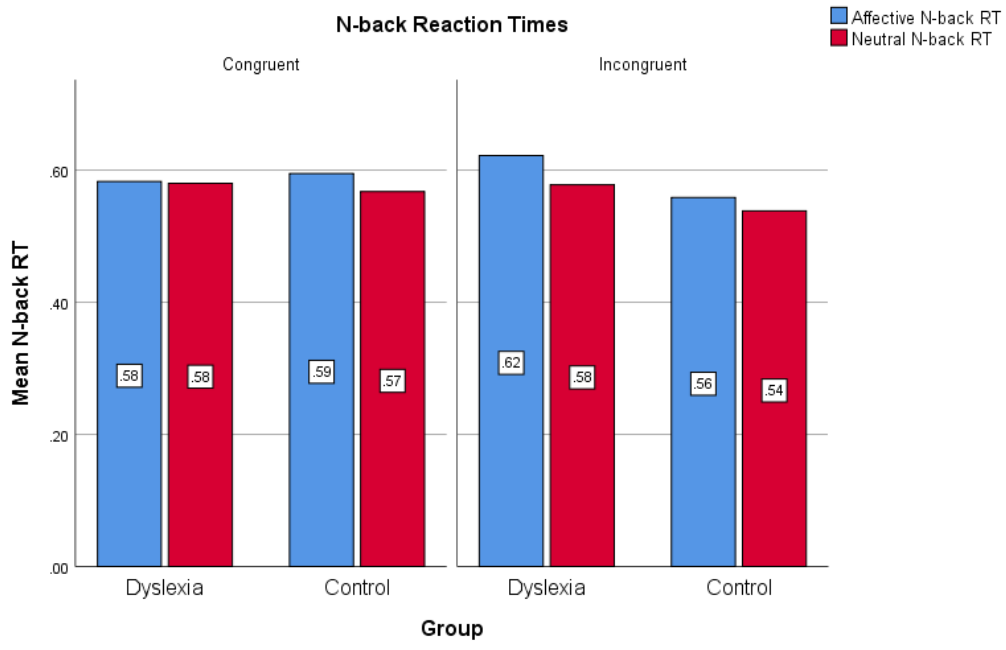
Table 5

N-back Reaction Times

	Dyslexia Group	**Control Group**
Affective Congruent Words	(*M* = .5829, *SD* = .6220)	(*M* = .5949, *SD* = .07490)
Affective Incongruent Words	(*M* = .6220, *SD* = .07390)	(*M* = .5587, *SD* = .06125).
Neutral Congruent Words	(*M* = .5802, *SD* = .0407)	(*M* = .5675, *SD* = .0751)
Neutral Incongruent Words	(*M* = .5779, *SD* = .1124)	(*M* = .5383, *SD* = .0535)
Reaction Time for the Affective Words	(*M* = .6018, *SD* = .0797)	(*M* = .5768, *SD* = .0698)
Reaction Time for the Neutral Words	(*M* = .5791, *SD* = .0819)	(*M* = .5529, *SD* .0659)

Figure 8

N-back Reaction Times



Note. This figure shows group differences in mean reaction time for affective and neutral words when congruent or incongruent with the maintenance task.

The four covariates were included in the mixed ANOVA to conduct an ANCOVA, however, this resulted in no significant interactions, $p > .025$ and a non-significant effect for N-back task-type $F(1, 59) = 1.28$, $p > .025$, partial $\eta 2 = .021$. ER strategies (positive re-appraisal, positive re-focusing, rumination, and catastrophizing) were not associated with N-back RT.

3.3.5 Accuracy/concordance of maintenance and retention interval tasks: combined interaction variables

The preceding analysis was based on the Mikels and Reuter-Lorenz experimental design (2008). Mikels and Reuter-Lorenz (2008) investigated the interaction of maintenance task with congruence by focusing on maintenance task reaction times and congruence as a purely grouping variable. This indirectly evaluates the impact of interval performance, but doesn't directly evaluate the actual performance scores during the interval task. As both maintenance and interval tasks are dependent on working memory, the interference between them may be bi-directional, so a focus on maintenance task performance only might not give a complete account of the effects of interest. Therefore, the researcher computed an interaction variable as the product of maintenance and interval task reaction time scores by trial and repeated the main analysis with this as the dependent variable. In doing this, it extended the conceptual design to include not only the interaction between the maintenance and interval tasks but also the combined interaction effect. This analysis of maintenance task type (affect or brightness), congruence between maintenance and interval task, and dyslexia grouping, affects working memory performance measured as the product of interval and maintenance scores. By using the interaction variable, it means the most accurate scores are those in which both tasks are accurate (least interaction), moderate scores will be those in which one of the two tasks is accurate (some interaction, and least accurate scores are those in which both tasks are inaccurate (can be interpreted as bidirectional or combined effect).

More inaccurate scores means greater interference between interval and maintenance scores. This means that the resulting means are no longer in the same scale as the original RTs so their absolute values are not meaningful for interpretation by themselves.

A three-way mixed ANOVA found a non-significant interaction between the maintenance task type, and its congruency with the N-back task for the dyslexia grouping, $F(1,64) = .511$, $p > .05$, partial $\eta 2 = .008$. However there was a significant two-way interaction between the maintenance task type and congruency $F(1,66) = 7.410$, $p = .008$, partial $\eta 2 = .101$. This finding is in line with Mikels et al. (2008) finding that the retention interval's affective quality impacts maintenance scores. However, Mikels et al. (2008) reported the affective interference task (down-regulation of images) interfered with the affective maintenance task, and the cognitive interference (visual search) interfered with the cognitive maintenance task; this study found affective interference during the retention intervals impacted on both affective and cognitive maintenance tasks. The observed pattern might relate to the choice of interval tasks in comparison to previous research. See Table 6 and Figure 9 below.

Table 6

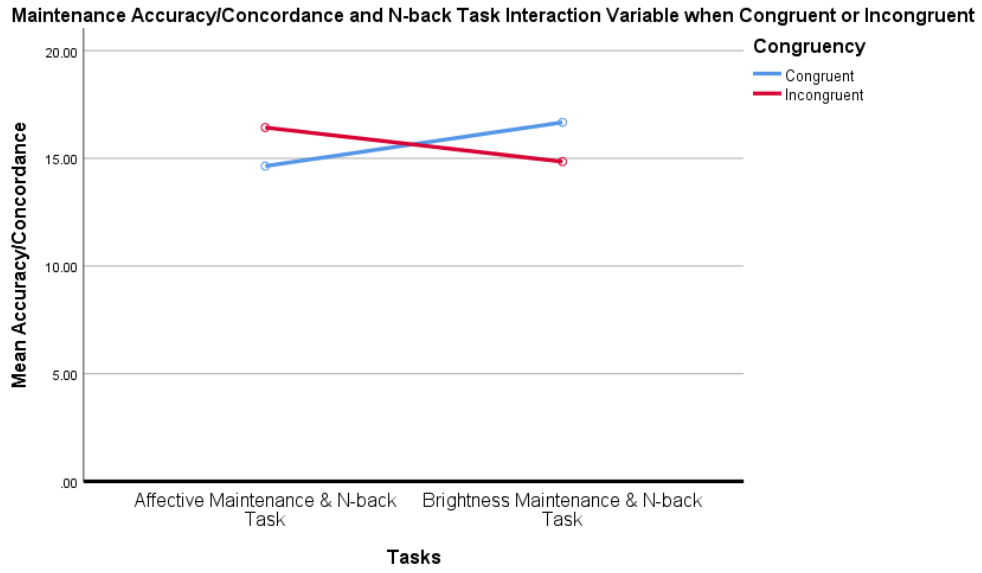
Maintenance and Interval Interaction Variable Accuracy

	Dyslexia Group	**Control Group**
Affective maintenance/ Congruent N-back	(*M* = 14.46, *SD* = 4.23)	(*M* = 14.81, *SD* = 5.35)
Affective maintenance/ Incongruent N-back	(*M* = 13.84, *SD* = 5.17)	(*M* = 19.01, *SD* = 5.61)
Brightness Maintenance/ Congruent N-back	(*M* = 16.35, *SD* = 4.92)	(*M* = 16.98, *SD* = 5.50)
Brightness maintenance/ Incongruent N-back	(*M* = 13.10, *SD* = 3.63)	(*M* = 16.58, *SD* = 3.11)

Note. This figure shows maintenance accuracy differences by group when congruent or incongruent with N-back tasks.

Figure 9

Maintenance and Interval Interaction Variable Accuracy/Concordance



Note. This figure shows mean accuracy/concordance for maintenance tasks when they are congruent or incongruent with the N-back task.

For affective maintenance tasks, the maintenance interval interaction variable showed higher concordance scores when the interval task was neutral (incongruent) (M = 16.6652, SD = 5.9405), than when the interval task was also affective (congruent) (M = 14.6557, SD = 4.88309). This is similar to Mikels et al. (2008) study. However, for the brightness maintenance tasks, the maintenance interval interaction variable showed higher accuracy scores when the interval task was neutral (congruent), than when the interval task was affective (incongruent). However, the brightness maintenance and interval interaction variable exhibited higher scores for the maintenance/interval tasks when congruent (M = 16.6971, SD = 5.1789) than incongruent (M = 15.8757, SD = 3.7473). Therefore, the affective word task may have operated as affective interference for both maintenance tasks.

Following, the significant two-way interaction effect between maintenance task type and congruency; simple main effects were then conducted for each maintenance task separately (i.e. affective and brightness maintenance) and congruency with N-back task. Two independent sample t-test investigated if these differences were statistically significant for each maintenance task. Both t-tests reported no significant difference in affective maintenance concordance or brightness maintenance accuracy when paired with a congruent or incongruent interval tasks, i.e. both $p > .05$.

However, the main mixed ANOVA also reported that there was an effect between the task congruency and the dyslexia grouping, $F(1,64) = 4.062$, $p = .048$, partial $\eta 2 = .06$, i.e. the grouping may impact on the difference found between task congruence. The dyslexia group scored similarly to peers on congruent tasks but found tasks that were incongruent more challenging. See Figure 10 and 11 below.

Figure 10

Maintenance and N-back Interaction Variable when Congruent

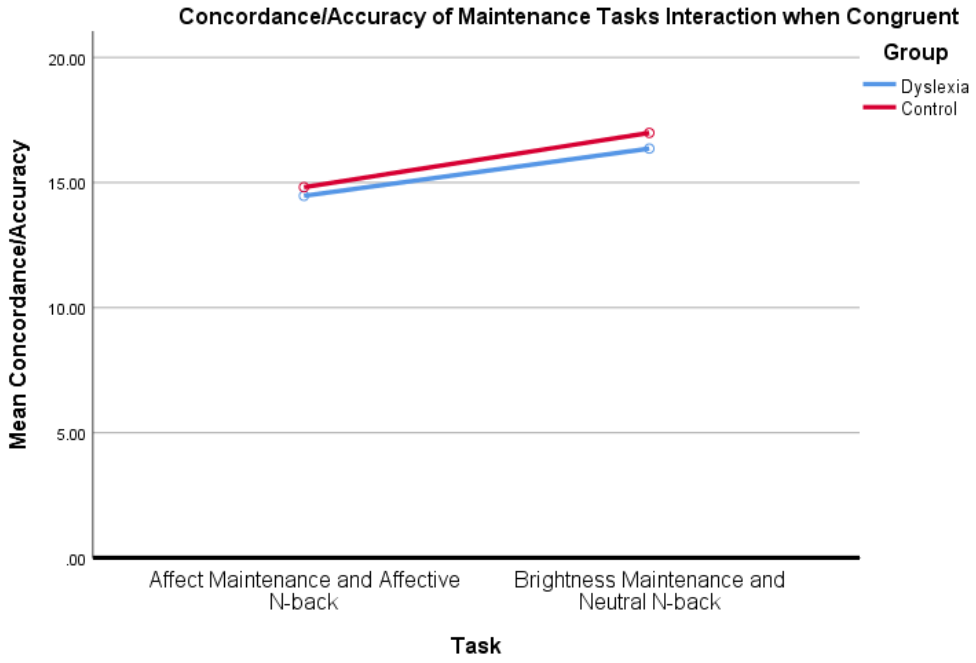
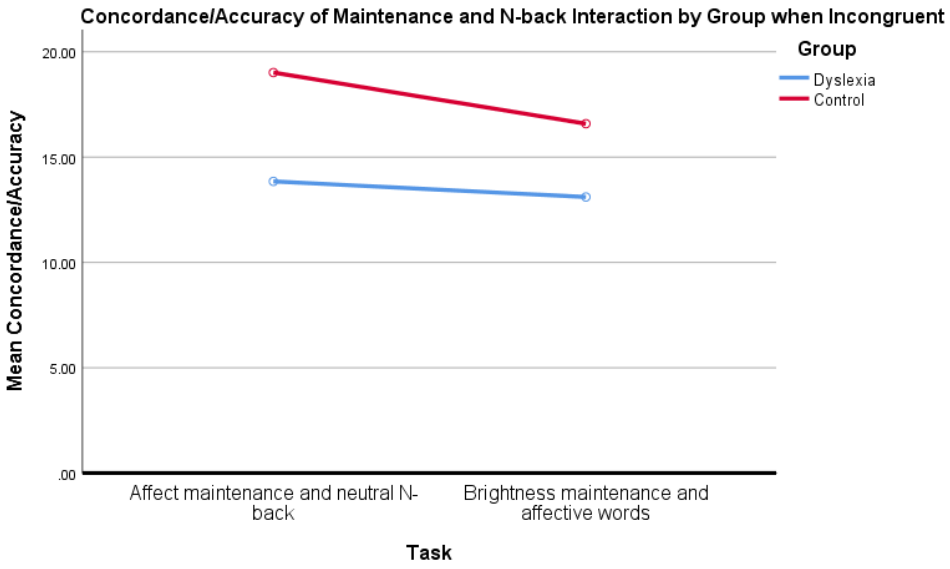


Figure 11

Maintenance and N-back Interaction Variable when Incongruent



Note. These two figures show the groups maintenance and N-back tasks investigated as an interaction variable, firstly when congruent and then incongruent.

Given the effect between dyslexia grouping and congruency on task performance; the two independent samples t-tests were conducted again to measure differences in brightness maintenance accuracy and affective maintenance concordance when congruent or incongruent with the N-back task, however, this time the dataset was split to compare the dyslexia and control group.

The first independent samples t-test noted a significant difference between the brightness maintenance accuracy when congruent or incongruent for the dyslexia group, $t(29) = 2.08$, $p = 0.046$, $d = 0.75$. The dyslexia group was significantly more accurate on brightness maintenance and the neutral N-back task (congruent) ($M = 16.35$, $SD = 4.91$), than brightness maintenance and the affective N-back task (incongruent) ($M = 13.10$, $SD = 3.63$), i.e. greater performance on visual tasks that were congruent. Brightness maintenance accuracy did not differ based on congruency for the control group, $p > .05$.

The second independent samples t-test noted a significant difference between the affective maintenance concordance when congruent or incongruent for the control group, $t(35) = 2.33$, $p = 0.026$, $d = 0.76$. The control group was significantly more concordant on affective maintenance and the neutral N-back task (incongruent) ($M = 19.01$, $SD = 5.61$), than affective maintenance and the affective N-back task (congruent) ($M = 14.81$, $SD = 14.81$). Affective maintenance concordance did not differ based on congruency for the dyslexia group.

Therefore, visual tasks that were incongruent caused particular difficulty for adolescents with dyslexia, but congruency of visual tasks did not change the accuracy of their peers. However, affective tasks that were incongruent enhanced the performance of the control group, but did impact the dyslexia group.

The mixed ANOVA also reported a main effect for the dyslexia grouping, $F(1,64) = 6.382$, $p = .014$, partial $\eta 2 = .091$. This main effect between groups highlights an overall

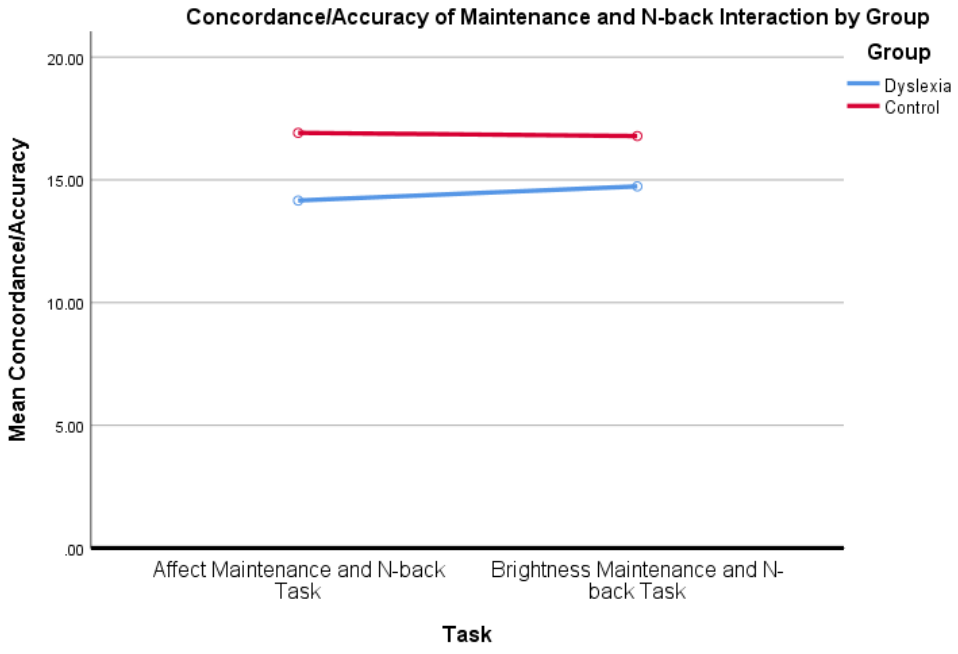
difference in accuracy and concordance for the maintenance and interval interaction variable for the dyslexia and control group. This difference was independent of congruency.

Further analyses of this main effect for group difference was conducted using two independent sample t-tests. The control group had statistically significant higher affect maintenance concordance (*M* = 16.86, *SD* = 5.81) than the dyslexia group (M = 14.17, SD = 4.73), *t* (66) = -2.066, *p* = .043, *d* = 0.51.

The second independent samples t-test reported a non-significant difference for brightness maintenance accuracy between the dyslexia (*M* =14.78, *SD* = 4.58) and control group (*M* =16.79, *SD* =4.44), *t* (66) = -1.828, *p* > .05, *d* = 0.44. See Figure 12 below.

Figure 12

Concordance/Accuracy of maintenance and N-back Interaction by Group



Note. This figure shows group differences for affect maintenance and N-back task interaction.

The four covariates were included in the mixed ANOVA to conduct an ANCOVA and analyse the role ER strategies might play on the accuracy/concordance of this maintenance interval interaction variable, however this resulted in a non-significant

interaction, $p > .025$. Given that catastrophising was associated with affect maintenance concordance, but has not shown up in this omnibus test where there are two interaction variables, further checks were completed for these maintenance and interval interaction variables. A linear regression noted that catastrophising did also predict affect maintenance and interval interaction concordance $F(1, 66) = 7.375$, $p = .008$, $R^2 = .101$, and similarly did not predict brightness maintenance and interval interaction accuracy, $F(1, 67) = 1.052$, $p > .05$, $R^2 = .016$.

3.3.6 Reaction times of maintenance and retention interval tasks-combined interaction variable

An interaction variable was also calculated as the product of maintenance and interval task reaction time scores by trial. The fastest scores are those in which both tasks are fast (least interaction). Moderate scores will be those in which one of the two tasks is relatively slow (some interaction), and the slowest scores are those in which both tasks are relatively slow (bidirectional effect). The main analysis was completed with this new interaction variable as the dependent variable. However, a three-way interaction of maintenance task type (affect or brightness with interval task combined), congruence between maintenance and N-back task, and dyslexia grouping found a non-significant interaction, $F(1,63) = .119$, $p > .05$, partial $\eta 2 = .002$. The combined maintenance and interval RT did not differ significantly based on the congruency between maintenance and interval tasks and dyslexia grouping.

A simple main effects analysis was conducted to analyse any group differences for reaction times of the maintenance interval interaction variable. Two independent sample t-tests found no significant difference between dyslexia grouping and maintenance task type, both $p > .05$, therefore there was no significant group differences in reaction times for either task. See Table 7 and Figure 13 below for visual of the reaction times for the maintenance and interval interaction variables.

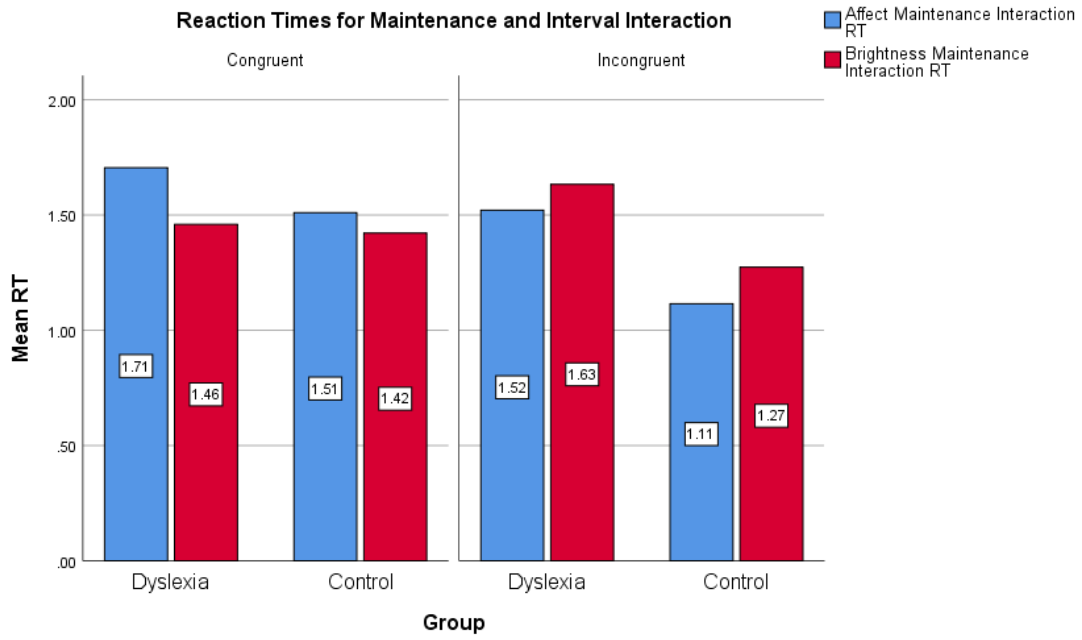
Table 7

Maintenance Task Reaction Time

	Dyslexia Group	**Control Group**
Affective maintenance/ Congruent N-back	(*M* = 1.70, *SD* = .89)	(*M* = 1.51, *SD* = .86)
Affective maintenance/ Incongruent N-back	(*M* = 1.52, *SD* = .68)	(*M* = 1.11, *SD* = .45)
Brightness Maintenance/ Congruent N-back	(*M* = 1.45, *SD* = .72)	(*M* = 1.42, *SD* = .70)
Brightness maintenance/ Incongruent N-back	(*M* = 1.63, *SD* = .85)	(*M* = 1.27, *SD* = .66)

Figure 13

Reaction Times for Maintenance and Interval Interaction



Note.

This figure shows the maintenance interval interaction when congruent and incongruent for the dyslexia and control group.

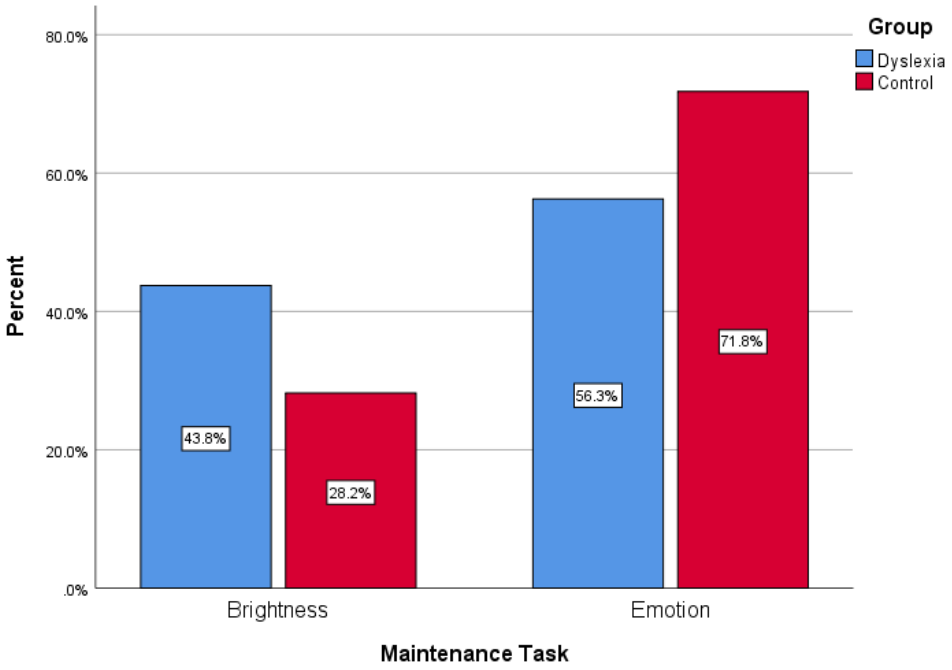
The four ER strategies were included once again in the mixed ANOVA to conduct another ANCOVA, and this resulted in non-significant interactions, all $p > .025$. The ER strategies were not associated with the reaction time of the maintenance interval interaction variable.

3.3.7 Subjective preference for maintenance task

A brief qualitative item recorded preference of maintenance tasks. Emotion maintenance was the preferred mode of information processing for all adolescents. However, this preference was less evident for adolescents with dyslexia, mirroring the quantitative findings, i.e. difficulties noted in affective maintenance tasks compared to peers. See Figure 14 below.

Figure 14

Subjective Preference of Maintenance Tasks



Note. This figure shows the subjective preference of maintenance tasks by group.

3.3.8 Summary of Results

- Adolescents with dyslexia had lower scores on both maintenance tasks than the control group.
- Adolescents with dyslexia overall showed less affective maintenance concordance than their peers without dyslexia, but they displayed similar accuracy overall for brightness maintenance. There was a similar finding for the affective maintenance and interval interaction variables.
- Incongruence between maintenance and interval task was significantly more challenging for students with dyslexia overall. Brightness maintenance with an incongruent N-back (i.e., affective N-back) was particularly difficult for adolescents with dyslexia. Affective maintenance with an incongruent N-back task (i.e., neutral N-back) increased performance for the control group, but not the dyslexia group.
- Reaction times for affective or less affective maintenance tasks did not differ between groups, but there were quicker accurate response times for less affective words. The type of maintenance task or participant's group did not significantly impact on these reaction times.
- Affective N-back word tasks served as interference during interval tasks for affective or less affective tasks.
- Catastrophising was a significant covariate for the maintenance of affective information. Other ER strategies (rumination, positive reappraisal, and positive refocusing) were not associated with the maintenance of affective information. All four ER strategies were not associated with the brightness maintenance task, reaction times for both maintenance tasks, or N-back tasks.
- Both groups preferred the maintenance of affective information to brightness maintenance, but this preference for maintaining affective information was reported to

a much lesser extent for adolescents with dyslexia (56.3%) than the control group (71.8%). In fact, the dyslexia group had an almost equal preference for both types of tasks.

- The dyslexia group reported increased use of positive cognitive ER strategies such as positive re-focusing strategies and positive reappraisal strategies compared to the control group.

3.4 Discussion

The results from the data analysis sought to answer the two main research questions. Firstly, the study was aimed at investigating the differences in working memory performance for adolescents with dyslexia in the context of affective information, in comparison to less affective information, and also in comparison to adolescents without dyslexia. Secondly, it was aimed at identifying differences in learning-based ER strategies for adolescents with and without dyslexia, in addition to which ER strategies could be associated with the processing of affect-related information.

3.4.1 What are the Differences in Working Memory Performance for Adolescents with and Without Dyslexia in the Context of Affective Stimuli?

3.4.1.1 Working Memory and Affective information. The affect-related working memory results demonstrate that students with dyslexia may find it more challenging to maintain affective information and experiences than peers. This links with Gray et al.'s (2019) finding of difficulty experienced with regard to maintaining mental representations (auditory and visual stimuli). Given the findings of reduced recall for affective information, this study raises the need for further evidence-based socio-emotional programmes which increase cognitive control of affective information and experiences. This finding is in line with the recent literature base which supports the inclusion of affective approaches such as

coping strategies and self-regulation for dyslexia reading interventions (Boyes et al., 2020; Cirino et al., 2017; Denton et al., 2020).

The maladaptive response of catastrophizing may require particular attention during interventions for adolescents (e.g., reframing and problem-solving automatic thoughts such as 'I'm going to fail this test' or 'I'll never get into college or get that job I want'). By targeting catastrophizing coping responses and how affective information is recalled, many emotional domains could benefit, which would impact on short- and long-term goals. It has been suggested to support affective forecasting and decision-making (Frank et al., 2020), motivation (Mikels et al., 2005), goal-directed learning (Schweizer et al., 2019) and general well-being (Broome et al., 2012)

3.4.1.2 Working Memory, Visual Information and Executive Functioning. The maintenance of brightness is described as a visual working memory task (Broome et al., 2012). This study found that adolescents with dyslexia were comparable to peers on this task, when tasks were congruent (i.e., there was less interference from other types of information). While Graham and Kershner (1996) report a lack of preference for either right-hemisphere (e.g., holistic/visual reading style) or left-hemisphere (e.g., sequential/auditory reading style) domains, this study found similar findings to Cooper (2006), who reported a preference for holistic visual thinking. This study adds to preceding literature stating that the primary deficit may not concern the visuospatial sketchpad (Jeffries & Everatt, 2004; Smith-Spark & Fisk, 2007), but rather when tasks must shift between different WM domains, such as from visual tasks to affective information. Romani et al. (2015) postulate that it is important to recognise positive contributing factors to reading abilities which are similar to peers (in this case, visual encoding), as it may circumvent other cognitive weaknesses through compensatory mechanisms.

Difficulties switching between different types of tasks may highlight executive functioning differences such as reduced competency in monitoring, inhibiting and paying attention to reading material for this cohort (Nachson & Horowitz-Kraus, 2018). While the control group had significant increases in maintenance of affect when the N-back task was incongruent, suggesting differences in WM subdomains for the control group, this same difference was not evident for adolescents with dyslexia.

3.4.1.3 Domain General Working Memory. While examining the group differences of tasks separately, the dyslexia group was less concordant on the maintenance of affective information and had similar accuracy to their peers with visual information. However, overall, each of the two groups scored similarly across both tasks. The scores between the affective maintenance and brightness maintenance were comparable for the control group, and at a lower level, the scores for the affective and brightness maintenance were also comparable for the dyslexia group. This pattern is suggestive of a domain general reduced resource interaction model of working memory (Daneman & Carpenter, 1980; Engle et al., 1992; Hachmann et al., 2020; Swanson et al., 2001).

Interestingly, this performance pattern was mirrored in the brief self-report preference. The dyslexia group had similar performance and preference for both tasks (brightness and affective maintenance), and had less of an aptitude and preference for affective maintenance than peers.

3.4.1.5 Maintenance Task Preference. Adolescents with dyslexia approximately rated both affective and brightness maintenance the same. However, in comparison to their peers, adolescents with dyslexia had much less of a preference for recalling affective information. There was still a slight preference for maintaining affective information as opposed to visual information. Tsukamoto et al. (2017) posit that participants tend to prefer tasks which require greater effort to achieve their goal (i.e., a task preference may not always

signify a strength). Nonetheless, it is important to elicit this preference towards the task, as it may influence participants' motivation for the task, which could be considered a more influential learning factor over the long term, rather than the participant's actual ability. Yüvrük et al. (2020) argue that positive motivation towards learning influences working memory performance among university students with dyslexia more than a person's emotional state, and others agree that motivation may influence academic endeavours more than cognitive factors (Livingston et al., 2018; Lockiewicz et al., 2014). Therefore, while AWM was less effective for adolescents with dyslexia, the use of affect was equally as popular as the visual encoding method for processing information.

3.4.1.6 Reaction Times. There was a non-significant difference between reaction times for adolescents with and without dyslexia. Similarly, previous literature concerning choice reaction times among children with dyslexia has shown comparable performance with peers (Bonifacci & Snowling, 2008; Gooch et al., 2012). Gooch et al. (2012) hypothesise that the difference in the speed of processing may be related solely to verbal information. Therefore, the processing time for familiar visual or affective information may not be impaired. However, processing other domains that were not part of this study, such as verbal/auditory information, may slow the processing speed required (Jeffries & Everatt, 2004; Kibby, 2004; Smith-Spark & Fisk, 2007).

Of note, participants demonstrated quicker reaction times for maintenance tasks as they progressed through the experiment; there was a main effect of task phase, with quicker reaction times for maintenance tasks in phase two in comparison to phase one. Adolescents with dyslexia can find novel tasks more difficult than peers (Gray et al., 2019; Smith-Spark & Fisk, 2007; Swanson & Sachse-Lee, 2001), primarily due to the requirement for coordination, automatisation and the integration of unfamiliar information (Nicolson et al., 1995, 2001). However, with practice in the novel tasks, skill integration was quickened. This finding

suggests that additional practice, and time to process any novel task should be given to adolescents with dyslexia, in order to enhance the fluency of new skills so that they become smoothly integrated within the learning process.

3.4.1.5 Affective Word Stimuli. There was greater accuracy for neutral words overall, similar to the findings of Raczy and Orzechowski (2019) and Mammarella et al. (2014). Mammarella et al. (2014) reported that shorter tasks favoured better memory recall for affective literacy; however, neutral words are easier to recall if there is a high working memory load. This accuracy in relation to neutral words did not differ between groups or depending on the affective nature of the tasks that came before and after this language-related task. Therefore, high WM load on language-related tasks may be easier to recall for all adolescents if they contain less affective language-related content.

3.4.1.5 Affective Interference. Affective concordance and brightness accuracy scores were higher when there were neutral interference tasks. These scores demonstrate that affective interference may have an influence on working memory performance, as with previous literature on affective maintenance for adolescents (Mirabolfathi et al., 2020). Furthermore, Schweizer et al. (2019) assert that this developmental stage may be particularly attuned to affective contexts, content and interference.

3.4.2 What are the Differences in Emotional Regulation Strategies for Adolescents with and without Dyslexia in the Context of Affective Learning Events?

3.4.2.1 Group Differences in Emotional Regulation Strategies. Previous literature relating to adolescents with specific learning difficulties has reported increased emotional distress experiences compared to their peers (Svetaz et al., 2001) and increased internalising behaviour such as feelings of anxiety, low self-esteem and depression (Bonifacci et al., 2020; Boyes et al., 2019; Nachson & Horowitz-Kraus, 2018). However, this study joins the growing literature base which identifies some strengths, such as positive adaptive coping strategies

(Jiboc, 2019; Kannangara et al., 2018). Adolescents with dyslexia in this study reported the efficacy of some positive ER strategies, which included positive re-focusing and reappraisal strategies. Positive emotional processing strategies may serve as important protective factors (Burden, 2008; Riddick, 2003).

It is possible that emotionally challenging experiences, such as having a specific learning difficulty, may result in the adoption of positive coping strategies. Evolutionary developmental biology (Evo-Devo) models of stress and dyslexia postulate that adverse stressors can encourage adaptive behavioural responses and stress responsivity, which may be costly, as the subclinical stress and physiological adaptations from dysregulation can attenuate neuroplasticity and compromise attentional network development (Kershner, 2021). Attentional networks involved in reading processes, such as cognitive growth in the right hemisphere ventral and dorsal attention networks, are known to modulate auditory phonological and visuospatial processing, regularly noted in dyslexia etiological literature (Elliott & Grigorenko, 2015; Kershner, 2021). Therefore, greater adaptive ER responses may be learned protective factors but may inhibit the development of other cognitive systems.

3.4.2.2 Catastrophising and Affect-related Learning. This study found that the ER strategy of catastrophising may be associated with affect-related learning. The relationship between this strategy and affective learning supports previous hypotheses that there may be some relationship between AWM and ER (Frank et al., 2020; Schweizer et al., 2020). However, rumination, positive reappraisal and positive refocusing were less likely to be involved in the process. Therefore, it suggests that some but not all ER strategies studied are associated with AWM.

3.4.3 Study Strengths

3.4.3.1 Design. Snowling (2015) postulates that the conceptualisation and operationalisation of dyslexia are enigmatic due to poor-quality studies being accepted within

the ‘dyslexia debate’. Snowling (2015) adds that accepted studies often have inappropriate development perspectives, in addition to participants not fulfilling rigorous criteria for dyslexia, a lack of screening for co-occurring difficulties and reliability in terms of reporting for measures. This study endeavoured to surpass these limitations by including adolescents’ perspectives, assessment tools with suitable reliability measures, and screening for dyslexia, and co-occurring difficulties in the control group by triangulating reports, i.e. from participant, parent, and special educational needs co-ordinator. However, screening may have been more rigorous if all participants’ reading abilities were assessed before the tasks.

3.4.3.2 Measuring Affect Related Working Memory. The interaction between maintenance and interference tasks when they were congruent or incongruent, as found in previous AWM studies, was not evident in this study until the interaction variable was analysed as a bi-directional variable. This demonstrates that there is additional understanding and information in the analysis of affect-related WM when analysed with this developed interaction variable. Although, the interval tasks which both involved visual word stimuli, may need to be adapted for further studies. While affective valence of words differed, they both may have employed visual encoding methods, i.e. the visuospatial sketchpad domain rather than the suggested affective WM domain.

3.4.4 Study Limitation

3.4.4.1 Participant Mood. Participants’ moods may impact the ratings they give (i.e., their current mood when partaking in the experiment may change their emotional experiences) (Baddeley et al., 2012). Therefore, the adolescents’ moods when beginning the experiment could have influenced how they maintained the information during participation.

3.4.4.2 Contextual Factors. Adolescents who participated in the school setting, as opposed to the home setting, may have engaged differently due to motivational factors such as why they took part, and if they participated on their own or as part of a group administered

session. Mirabolfathi et al. (2020) argue that the context in which learning unfolds impacts the affective experience, and Andresen et al. (2018) report that students with dyslexia perform worse when perceiving tasks as scholastic as opposed to less academic.

3.4.4.3 Affective Judgements. While it is anticipated that the participants maintained the affect during the affect-related working memory tasks, it is difficult to ascertain whether this introspective task was completed as instructed or whether participants used other methods to make this judgement.

3.4.4.4 Emotional Regulation Measurement. ER can be analysed and understood using different approaches or measures, e.g. neural measures, behavioural, peripheral psychophysiological, or, as in this study, a self-report (Young et al., 2019). Questionnaires do not measure strategies as experienced in everyday life (Pe et al., 2013). Therefore, further ER measures are required to gain a comprehensive overview of these participants' ER strategies that are not only perceived as efficacious, but also applied within everyday life.

3.4.4.3 Intensity Data Normed for the Population. Affective intensity data was not normed for an adolescent population (Mikels et al., 2008). The affective norms for the affect experienced with each image were obtained from an adult population. Given the known differences in affective experiences between age groups (Mikels et al., 2005), the affective intensity ratings obtained from the adult population may vary for affective concordance with regard to an adolescent population. Future research should obtain normed intensity data for the adolescent age group.

3.4.4.4 Mixed Design. While the prolonged attentional demands on participants constrained the number of trials and phases, further trials, perhaps separated over a period of time, could have improved the research design (Broome et al., 2012). These additional trials would have allowed all participants to engage in counterbalanced, congruent and incongruent

variants of the tasks. However, this would produce added demands for participants which might reduce participation levels or elicit boredom/distraction in later trials.

3.4.5 Scientific and Professional Implications of the Findings

3.4.5.1 Dyslexia Conceptualisation. The definition of dyslexia must expand beyond the bi-variate relationships between dyslexia and socio-emotional factors, and dyslexia and working memory. The dyslexia definitions offered by the Irish Task Force on Dyslexia (2001), the Dyslexia Association of Ireland (2020), and the Rose report (2009) in the UK all refer to affect (Dyslexia Association Ireland, 2020; Government of Ireland, 2001; Rose, 2009). This study adds to this understanding and suggests the definition should incorporate not just the impact of reading difficulties on emotional experiences and development, but also the interaction between working memory and affect, i.e. how affect is experienced, processed and recalled.

3.4.5.2 Supporting Dyslexia Working Memory Differences. Given the domain general working memory difference noted, it is argued that it is important to accommodate or preferably to universally design learning in a way that supports this difference (Reid et al., 2013). This is worth noting as there is weak evidence for previous working memory programmes such as Cogmed (Cogmed, 2009) or Jungle Memory (Memosyne, 2007). Programmes to enhance working memory have not always generalised to real-life settings, with additional difficulty with transfer for students with lower-rated attention abilities (Apter, 2012; Gray et al., 2012).

Until now, working memory strategies have been viewed as affectively neutral. This study suggests that while affective material may increase performance for adolescents without dyslexia, it may cause additional strain on attentional resources for students with a reduced working memory capacity when completing tasks which involve several modalities (i.e. visual, verbal, and affective). New models of resourcing within Ireland (DES, 2017) endorse increased

autonomy within schools. However, implementation has been inconsistent between schools and has been questioned in relation to equitable access for some students with dyslexia, with Tiernan and Casserly (2017) advising that further guidance and support in managing these teaching supports was required. Knowledge and cognisance of this impact of mixed modality learning will be important for dyslexia specific methodologies.

3.4.5.3 Social Media Platforms. Difficulty maintaining affect may require further investigation in affect-specific contexts, such as social media platforms. Some research has examined the experiences of adolescents with dyslexia online, reporting greater emotional intensity experienced when writing online and from feedback received from peers compared to adolescents without dyslexia (Reynolds & Wu, 2018). However, it is not known how adolescents maintain this affective experience in an online affective context. Affective experiences in affective contexts are important due to 96% of Irish adolescents having a social media account, and two thirds spending more than two hours per day online (Dooley et al., 2019). Furthermore, experiences are often experienced as more intense in these online settings (McCrae et al., 2017; Schønning et al., 2020).

3.5 Conclusion

While variance in working memory and socio-emotional factors are suggested to influence reading abilities, the simultaneous processing and maintenance of affect remain complex and are likely situated within an interacting system of biopsychosocial factors (George & Engel, 1980). There was an overall domain-general working memory difficulty for adolescents with dyslexia and the maintenance and recall of affective information was challenging for adolescents with dyslexia in comparison to peers. Adolescents with dyslexia performed similarly to peers on maintenance of less affective information, until it required switching between subdomains of WM. Despite this, or perhaps because of these challenges, there was higher reported effectiveness for positive reappraisal and positive refocussing

strategies. However, catastrophising was the only coping strategy that was significantly associated with affect-related working memory. While there was a slight preference reported by adolescents with dyslexia for processing affective information, the more neutral language stimuli used was the quickest and most accurately recalled, while affective language served as interference for other affective or less-affective information. Therefore, the current study indicates that the affective quality of information processed influences learning for adolescents, and for those with dyslexia in particular.

Chapter Four: Critical Review and Impact Statement

4.1 Introduction

This critical review is the final chapter of the thesis. It reflects on the research undertaken and the researcher's experiences during the process. It provides an overview of how the study developed, as influenced by epistemological and theoretical perspectives. It gives a critical appraisal of the design selection, measures and analysis methods, while also considering viable alternatives. Following this, a personal reflection on the research process and its implications is considered from a psychological theory and practice perspective. The final section is the impact statement, which outlines how the insight and knowledge attained from conducting this study could benefit several domains, including educational psychology theory and practice, methodological considerations in affect-related working memory research, teaching methodologies and adolescent well-being.

4.2 Study Overview

4.2.1 Research Development

Extensive research in the domain of cognitive psychology has been undertaken to understand the phenomenon of dyslexia and inform the design of dyslexia-specific assessment and interventions. To date, working memory assessments have persisted as affectively neutral measures (Rosen & Engle, 1997; Schweizer et al., 2019) and interventions have remained heavily influenced by phonological awareness and processing (Elliott & Grigorenko, 2015). Socio-emotional factors are known to influence learning within this heterogenous group of learners (Burden, 2008; Burton, 2004) and this variance in socio-emotional factors suggested the possibility that the resilience developed over time and affective strengths could provide an alternative channel for encoding learning (Mikels et al., 2005). This affect-related working memory domain may be separate to the other WM domains, and other domains all have known difficulties in this cohort (Swanson et al., 2009).

The author was curious as to whether these constructs were separate areas for development and merely related or whether they were integrated and integral to learning (i.e., whether affective information is remembered in a different manner). To better understand these phenomena, it was important to gather empirical data and also to briefly seek the participants' views on their preferred method of information processing.

4.2.2 Epistemological Position Adopted and Theoretical Perspective

In developing these ideas mentioned, the study was underpinned by the postpositivist theoretical perspective. Post-positivism ascertains that there is only one reality, but that it can only be understood with a certain level of probability rather than being definite (Creswell & Plano Clark, 2011). It acknowledges that working memory, when explored with such a complex construct such as emotion, is open to revision from a critical realist perspective (Young, 2001). The voice of the individual is important to elicit (even briefly), as affect-related working memory could be influenced by the individual's own emotions and mood (Young, 2001). Participants' very brief perspectives on task preference were included to enrich the understanding of affect-related working memory. The researcher acknowledges that he/she may have biases and background knowledge but must remain objective and neutral within the process to avoid affecting the research process (Creswell & Plano Clark, 2011). This understanding of AWM will require ongoing revision and construction to understand this complex concept fully. It does not aim to disprove previous analytical facts regarding WM. However, it reinvestigates AWM and supplements the positivism paradigm's limitations by triangulating methods, thus avoiding educational research biases (Panhwar et al., 2017).

4.3 Critical Appraisal

Having developed and completed the research, this next section will critically appraise various aspects regarding the study's design, measures used and the methods of analysis. It will reflect on the study's design in consideration of the experiment's overall administration, the tasks' validity for measuring AWM, the sample size recruited and the screening conducted. The measures used will then be reviewed, including the maintenance tasks, N-back tasks and ER tasks. Following this, the methods of analysis will then be examined, including hardware and software variance and data normalisation procedures.

4.3.1 Study Design

4.3.1.1 Experimental Administration. Given the COVID-19 global pandemic and ongoing uncertainty around school closures during the period of data collection, this study was made available online as well as in-schools. Most participation was within school settings, which allowed for the verification of diagnoses and additional screening with special educational needs co-ordinators, support with technological issues and motivation via the presence of the researcher.

Nevertheless, in-person administration may also have negative effects such as the Hawthorne effect (Krathwohl, 1993), where individuals may change behaviours. In this case, ER answers could have been influenced by the presence of peers during group administration (Fernald et al., 2012; McCambridge et al., 2015). However, unobtrusive data collection, (i.e., completing the experiment and answering the emotion questions on their own computer) potentially mitigated some aspects of the Hawthorne effect (Gray et al., 2009).

Another factor that may have impacted engagement during the experimental administration was boredom. Trait and state boredom can impact on sustained attention (Hunter et al., 2018). Given the repetitive trial nature of this experiment, it is plausible that sustained attention may have been impacted by boredom. However, given the phase-related

main effect where participants got better or faster completing maintenance tasks as they progressed in the experiment, it is unlikely boredom impacted sustained attention.

Administering this experiment during a global pandemic also raised other concerns. Townsend et al. (2020) note that research conducted during COVID-19 may add additional distress to participants who already have a strain on their mental health due to the global pandemic, and because online research does not allow the researcher to provide support in the usual way. However, administering this study in person allowed the investigator to provide a debrief and reassure them that most answers were subjective and that their perspective was important, which participants seemed to appreciate. The debrief was also possible online due to the small number who participated in this way. While, Hawker et al. (2011) argue that there are limitations to psychological debriefing, relating to such factors as timing, and training received in debriefing, they also state the value of a thorough briefing before the research is undertaken to mitigate distress. Accordingly, the researcher gave a comprehensive briefing before the experiment began, reminding the participants of the subjective nature of emotions and their right to stop the research at any stage without having to explain why.

4.3.1.2 The Validity of the Tasks for Measuring AWM. Affect-related working memory research identifies AWM as a domain-specific informational subsystem of working memory, in the same way that visual/spatial, or verbal/auditory working memory are domain-specific subsystems (Frank et al., 2020; Mammarella et al., 2012; Mikels et al., 2005; Mikels et al., 2008; Mikels, 2019; Mirabolfathi et al., 2019; Schweizer et al., 2019). Tasks that aim to measure AWM, as distinct from other WM subsystems, require affect to be maintained while also completing an interference task from another WM domain-specific subsystem, such as visual/spatial or verbal/auditory information. The difference in affect maintenance depending on the type of interference task (i.e., whether tasks are congruent or incongruent) could suggest AWM as a separate subsystem to the other domains (Mikels et al., 2019). This study

did not have the same effect as that of Mikels et al. (2008), which found maintenance tasks that were incongruent with the interval task to have higher accuracy and concordance. The affect maintenance and visual search tasks were more concordant than congruent tasks, e.g., affect maintenance and down-regulation of a negative image, i.e., to reframe negative thought. In this study, affective interference tasks interfered with affective maintenance and brightness maintenance tasks. There was a decrease in affective and brightness maintenance performance when affective interference (word stimuli) was used instead of neutral interference. This demonstrates the impact of affect interference for adolescents, as in Mirabolfathi et al.'s (2019) study. Having varied the measures used, it makes it difficult to make definite conclusions on AWM (Schmeichel & Tang, 2014).

However, this affective interference may be particularly influential given the participants' developmental stage; e.g., the negativity bias during adolescence may particularly impact the negatively valenced stimuli's performance (Kauschke et al., 2019; Marusak et al., 2017). Witkin et al. (2020) argue that further consideration should also be given to the effect that affective interference has on the current task and also the following task. While high WM load and affective interference (negatively valenced) can decrease performance in the current task, Witkin et al. (2020) posit that affective interference can increase performance in the subsequent task.

4.3.1.4 Sample Size. This study's sample size is greater than the power analysis suggested, based on studies of similar conceptual design (Mikels et al., 2008) and meta-analytic studies investigating the WM of students with dyslexia (Swanson et al., 2009). Increased sample sizes make findings more robust, with increased reliability and predictive value (Grady et al., 2021; Kim, 2009).

4.3.1.5 Screening. Initially, this project's design included a reading screener at the beginning of the experiment to screen for reading difficulties in the control group. Due to

COVID-19 and uncertainty relating to in-person administration, having a reading test screener was not feasible for the current study. The interval task could be described as a sight word reading task (if they engaged with the task as requested), however, sight word reading is often accomplished by this developmental stage, and is less predictive of complete reading ability, with vocabulary and verbal working memory being more influential factors in terms of adolescents' reading ability (Rose & Rouhani, 2012). Using a comprehensive reading screener at the beginning of the assessment could have informed findings further; i.e., to determine the reading abilities of participants in each group. The control group had to self-report reading and spelling difficulties, and strong weighting and predictive value was given to these reports (Deacon et al., 2012; Leavett et al., 2014; Tamboer & Vorst, 2015). Self-reporting was also used to screen for co-occurring developmental and attentional difficulties. Screening for these co-occurring difficulties should have given a purer sample of AWM profiles for adolescents with dyslexia (Savage et al., 2006). Future research should take into account previous educational settings, including attendance at a reading school. Attending a reading school has shown some positive effects on socio-emotional factors, such as self-esteem (Casserly, 2013; Nugent, 2008; O'Brien, 2019).

Students with a diagnosis of dyslexia were included in this research project. However, Waesche et al. (2011) note that the use of different definitions of dyslexia causes low levels of agreement when diagnosing students with dyslexia, and the method or assessment tools used can prioritise specific indicators over others, which increases measurement error (Francis et al., 2005). Historically, a discrepancy analysis between a student's reading achievement and intellectual abilities (IQ) was completed to differentiate an individual with dyslexia (Elliott & Grigorenko, 2015). However, legislation relating to the assessment of dyslexia in Ireland recommends a phased or staged process of assessment (National Educational Psychological Service (NEPS), 2010; Task Force on Dyslexia, 2001), including a response to intervention

and psychological assessment to identify and support the needs of children and adolescents with dyslexia depending on their patterns of strengths and weaknesses (Tiernan & Casserly, 2018). Fletcher et al. (2013) have reported the benefits of a hybrid model where multiple methods are used to agree on the diagnosis of dyslexia. Given the variety of approaches, this study did not specify acceptable diagnostic methods, but the criterion group had to have a diagnosis of dyslexia, as verified by the individual, a parent and a special educational needs co-ordinator, as in previous research (Rose, 2019). As there is a move towards more comprehensive assessment methods and minimising limitations regarding diagnostic assessment quality, future research could require the use of two of the following diagnostic methods: a response to intervention, discrepancy analysis or patterns of strengths and weaknesses.

4.3.2 Measures

4.3.2.1 Maintenance Tasks. The variance between WM tasks and procedures used makes WM profiles more complicated to interpret (Savage et al., 2006). The brightness maintenance tasks were conceptually similar to the affective maintenance tasks, as both required keeping in mind a piece of information while completing an interference task. However, Broome et al. (2012) suggest considering the difficulty of the brightness maintenance trials used as a visual WM measure (i.e., because brightness maintenance is difficult) and suggest that easier comparisons of brightness maintenance images are required to obtain the higher reliability of the task. Therefore, while the brightness maintenance measures can be compared between groups, it may be less accurate to compare brightness and affect maintenance for groups, as brightness maintenance has greater variance. However, this study did note that the control group scored similarly in both tasks. This study also noted that the brightness maintenance was comparable between groups, showing that both groups had similar visual WM in this task. Of note, the affect maintenance task is reported to be

more reliable for measuring affect maintenance for higher performers (Broome et al., 2012). Therefore, scores from individuals with higher working memory capacity may be more reliable.

4.3.2.2 N-back Tasks. The two N-back phases had words that were rated as affective or of neutral valence. The affective words were not split into positively and negatively affective words, which other studies previously did; therefore, this positive/negative affect split may require future investigation, given the differences found in particular for negatively valenced words in previous literature (Perry et al., 2019; Raczy & Orzechowski, 2019).

4.3.2.3 Emotional Regulation Tasks. Participants' metacognition is pivotal in Zeidner and Mathews's (2005) self-regulatory model. Participants' awareness, thinking and reflection on their feelings are necessary to get accurate reports of cognitive self-regulation strategies in use (Putwain, 2008). The multi-choice questionnaire does not measure metacognition. However, the Cognitive Emotional Regulation Questionnaire as an ER measure has high levels of validity and reliability, even for the shorter version (Garnefski & Kraaij, 2006).

4.3.3 Methods of Analysis

The methods employed for analysing data must also be considered, in particular the variance in hardware and software variance, the process of data normalisation, and reaction time analysis.

4.3.3.1 Hardware and Software Variance. Woods et al. (2015) argue that the computer hardware used can alter the precise computer-based measurement of simple reaction times, and this study required the use of students' own computers or school computers. While there may have been some variability in the hardware used and internet connection speeds to measure reaction time, Bridges et al. (2020) report Psychopy software to be impressively precise with regard to RT measurement, recording reactions within four

milliseconds on all browsers. However, within the school context, there were times when a bell to signal a change of class or announcement would interject over the room's speaker, and depending on the stage of the experiment, this could plausibly have increased some task reaction times.

4.3.3.2 Data Normalisation. Additional pre-processing steps, such as log transformations in normalising reaction time data distribution, can increase false-positive rates (Fernandez & Vadillo, 2020). Nonetheless, it is an established and supported procedure for stabilising variance and normalising data, ensuring the least amount of heteroscedasticity before analysis (Balota et al., 2013; Lo & Andrews, 2015; Whelan, 2008). A possible alternative would be to use distributional analysis based on Ex-Gaussian or Wald probability distributions rather than the standard normal distribution (Whelan, 2008).

4.3.3.2 Reaction Time Analysis. The reaction time data analysed speed of responses for correct answers. It measured neutral words to have the fastest correct responses. However, incorrect affective responses were not accounted for. Therefore, this is another area for future development of the study.

4.4 Reflections

Mortari (2015) states that the researcher must engage in reflection to be a competent practitioner of research. This next section includes a personal reflection on the research process. It discusses some problems that arose and learning from this research process.

4.4.1 Reflections on Anticipated and Unanticipated Ethical Dilemmas. The Research Ethics Committee in Mary Immaculate College, Limerick, granted ethical approval. The study followed ethical guidelines (e.g., the PSI Code of Ethics). Students' data were assigned a randomly selected number, and results were recorded on the Pavlovia platform, without any identifiers except the assigned number. The online platform Pavlovia records IP addresses, but they are not linked with user data or shared with third parties, and the data

policies are GDPR-compliant. Participants had the right under the self-determination principle (Section 1.4.3) of the PSI Code of Ethics to withdraw at any time during the research project. The right to withdraw also applied to participants who felt that the cognitive or emotional demands were too taxing during the working memory tasks. This research project also involved words and pictures that were age-appropriate, both for positively and negatively valenced stimuli.

Informed consent, assent and information letters also ensured that participants with dyslexia who chose to participate were aware of their reading difficulty and diagnosis before participating in the experiment. Informed consent was necessary, as their dyslexia diagnosis may have evoked different feelings depending on their self-concept and self-identity (Burden, 2008). The benefits of being diagnosed are often contingent on the individual developing a strong knowledge of his/her dyslexia and own personal strengths (Pino & Mortari, 2014).

Therefore, those who did partake were aware of their diagnosis and were perhaps socially and emotionally well-adjusted to having dyslexia (Morgan & Klein, 2000; Sako, 2016). This may have skewed the dyslexia population represented (i.e., only those who were aware and comfortable to partake and/or had parents as active advocates for dyslexia may have participated). This social and emotional adjustment may have reflected in the positive ER strategies reported, as adolescents with dyslexia reported using increased positive reappraisal and positive refocusing compared to peers. Of note, positive refocusing and reappraisal subscales from the CERQ were previously noted to be correlated with self-esteem (Garnefski et al., 2002), and self-esteem can increase from positive adaptation to dyslexia diagnosis (Singer, 2005).

A critical interpretation of findings using the researcher's reflexivity and the student's perspectives of task preference ensured that the knowledge generated was not biased. The researcher set out to avoid harm when working with participants (i.e., adolescents with and

without dyslexia). One participant found sections of the experiment challenging to follow (i.e., because of the interoceptive nature of maintaining the feeling). After verifying the pre-experiment screening with the special educational needs co-ordinator (SENCO), it was noted that this student had additional needs. However, under principle one of the PSI Code of Ethics (respect for the rights and dignity of the person) and principle three (responsibility), the investigator offered further explanation of the tasks and the opportunity to complete the study if desired. The participant chose to continue in the knowledge that they could withdraw at any stage. The investigator considered the student's dignity and rights by allowing them to partake, but excluded the results from the study.

4.4.2 Personal Reflection on Problems that Arose During the Project

Gibb's reflective cycle structures the learning gained from this experience of conducting a research project. It presents some of the many challenges which led to reflection, refinement of thought and action several times along this research journey (Moon, 2013).

4.4.2.1 Description. This research was particularly affected by the COVID-19 pandemic, as data collection was scheduled to take place just as the pandemic began. The way data was to be collected required changing the software and the programming of the experiment, which were both challenging in terms of learning how to code and construct. This software change also required the provision of the opportunity for online participation, which required a launch platform (Pavlovia). This presented additional demands and problems for running and analysing the data, such as site maintenance occurring during data collection, incomplete link identification spoiling collection and technology compatibility difficulties with certain hardware (i.e., iPads). There were also greater challenges with recruitment due to limited access for non-essential visitors in schools, because of the virus and a lack of motivation for engagement in additional online tasks given the day-to-day

online school demands. Overall, conducting research and collecting data during COVID-19 was difficult as it meant unnecessary non-essential contact was eliminated to reduce the spread of the virus (Mourad et al., 2020).

4.4.2.2 Feelings. This research was a steep learning curve for me as a student researcher. I felt and knew that this topic was very relevant from a practitioner viewpoint, but the reality of researching this novel area within cognitive psychology meant there were many new learning challenges to overcome in order to carry out the actual investigation, such as learning to code and programme the experiment. Conversely, these challenges made succeeding more enjoyable. However, each stage of the process required many revisions and refinements, ranging from such aspects as ethics to data analysis, and the COVID-19 pandemic escalated all challenges by adding further complications and stipulations.

4.4.2.3 Evaluations. Due to COVID-19 challenges, and the novel nature of most aspects of the research process, the project entailed many time/planning revisions; i.e., everything took much longer than anticipated. This often happens with postgraduate research projects (Buehler et al., 1994). However, this time was well spent and necessary, given the requirement to become familiar with conducting research again, learning about new constructs, research designs, and also to try to develop and evolve this area of research. This research design, the measures used and the entire process required a great deal of reflection, distillation and re-integration, so that the study could be refined and reconsidered to best answer the research questions. Reyman et al. (2006) postulate that repeated reflection over time is critical for the evolvement of research designs. This process was greatly supported by supervision, which helped to guide and challenge my reflection and thinking. The study also benefited from reaching out to respected authors in the field of AWM and ER to use some of their established measures and intensity data, and obtaining Professor Mikels perspective on how this particular project may fit within the already growing literature base of AWM.

4.4.2.4 Action Plan. While time was pivotal for research developments, time out was also essential to allow meaning to be distilled and to maximise productivity when re-engaged in the study. This understanding and patience with the research process will be important for the quality and implementation of future research projects. Furthermore, in undertaking this project, I understood that it was a requirement of the Professional Doctorate in Educational and Child Psychology, and would hopefully have worthwhile implications for future psychological theory and practice. However, I was amazed at the feedback received from students with dyslexia and from their parents. They were very eager to participate, and they reported that it was important to get their perspectives and feel 'heard'. One special educational needs co-ordinator noted that there were many projects and research studies within other special educational needs domains, but less focus had recently been given to this larger population of adolescents within the school, and schools were not always sure how best to support these capable students. This echoes the findings relating to the implementation of optimal support for students with dyslexia in the context of the revised resourcing model (DES, 2017; Tiernan & Casserly, 2018). While there has been some very valuable Irish research on the voice of the child with dyslexia (Casserly, 2013; Casserly & Gildea, 2014; Nugent, 2008; O'Brien, 2019), further research with this adolescent age group could be very informative. While this research had a brief self-report measure, comparing the preference of tasks, the response and the experience of conducting this research informed me that the voice of the Irish adolescent with dyslexia has not been fully heard. There seemed to be a great deal of rich qualitative data beyond this study's remit, but would be very informative for future studies involving these adolescents. It was important to gain their perspectives regarding preference of tasks, but as a student researcher, I was cognisant that self-reported memory preferences are less valid than neuropsychological tests (Bowler et al., 2017).

4.4.2.5 Conclusion. COVID-19 prompted reconceptualisation of how to conduct the research most effectively, but it also brought about positive change by encouraging online group administration. This assisted with the amount of time required for administration and unobtrusive data collection in a safe, engaging and convenient environment (Dodds & Hess, 2020; Gray et al., 2009). This research has deepened my understanding of the cognitive foundations and affective factors that interact to influence how reading difficulties present in adolescents with dyslexia. I know this is very important for adolescents with dyslexia, but also for long-term outcomes in their chosen careers as adults. Nalavany et al. (2016) state that higher levels of negative or uncomfortable affect from living with dyslexia predict lower self-efficacy, competency and anxiety in work, even when contextual factors are controlled for. Therefore, this appreciation for the relationship between affect and working memory will continue to influence my practice and passion for strengths-based dyslexia research, so that I can support the current and future needs of people with dyslexia.

4.4.3 How the Research has Modified my views of the Phenomenon

This research has modified my view in relation to how affect and working memory interact for adolescents with dyslexia. Although the interactions remain complex, the findings add to the Mikels et al. (2019) framework of interacting modes between affect and working memory in some interesting ways, as detailed below.

4.4.3.1 Mode 1: Affect Can Influence Working Memory. Affective literacy differences, i.e., positive and negative words in comparison to neutral words, altered the speed and accuracy in N-back working memory tasks. The affective coping strategy of catastrophising was associated with affect related working memory tasks. This changed my view of how words and phrases are perceived and processed, i.e., the valence from literacy changes the attentional processes and recall of information. These subtle differences can act

as an additional processing load within learning contexts and make literacy more difficult to recall.

4.4.3.2 Mode 2: Working Memory Can Influence Affect. Working memory is integral to the learning process (Swanson et al., 2009). This study measured elements of working memory and reported ER responses to 'When I experience difficulty learning'. While it is not a causal relationship between the working memory and ER responses, this study did report overall lower working memory performance for adolescents with dyslexia and increased reporting of some positive ER strategies. Therefore, working memory abilities may play a role in ER strategies adopted.

4.4.3.3 Mode 3: Emotional Feelings can Manifest as the Mental Representation Stored and Maintained in WM. Storing, processing and recalling affective information such as feelings and moods are more challenging for students with dyslexia than those without dyslexia. Thus, affect-related working memory is an area of greater difficulty than storing, processing and recalling visual information.

4.4.4 Implications of the Research for Understanding and Knowledge of the Topic in Psychology

Ensuing the new and modified views of the relationship between affect and WM for adolescents with dyslexia, this research study adds to the understanding and knowledge of a number of topics. This section will firstly detail how it adds to the conceptualisation of dyslexia. Secondly, it will describe how it develops the understanding of the broader working memory profile of adolescents with dyslexia. Thirdly, it will introduce the idea of affect-related working memory for this cohort. This section will also raise questions regarding the relationship between AWM and emotional intelligence, extending the understanding of the relationship between AWM and ER.

4.4.4.1 Dyslexia. A summarised definition of dyslexia from leading authors and dyslexia agencies was created to define dyslexia as '*a neurodiverse and multidimensional model of learning, which impacts on the acquisition of fluent reading and spelling skills (e.g., the word level and decoding) to varying amounts on a continuum of need. This difficulty is unexpected amongst other cognitive abilities and/or strengths, along with learning opportunities. This continuum of strengths and needs also includes variance in socio-emotional factors, including but not limited to anxiety, resilience and self-esteem'.*

It was important to create a synthesised definition of dyslexia to share my developing understanding of dyslexia and how it may have influenced and steered this project; a current definition which attempted to capture similarities across leading dyslexia organisations and authors rather than debating differences. In creating a synthesised definition, it challenged my thoughts to not just analyse definitions to date, but to begin to consider what else was missing. The challenge and aim was to provide a comprehensive yet broadly inclusive description which captured all of this heterogenous cohort, while considering additional biopsychosocial factors that may belong in this definition (e.g. including socio-emotional factors which were not usually included in the definition). This refining and regenerating process was important, because how dyslexia is conceptualised deciphers how dyslexia is assessed, and the type of assessment used influences how dyslexia is further understood (Snowling et al., 2020). This applies to the use of discrepancy testing. Dyslexia literature postulates that a struggling reader without a discrepancy between their cognitive and reading ability could also have dyslexia (Rose, 2009), however, this position may not yet be fully embraced in practice (Ryder & Norwich, 2018; Stanovich, 2020). This thesis' definition incorporated the unexpectedness of this difficulty 'amongst other cognitive abilities and/or strengths'. While adding the 'and/or strengths' it attempted to broaden the unexpectedness from solely cognitive abilities. However, it may be argued that some of the control group may

be struggling readers who have dyslexia but do not have a discrepancy between abilities. The challenge continues in theory and practice to decipher where the differentiation between general and specific learning difficulties lie and if there needs to be this differentiation and if there is no differentiation, does dyslexia exit (Gibbs & Elliott, 2020)? While omitting the discrepancy style may theoretically be more inclusive, others argue this it is an injustice and in inaccurate evaluation of learners with this specific need (Cameron, 2021). Savage et al. (2006) question the purity of WM and attentional assessments if the screening process is not strict enough. Therefore, defining dyslexia continues to be challenging as each positioning is debated to be somewhat subjective and perhaps mixed with bureaucratic, social, political and personal reasoning attached (Elliott, 2020). This definition endeavours to define dyslexia as best understood from current literature and practice with the awareness of socio-emotional factors embedded within the learning and life experiences of these individuals, and indeed it will continue to evolve with theory and practice.

This study complements the multidimensional model approach to learning. To understand and support difficulties regarding reading and spelling, a comprehensive picture of interacting factors must be understood, such as affect and working memory. Darling-Hammond et al. (2019, p. 129) state that 'Cognitive, social and emotional competencies develop within a complex system of contexts, interactions and relationships, all of which matter for children's outcomes'.

4.4.4.2 Working Memory of Adolescents with Dyslexia. Peng et al.'s (2018) meta-analysis previously identified three main WM theories which are relevant for students with dyslexia, namely the domain-specific theory, cognitive load theory and dual process theory. This study highlights all three and the role that affect plays within these theories; i.e., affect may potentially be processed within a separate domain, or the overall affective cognitive load

affects attentional processes, and dual processing within affectively incongruent states is particularly difficult for students with dyslexia.

In particular, this study adds to the understanding of the relationship between affect and WM ability through attentional factors. Attentional factors have been proposed as possible factors that underlie magnocellular deficits such as sluggish attentional shifting (Franceschini et al., 2012; Lallier et al., 2010) or visual attention span difficulties (i.e., a difficulty processing many words simultaneously) (Bosse et al., 2007). The processing of many word stimuli was easiest when the word stimuli were affectively neutral, and shifting between affective states proved more challenging for students with dyslexia. Therefore, affect should be considered in tandem with attentional factors associated with a dyslexia WM profile.

4.4.4.3 Affect-related Working Memory as Part of a Working Memory Model. This study adds to the discourse concerning which model of WM is most appropriate to explain AWM. Affect-related working memory is postulated to take place as part of the episodic buffer (Mikels et al., 2019). Elliott and Grigorenko (2015) state that there is little dyslexia research on the episodic buffer domain of Baddeley and Hitch's model of WM. This study adds to the literature that supports the idea of AWM as at least partially separate to other WM domains.

However, there was also an overall affective effect on attentional resources for all tasks. Therefore, these affect-related working memory tasks and results may well fit the theoretical understanding of Cowan's attentional embedded process model of WM (1999). This model hypothesises that the way we process and recall information is subject to the attentional resources available at that time. This domain general model of WM may suit this population and may suit this study more than a domain-specific approach. Swanson and Sachse-Lee (1999) analysed domain-specific versus domain-general challenges in students

with reading difficulties, highlighting the importance of domain-general processing for this cohort and how it contributes to their known difficulties in WM. This research study advocates understanding affective recall of states and stimuli as embedded within the attentional WM capacity of the individual. It is also worth noting that the scope of a person's attentional control and capacity in WM tasks predicts cognitive aptitude measures and individual variance in intelligence (Cowan et al., 2006).

4.4.4.4 AWM and EI. Cattell Horn Carroll's theory of cognitive abilities conceptualises emotional intelligence as a broad tentative intelligence ability, with emotional perception, knowledge, management and utilisation as narrow abilities (McGrew & Schneider, 2017). These latter two abilities appear to overlap with the integration of AWM and ER measures used in this study; i.e., the management of learning-related emotions and using affect to process information. The variance in affect-related working memory and ER strategies found in this study supports the understanding of Cattell-Horn-Carroll Theory of Intelligence and tentative broad cognitive ability of emotional intelligence relative to dyslexia (Schneider & McGrew, 2018). If AWM is comparable to abilities within emotional intelligence, it could be argued that AWM may be suggestive of a person's cognitive ability. It also adds to the knowledge and understanding of AWM as a higher-order emotional processing construct (Schweizer et al., 2019).

4.4.4.5 AWM and ER. Schweizer et al. (2019) highlight that there is activation of the inferior temporal gyrus during AWM studies, which is also noted with ER. While Lee and Xue (2018) posit that the same neural substrates are not used, this study found that not all ER strategies may be implicated in ER processing. However, levels of catastrophising could be associated with the processing and recall of affective states and stimuli. This relationship adds to the knowledge of specific negative ER skills (i.e., catastrophising, and its relationship with the processing and maintenance of information).

4.4.5 Implications for Professional Practice in Educational Psychology, Schools and Services for Children and Adolescents

The knowledge and understanding this study brings could also impact on the professional practice of educational psychology, schools and services received by adolescents with dyslexia. This section will delineate how affect-related working memory research could be useful for supporting educational psychologists with the assessment and intervention of adolescents with dyslexia, and also how it could impact on teaching methodological considerations. It will also consider the implications for the learner.

4.4.5.1 The Role of Affect in Dyslexia Assessment and Intervention. Affective difficulties are task- and age-dependent; e.g., affect maintenance is superior to other subdomains of WM in ageing individuals (Berger et al., 2017; Mikels et al., 2005; Reed et al., 2014). Affect can also have an impairing effect on updating abilities (i.e., the ability to filter and retain task-relevant information), for other age groups (Schweizer et al., 2019). This study noted differences in the speed and accuracy of adolescents ability to process affective word stimuli in comparison to more neutral word stimuli when under a high WM load. Therefore, adolescents completing word reading subtests of attainment assessments may be compromised by the valence of the words.

4.4.5.2 Positive Coping Strategies and Person Centred Approaches. Positive coping strategies used by adolescents with dyslexia cannot be underestimated as protective factors for academic success and general wellbeing (De Beer et al., 2014; Firth et al., 2013; Novita et al., 2019; Passe, 2006; Riddick, 2003; Singer, 2008). This study identified positive reappraisal and positive re-focusing as two specific strengths for adolescents with dyslexia in comparison to their peers. Knowledge of these preferred positive coping strategies or learned dispositions are important when beginning to develop person centred approaches. Long and

McPolin (2009) state that best-practice dyslexia psychological assessments and interventions include emotional and mental well-being aspects using a person-centred approach.

4.4.5.3 Targeting Catastrophizing in Adolescents. The reframing of catastrophic thoughts may be particular important for adolescents when recalling affective information and experiences. Catastrophising is well established in medical research in its association with negative affect and maladaptive evaluation or attention to certain symptoms (Lukkahatai & Saligan, 2013). It has been linked with primary and secondary mechanisms of Folkman & Lazarus' (1984) seminal work on stress, appraisal, and coping (Engel et al., 2013). Primary appraisal mechanisms focus on interpretation of affect and secondary appraisal mechanisms analyse coping resources (Folkman & Lazarus, 1984). It is also known to correlate with anxiety (Garnefski & Kraaij, 2002), and this links with literature proposing that variance in reading abilities is explained by WM, negative affect such as anxiety and ego resilience (Donolato et al., 2019). Therefore, catastrophizing may be particularly important to target in adolescent interventions.

4.4.5.4 Dyslexia and Visual Working Memory This study reported adolescents with dyslexia to encode visual information similarly to peers. Therefore, visual WM was a relative subdomain strength, when tasks were congruent. Therefore visual approaches could support the learning of adolescents with dyslexia when the approaches do not involve switching between tasks.

4.4.5.5 Pre-teaching and Dynamic Assessments. Similar to previous research (Gray et al., 2019; Swanson et al., 2009), this study noted that adolescents with dyslexia found it difficult to switch between incongruent tasks and update information required to complete the task. This links with Toffalini et al.'s (2019) study which indicated that students with dyslexia have a cross-modal WM binding span deficit. Pre-teaching methodologies employed by educators could maximise recall of information on new tasks that are cross-modal (i.e.,

dependent on more than one WM subsystem). Berg and Wehby (2013) suggest three main pre-teaching methodologies; pre-teaching important vocabulary, pre-teaching background knowledge; and using visual organisers before the lesson begins to help structure and prime new information and skills.

Furthermore, additional dynamic assessment approaches during cognitive ability testing could support an accurate evaluation in assessing students with dyslexia and predict their response to intervention (Aravena et al., 2016; Grigorenko, 2009) .Dynamic assessment approaches for learners with dyslexia are defined as approaches which evaluate learning potential instead of learning outcomes (Aravena et al., 2016; Grigorenko, 2009). It would reduce the impact of known difficulty integrating and coordinating new information and completing novel tasks for students with dyslexia (Gray et al., 2019; Nicolson et al., 2001; Smith-Spark & Fisk, 2007).

4.4.5.6 Implications for the learners. This study noted some similarities and difference in the way learners with dyslexia learn in comparison to their peers. Tasks that are novel may be initially more challenging for adolescents with dyslexia, therefore, they may need to practice a little more than peers at the start. Likewise, tasks that involve multiple modes of learning may be difficult (e.g. visual, auditory, and kinaesthetic learning). Therefore, focusing on one mode of learning would be preferrable. Remembering and recalling information may be difficult for this cohort, however, their recall of visual information is comparable to peers, therefore, incorporating more visual organisers may be helpful when learning new information. Adolescents with dyslexia can process certain information at a similar speed to their peers. Adolescents with dyslexia reported to chose positive refocusing and positive reappraisal strategies during learning experiences. Using these preferred coping strategies may be helpful during learning, whereas catastrophising thought (e.g. I'm going to fail this test) may be associated with how effectively emotions are processed. Catastrophising

literature often focuses on coping with medical difficulties and pain (Pare et al., 2019; Quartana et al., 2009), however, this style of coping may play an important role in more general processing of emotions and experiences. Therefore, catching and rephrasing any catastrophic thinking will be important for positive mental health and wellbeing. Given the reported effectiveness with regard positive coping strategies, it may be useful to consider using positive declarations when learning such as 'I will become a good reader' and 'I am making progress' (Mckay, 2006). Similarily, Carol Dweck stated that learners beliefs about their character, creativity, and intelligence are important to school and life success (Dweck, 2016). Dweck (2016) highlighted that learners should understand that these constructs are not static and it is effort, along with good learning strategies and support from others that brings mastery and success. Therefore, learners should focus on the progress rather than the outcome (Dweck, 2016). See inclusively designed handout in Appendix N which is available to share with these young people.

4.4.6 Implications for Future Research

This research has implications for future AWM research, and could be very relevant to other neurodiverse groups.

4.4.6.1 Further Neurodiverse Research in AWM. Findings from this study were focused on adolescents with a specific learning difficulty. However, future research into affect-related working memory and the interaction of affect and working memory could be useful in other neurodiverse groups, such as adolescents with autism spectrum disorder, due to prior knowledge of interoception (DuBois et al., 2016) and working memory differences (Wang et al., 2017).

4.4.7 Distinctive Contribution

This research is based on the conceptual design of a seminal study conducted by Mikels et al. (2008), and it adds to the growing literature base of affect-related working

memory (Frank et al., 2020; Mammarella et al., 2012; Mikels et al., 2005; Mikels et al., 2008; Mikels, 2019; Mirabolfathi et al., 2019; Schweizer et al., 2019). It is distinctively different from other AWM studies, as it is adapted for adolescents with dyslexia to include a language-related component. This develops the idea of affective-working memory in an academic context with a specific neurodiverse group at a particular developmental stage.Furthermore, this understanding of differences in AWM between cohorts (which Schweizer et al. (2019) posits may be a transdiagnostic mechanism for mental wellbeing) is important to consider when implementing and creating documents such as the *National Well-being Policy Statement and Framework for Practice 2018-2023* (Government of Ireland, 2018) and the *Junior Cycle Wellbeing Programme* (NCCA, 2017).

This study develops the methodological framework of emotion maintenance. Mikels et al. (2008) investigated the impact of a secondary interval task on successful maintenance of affective or non-affective information in working memory. They found that an affective interval task was most impactful on an affective maintenance task, and a non-affective interval task was most impactful on a non-affective maintenance task, implying a dissociation between affective and non-affective WM subdomains. However, the analytical strategy assumed that one WM task (the interval task) is unidirectionally affecting the other (the maintenance task) is developed, as some bidirectionality is arguably more likely to be the case. As such, the present study explored this bidirectionality by analysing a composite performance score created from the interaction of interval and maintenance tasks. By doing this, this study investigating the interaction of maintenance tasks and congruency of interval task as not just a grouping variable, but also considering performance scores of the interval in the main statistical analysis.

It hypothesises that the maintenance task and interval tasks should interact with each other, and not necessarily in the same direction in each case. This was not previously

analysed as such, and instead, maintenance and interval tasks were analysed separately to show affect and cognitive tasks as separate domains. By analysing the tasks as separate variables, but also as an integrated interaction variable, the construct of affect-related working memory can be understood as a full construct. The idea here is, as stated by Aristotle, that 'the whole is sometimes greater than the sum of the parts' (Aristotle, ca. 350 B.C.E./1981). Therefore, this study incrementally adds to the methodological analysis of emotion maintenance (Broome et al., 2012).

4.4.8 Impact Statement

While there will be some repetition in this final section, the information will culminate to draw together key elements and implications for practice.

This study adds to the theoretical understanding of affect-related working memory and specifically focuses on a neurodiverse population at a critical stage of development; i.e., adolescents with dyslexia. It develops the affect maintenance methodology (Broome et al., 2012) used, to include performance-based measures during the interval, which provides measurable and on-task behaviour during the intervals, unlike the down-regulation task previously used, which involved reframing negative feelings about an image, and which could be described as less observable or measurable.

The findings also have an impact on the theoretical understanding of the working memory model. Baddeley and Hitch's most recent working memory model recently included the hedonic detector (Baddeley et al., 2012). This study implies that further developments may be necessary to include the domain of AWM as a consideration, given the differences in processing affect and less affect-related information, along with the growing research which postulates it as a separate domain (Frank et al., 2020; Mammarella et al., 2012; Mikels et al., 2005; Mikels et al., 2008; Mikels, 2019; Mirabolfathi et al., 2019; Schweizer et al., 2019).

Alternatively, this study raises the question of whether AWM should be an additional domain consideration within the multicomponent model of WM (Baddeley & Hitch, 200) or whether it should be viewed from a domain-general WM perspective (Cowan, 1999). Engle (2010) states that domain-general working memory (i.e., attentional control) has strong reliability and validity, but measuring domain-specific stores has less established reliability and validity. AWM has previously been viewed as a separate domain-specific store. However, perhaps AWM is limited in its understanding if analysed within Baddeley's model of domain-specific stores, as, instead, AWM permeates through the domain-general, attention-control-based WM model of Cowan (1999).

This study has implications for how AWM and ER are understood together and under the umbrella of Cattell Horn Carroll's theory of cognitive abilities (McGrew, 2005). While considering the broad tentative cognitive ability of emotional intelligence, the four narrow abilities of emotion perception, knowledge, management and utilisation (particularly the latter two) align with the construct of AWM and ER integrated (McGrew & Schneider, 2017). Mayer et al. (2008, p. 503) define emotional intelligence as 'sophisticated information processing about emotions and emotion-relevant stimuli', explaining much of the AWM construct. Therefore, this study has implications for how AWM may be part of a working memory model and where it might be situated in the CHC theory of cognitive abilities.

This study has a potential impact on professional practice regarding the psychological assessment of students with dyslexia. The CHC Theory of Cognitive Abilities influences how cognitive ability assessments are interpreted and measured (Alfonso et al., 2005). This study supports the knowledge of previous relative strengths for students with dyslexia in visual processing, based on Catell-Horn-Carroll factors in the Woodcock Johnson intelligence assessment (Abu Hamour et al., 2020). In consideration of the differences present in this study for AWM and ER and how these constructs may constitute emotional intelligence; a

measure of emotional intelligence could plausibly be very beneficial to an SLD assessment. Furthermore, additional affective content within the learning experiences or psychological assessment may be altering experiences. Practitioners should be cognisant of this additive effect of affect on reading stimuli; the association between catastrophizing coping strategies and how affective information is maintained; the reduced domain-general WM resources; the impaired performance when switching and updating between tasks; the role dynamic assessment could play in the assessment of students with dyslexia; and positive dispositional attributes associated with adolescents with dyslexia. This understanding may enhance consideration of affect and WM interacting in learning contexts and general life experiences, which may support quality of life for adolescents with dyslexia incrementally over time.

Dyslexia directives and policies in Ireland, such as the Task Force for Dyslexia, are 20 years old (Government of Ireland, 2001). The Task Force for Dyslexia and other international documents pertaining to dyslexia, such as the Rose Report (2009), refer to difficulties in WM and socio-emotional factors. Policies may need further updates concerning the interaction between the constructs rather than as isolated concepts, given the changing affective contexts in society which are pertinent to adolescents (i.e., social media) (Dooley et al., 2019) and the differences noted in affective tasks for students with dyslexia. Newer dyslexia policies that embrace this knowledge of how working memory and affect interact could inform newer educational circulars, and those advising on special educational needs resourcing (0013/2017 and 0008/2019) (DES, 2017, 2019).

While this study focused on AWM and ER, it would be remiss not to mention some of the many other potential interacting factors. Motivation and previous academic experiences (Livingston et al., 2018; Lockiewicz et al., 2014; Yüvrük et al., 2020), along with strong supportive relationships and well-designed programmes, can alter the affect experienced from learning experiences (Spencer, 2007). Therefore, while this study informs psychological

policy, practice and theory, it also calls for future research in this area (AWM), accounting for a range of interacting factors and variables.

The findings of this thesis are due to be presented at the 2021 International Research Methods Summer School in Mary Immaculate College.

References

Abu-Hamour, B., & Al Hmouz, H. (2020). Cattell-horn-carroll broad cognitive ability profiles for dyslexia and intellectual disability. *International Journal of Inclusive Education*, *24*(13), 1444-1460. https://doi.org/10.1080/13603116.2018.1534999

Alexander-Passe, N. (2006). How dyslexic teenagers cope: An investigation of self-esteem, coping and depression. *Dyslexia*, *12*(4), 256-275. http://doi.org/10.1002/dys.318

Alfonso, V. C., Flanagan, D. P., & Radwan, S. (2005). *The Impact of the Cattell-Horn-Carroll Theory on Test Development and Interpretation of Cognitive and Academic Abilities.* In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (p. 185–202). The Guilford Press.

Alloway, T. P., & Carpenter, R. K. (2020). The relationship among children's learning disabilities, working memory, and problem behaviours in a classroom setting: Three case studies. *Educational & Developmental Psychologist*, *37*(1), 4-10. https://doi-org.libraryproxy.mic.ul.ie/10.1017/edp.2020.1

Alloway, T. P., Rajendran, G., & Archibald, L. M. D. (2009). Working memory in children with developmental disorders. *Journal of Learning Disabilities*, *42*(4), 372-382. http://doi:10.1177/0022219409335214

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Author.

American Psychological Association. (n.d.a). *APA Dictionary of Psychology: Affect*. https://dictionary.apa.org/affect

American Psychological Association. (n.d.b). *APA Dictionary of Psychology: Emotion*. http://dictionary.apa.org/emotion

American Psychological Association. (n.d.a). *APA Dictionary of Psychology: Specific Learning Disability*. https://dictionary.apa.org/specificlearningdisability

Amsler, M. (2001). Affective literacy: Gestures of reading in the later middle ages. *Essays in Medieval Studies, 18*(1), 83-110. http://doi:10.1353/ems.2001.0001

Andresen, A., Anmarkrud, Ø., & Bråten, I. (2018). Investigating multiple source use among students with and without dyslexia. *Reading & Writing, 32*(5), 1149-1174. https://doi:10.1007/s11145-018-9904-z

Apter, B. (2012). Do computerised training programmes designed to improve working memory work? *Educational Psychology in Practice, 28*(3), 257-272. https://doi.org/10.1080/02667363.2012.712915

Aravena, S., Tijms, J., Snellings, P., & van der Molen, Maurits W. (2016). Predicting responsiveness to intervention in dyslexia using dynamic assessment. *Learning and Individual Differences*, 49, 209-215. https://doi.org/10.1016/j.lindif.2016.06.024

Archibald, L. M. D., & Gathercole, S. E. (2006). Short-term and working memory in specific language impairment. *International Journal of Language & Communication Disorders, 41*(6), 675-693. http://doi:10.1080/13682820500442602

Aravena, S., Tijms, J., Snellings, P., & van der Molen, Maurits W. (2016). Predicting responsiveness to intervention in dyslexia using dynamic assessment. *Learning and Individual Differences, 49*, 209-215. https://doi.org/10.1016/j.lindif.2016.06.024

Aristotle. (1981). *Aristotle's metaphysics*. (W. D. Ross, Trans.). Oxford: Clarendon Press (Original work published ca. 350 B.C.E.)

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19-32. http://doi:10.1080/1364557032000119616

Armstrong, T. (2010). *Neurodiversity: Discovering the extraordinary gifts of autism, ADHD, dyslexia, and other brain differences*. Hachette UK.

Baddeley, A. (2010). Working memory. *Current Biology*, *20*(4). http://doi:10.1016/j.cub.2009.12.014

Baddeley, A., Banse, R., Huang, Y., & Page, M. (2012). Working memory and emotion: Detecting the hedonic detector. *Journal of Cognitive Psychology*, *24*(1), 6-16. http://doi:10.1080/20445911.2011.613820

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*(11), 417-423. https://doi:10.1016/s1364-6613(00)01538-2

Baddeley, A. D. (2007). *Working memory, thought, and action*. Oxford University Press.

Baddeley, A. D., & Hitch, G. J. (2000). Development of working memory: Should the Pascual-Leone and the Baddeley and Hitch models be merged? *Journal of Experimental Child Psychology*, *77*(2), 128-137. http://doi:10.1006/jecp.2000.2592

Ball, M., Hughes, A., McCormack, W., & Dyslexia Association of Ireland. (2011). *Dyslexia: An Irish perspective* (Revised ed.). Dyslexia Association of Ireland.

Barkus, E. (2020). Effects of working memory training on emotion regulation: Transdiagnostic review. *PsyCh Journal*, *9*(2), 258-279. http://doi:10.1002/pchj.353

Barrett, L. F., & Bliss-Moreau, E. (2009). Affect as a psychological primitive. *Advances in Experimental Social Psychology*, *41*, 167-218.

Beck, G. J., Hazzard, D., McPhillips, T., Tiernan, B., & Casserly, A. (2017). Dyslexia policy and practice: Cross-professional and parental perspectives on the Northern Ireland context. *British Journal of Special Education*, *44*(2), 144-164. http://doi:10.1111/1467-8578.12172

Bell, S., McPhillips, T., & Doveston, M. (2011). How do teachers in Ireland and England conceptualise dyslexia? *Journal of Research in Reading*, *34*(2), 171-192. http://doi:10.1111/j.1467-9817.2009.01419.x

Belletier, C., & Camos, V. (2018). Does the experimenter presence affect working memory? *Annals of the New York Academy of Sciences*, *1424*(1), 212-220. https://doi-org.libraryproxy.mic.ul.ie/10.1111/nyas.13627

Berger, N., Richards, A., & Davelaar, E. J. (2017). When emotions matter: Focusing on emotion improves working memory updating in older adults. *Frontiers in Psychology, 8*, 1565-1565. https://doi.org/10.3389/fpsyg.2017.01565

Bogdanowicz, M. (2003). Children at risk of dyslexia: Early identification and intervention. *Psychological Test and Assessment Modeling, 45*, 71.

Bonifacci, P., Massi, L., Pignataro, V., Zocco, S., & Chiodo, S. (2019). Parenting stress and broader phenotype in parents of children with attention deficit hyperactivity disorder, dyslexia or typical development. *International Journal of Environmental Research and Public Health, 16*(11), 1878. http://doi:10.3390/ijerph16111878

Bonifacci, P., & Snowling, M. J. (2008). Speed of processing and reading disability: A cross-linguistic investigation of dyslexia and borderline intellectual functioning. *Cognition, 107*(3), 999-1017. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.cognition.2007.12.006

Bosse, M. L., Tainturier, M. J., & Valdois, S. (2007). Developmental dyslexia: The visual attention span deficit hypothesis. *Cognition, 104*(2), 198-230.

Bowler, R. M., Adams, S. W., Schwarzer, R., Gocheva, V. V., Roels, H. A., Kim, Y., & Lobdell, D. T. (2017). Validity of self-reported concentration and memory problems: Relationship with neuropsychological assessment and depression. *Journal of clinical and experimental neuropsychology, 39*(10), 1026-1036.

Box, G. E. P., & Cox, D. R. (1964). An analysis of transformations. *Journal of the Royal Statistical Society, Series B., 26*(2), 211-252.

Boyes, M. E., Leitão, S., Claessen, M., Badcock, N. A., & Nayton, M. (2019). Correlates of externalising and internalising problems in children with dyslexia: An analysis of data from clinical casefiles. *Australian Psychologist*. *55*(1), 62-72. http://doi:10.1111/ap.12409

Boyes, M. E., Leitão, S., Claessen, M., Dzidic, P., Badcock, N. A., & Nayton, M. (2020). Piloting 'Clever Kids': A randomized-controlled trial assessing feasibility, efficacy, and acceptability of a socioemotional well-being programme for children with dyslexia. *British Journal of Educational Psychology*, e12401-e12401. https://doi.org/10.1111/bjep.12401

Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings. Technical report C-1*. Center for Research in Psychophysiology, University of Florida.

Bridges, D., Pitiot, A., MacAskill, M. R., & Peirce, J. W. (2020). The timing mega-study: Comparing a range of experiment generators, both lab-based and online. *PeerJ (San Francisco, CA), 8*, e9414-e9414. https://doi.org/10.7717/peerj.9414

Brien, T. O. (2019). Affective issues impacting children with dyslexia in a special school in Ireland. *Journal of Research in Special Educational Needs*, *19*(4), 315-324. http://doi:10.1111/1471-3802.12450

British Dyslexia Association. (n.d.). *Creating a dyslexia friendly workplace*. British Dyslexia Association. https://www.bdadyslexia.org.uk/advice/employers/creating-a-dyslexiafriendly-workplace/dyslexia-friendly-styleguide#:~:text=Readable%20fonts,may%20request%20a%20larger%20font

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press.

Broome, R., Gard, D. E., & Mikels, J. A. (2012). Test-retest reliability of an emotion maintenance task. *Cognition and Emotion*, *26*(4), 737-747. http://doi:10.1080/02699931.2011.613916

Buehler, R., Griffin, D., & Ross, M. (1994). Exploring the "planning fallacy": Why people underestimate their task completion times. *Journal of Personality and Social Psychology*, *67*(3), 366.

Burden, R. (2008). Is dyslexia necessarily associated with negative feelings of self-worth? A review and implications for future research. *Dyslexia*, *14*(3), 188-196. http://doi:10.1002/dys.371

Burton, S. (2004). Self-esteem groups for secondary pupils with dyslexia. *Educational Psychology in Practice*, *20(*1), 55-73. http://doi:10.1080/0266736042000180410

Cahill, L., & McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neuroscience*, *21*(7), 294-299. http://doi:10.1016/s0166-2236(97)01214-9

Cai, H. (2016). Luminance gradient for evaluating lighting. *Lighting Research & Technology*, *48*(2), 155-175. https://doi.org/10.1177/1477153513512501

Cameron, H. (2016). Beyond cognitive deficit: The everyday lived experience of dyslexic students at university. *Disability & Society*, 1-18. https://doi.org/10.1080/09687599.2016.1152951

Cameron, H. (2021). 'It's been taken away': An experience of a disappearing dyslexia diagnosis. *International Journal of Inclusive Education*, 1-15. https://doi.org/10.1080/13603116.2021.1902003

Cameron, H., & Billington, T. (2017). "Just deal with it": Neoliberalism in dyslexic students' talk about dyslexia and learning at university. *Studies in Higher Education*, *42*(8), 1358-1372. https://doi.org/10.1080/03075079.2015.1092510

Carawan, L. W., Nalavany, B. A., & Jenkins, C. (2016). Emotional experience with dyslexia and self-esteem: The protective role of perceived family support in late adulthood. *Aging & Mental Health, 20*(3), 284-294. http://doi:10.1080/13607863.2015.1008984

Casserly, A. M. (2013). The socio-emotional needs of children with dyslexia in different educational settings in Ireland. *Journal of Research in Special Educational Needs, 13*(1), 79-91. http://doi:10.1111/j.1471-3802.2011.01227.x

Casserly, A. M., & Gildea, A. (2015). A review of a reading class placement for children with dyslexia, focusing on literacy attainment and pupil perspectives. *European Journal of Special Needs Education, 30*(3), 304-322. http://doi:10.1080/08856257.2015.1009700

Chiappe, P., Hasher, L., & Siegel, L. S. (2000). Working memory, inhibitory control, and reading disability. *Memory & Cognition, 28*(1), 8-17. https://doi-org.libraryproxy.mic.ul.ie/10.3758/BF03211570

Cirino, P. T., Miciak, J., Gerst, E., Barnes, M. A., Vaughn, S., Child, A., Huston-Warren, E. (2017). Executive function, self-regulated learning, and reading comprehension: Training studies. *Journal of Learning Disabilities, 50*, 450-467.

Cogmed. (2009, June). *Working memory training (promotional brochure)*. http://www.cogmed.com

Cooper, R. (2006). *Neurodiversity and dyslexia: Challenging the social construction of specific learning difficulties*. London South Bank University.

Cotton, S. M., Crewther, D. P., & Crewther, S. G. (2005). Measurement error: Implications for diagnosis and discrepancy models of developmental dyslexia. *Dyslexia, 11*(3), 186-202.

Cowan, N. (1999). *An embedded-processes model of working memory*. (pp. 62-101). Cambridge University Press. https://doi.org/10.1017/CBO9781139174909.006

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioural & Brain Sciences, 24*(1), 87-114. https://doi-org.libraryproxy.mic.ul.ie/10.1017/S0140525X01003922

Cowan, N., & Alloway, T. (2009). Development of working memory in childhood. In M. L. Courage & N. Cowan (Eds.), *Studies in developmental psychology: The development of memory in infancy and childhood* (pp. 303-342). Psychology Press.

Cowan, N., Fristoe, N. M., Elliott, E. M., Brunner, R. P., & Saults, J. S. (2006). Scope of attention, control of attention, and intelligence in children and adults. *Memory & Cognition, 34*(8), 1754-1768. https://doi.org/10.3758/BF03195936

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research*. SAGE.

Dalgleish, T. (2019). The impact of affective information on working memory: A pair of meta-analytic reviews of behavioural and neuroimaging evidence. *Psychological Bulletin, 145*(6), 566-609. http://doi:10.1037/bul0000193

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behaviour, 19,* 450-466. https://doi.org/10.1016/S0022-5371(80)90312-6

Dawes, E., Leitão, S., Claessen, M., & Nayton, M. (2015). A profile of working memory ability in poor readers. *Australian Psychologist, 50*(5), 362-371. https://doi-org.libraryproxy.mic.ul.ie/10.1111/ap.12120

De Beer, J., Engels, J., Heerkens, Y., & van der Klink, J. (2014). Factors influencing work participation of adults with developmental dyslexia: A systematic review. *BMC Public Health, 14*(1), 77-77. http://doi:10.1186/1471-2458-14-77

Delatorre, P., Salguero, A., León, C., & Tapscott, A. (2019). The impact of context on affective norms: A case of study with suspense. *Frontiers in Psychology, 10*. http://doi:10.3389/fpsyg.2019.01988

Denton, C. A., Montroy, J. J., Zucker, T. A., & Cannon, G. (2020). Designing an intervention in reading and self-regulation for students with significant reading difficulties, including dyslexia. *Learning Disability Quarterly,* , 73194871989947. https://doi.org/10.1177/0731948719899479

Department of Education and Skills (DES). (2011). *Literacy and numeracy for learning and life: The national strategy to improve literacy and numeracy among children and young people 2011-2020.* Department of Education and Skills. https://www.education.ie/en/publications/education-reports/pub_ed_interim_review_literacy_numeracy_2011_2020.pdf

Department of Education and Skills (DES). (2017). *Special education teaching allocation circular 0014/2017*. Department of Education and Skills. https://www.education.ie/en/Circulars-and-Forms/Active-Circulars/cl0014_2017.pdf

Department of Education and Skills (DES). (2020). *Data on individual schools*. Department of Education and Skills. https://www.education.ie/en/Publications/Statistics/Data-on-Individual-Schools/

Dodds, S., & Hess, A. C. (2020). Adapting research methodology during COVID-19: Lessons for transformative service research. *Journal of Service Management, 32*(2), 203-217. https://doi.org/10.1108/JOSM-05-2020-0153

Donolato, E., Giofrè, D., & Mammarella, I. C. (2019). Working memory, negative affect and personal assets: How do they relate to mathematics and reading literacy? *PLoS ONE, 14*(6), 1-17. https://doi-org.libraryproxy.mic.ul.ie/10.1371/journal.pone.0218921

Dooley, B. A., Fitzgerald, A., & O' Reilly, A. (2019). *My world survey 2: National study of youth mental health in Ireland. Jigsaw and UCD School of Psychology*. My World Survey. http://www.myworldsurvey.ie/content/docs/My_World_Survey_2.pdf

DuBois, D., Ameis, S. H., Lai, M., Casanova, M. F., & Desarkar, P. (2016). Interoception in autism spectrum disorder: A review. *International Journal of Developmental Neuroscience, 52*(1), 104-111. https://doi.org/10.1016/j.ijdevneu.2016.05.001

Dunn, E. W., Brackett, M. A., Ashton-James, C., Schneiderman, E., & Salovey, P. (2007). On emotionally intelligent time travel: Individual differences in affective forecasting ability. *Personality & Social Psychology Bulletin, 33*(1), 85-93. http://doi:10.1177/0146167206294201

Dweck, C. (2016). What having a "growth mindset" actually means. *Harvard Business Review*, 13, 213-226.

Dyslexia Association Ireland. (2020, December 13). *What is Dyslexia?* Dyslexia Association Ireland. https://dyslexia.ie/info-hub/about-dyslexia/what-is-dyslexia/#:~:text=The%20Dyslexia%20Association%20of%20Ireland,access%20to%20appropriate%20learning%20opportunities

Elliott, J. G. (2020). It's time to be scientific about dyslexia. *Reading Research Quarterly, 55*(1), 61-75. http://doi:10.1002/rrq.333

Elliott, J. G., & Gibbs, S. (2008). Does dyslexia exist? *Journal of Philosophy of Education, 42*(3-4), 475-491. http://doi:10.1111/j.1467-9752.2008.00653.x

Elliott, J., & Grigorenko, E. L. (2015). *The dyslexia debate*. Cambridge University Press.

Elzinga, B. M., & Roelofs, K. (2005). Cortisol-induced impairments of working memory require acute sympathetic activation. *Behavioral Neuroscience, 119*(1), 98-103. http://doi:10.1037/0735-7044.119.1.98

Enferm, A. P. (2007). Systematic literature review X narrative review. *Acta Paul Enferm*, *20*(2), vii-viii. https://www.scielo.br/pdf/ape/v20n2/en_a01v20n2.pdf

Facoetti, A., Paganoni, P., Turatto, M., Marzola, V., & Mascetti, G. G. (2000). Visual-spatial attention in developmental dyslexia. *Cortex*, *36*(1), 109-123.

Fairfield, B., Mammarella, N., Di Domenico, A., & Palumbo, R. (2015). Running with emotion: When affective content hampers working memory performance. *International Journal of Psychology*, *50*(2), 161-164. https://doi-org.libraryproxy.mic.ul.ie/10.1002/ijop.12101

Fartoukh, M., Chanquoy, L., & Piolat, A. (2014). Mood induction in children: Effect of the affective valence of a text on phonological working memory. *Advances in Cognitive Psychology*, *10*(3), 113-118. http://doi:10.5709/acp-0162-z

Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). GPower 3: A flexible statistical power analysis program for the social, behavioural, and biomedical sciences. *Behaviour Research Methods*, *39*(2), 175-191. http://doi:10.3758/bf03193146

Feliu-Soler, A., Reche-Camba, E., Borràs, X., Pérez-Aranda, A., Andrés-Rodríguez, L., Peñarrubia-María, M. T., & Luciano, J. V. (2017). Psychometric properties of the cognitive emotion regulation questionnaire (CERQ) in patients with fibromyalgia syndrome. *Frontiers in Psychology*, *8*, 2075-2075. http://doi:10.3389/fpsyg.2017.02075

Fernald, D. H., Coombs, L., DeAlleaume, L., West, D., & Parnes, B. (2012). An assessment of the Hawthorne effect in practice-based research. *Journal of the American Board of Family Medicine*, *25*(1), 83-86. https://doi.org/10.3122/jabfm.2012.01.110019

Fernández, M. L., & Vadillo, M. A. (2020). Flexibility in reaction time analysis: Many roads to a false positive? *Royal Society Open Science*, *7*(2), 190831-190831. http://doi:10.1098/rsos.190831

Fernandez, K., Jazaieri, H., & Gross, J. (2016). Emotion regulation: A transdiagnostic perspective on a new RDoC domain. *Cognitive Therapy and Research.*, *40*(3). https://doi.org/10.1007/s10608-016-9772-2

Field, A. P. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE.

Firth, N., & Frydenberg, E. (2010). Coping styles and strategies: A comparison of adolescent students with and without learning disabilities. *Journal of Learning Disabilities*, *43*(1), 77-85. http://doi:10.1177/0022219409345010

Fischbach, A., Könen, T., Rietz, C., & Hasselhorn, M. (2014). What is not working in working memory of children with literacy disorders? Evidence from a three-year-longitudinal study. *Reading & Writing*, *27*(2), 267-286. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s11145-013-9444-5

Fletcher, J. M., & Miciak, J. (2017). Comprehensive cognitive assessments are not necessary for the identification and treatment of learning disabilities. *Archives of Clinical Neuropsychology*, *32*(1), 2-7. http://doi:10.1093/arclin/acw103

Fostick, L., & Revah, H. (2018). Dyslexia as a multi-deficit disorder: Working memory and auditory temporal processing. *Acta Psychologica*, *183*, 19-28. http://doi:10.1016/j.actpsy.2017.12.010

Franceschini, S., Gori, S., Ruffino, M., Pedrolli, K., & Facoetti, A. (2012). A causal link between visual spatial attention and reading acquisition. *Current Biology*, *22*, 814-819.

Frank, C. C., Iordan, A. D., Ballouz, T. L., Mikels, J. A., & Reuter-Lorenz, P. A. (2020). Affective forecasting: A selective relationship with working memory for emotion. *Journal of Experimental Psychology*. *150*(1), 67-82. http://doi:10.1037/xge0000780

Fuchs, D., & Fuchs, L. S. (2006). Introduction to response to intervention: What, why, and how valid is it? *Reading Research Quarterly, 41*(1), 93-99. https://doi.org/10.1598/RRQ.41.1.4

Gard, D. E., Cooper, S., Fisher, M., Genevsky, A., Mikels, J. A., & Vinogradov, S. (2011). Evidence for an emotion maintenance deficit in schizophrenia. *Psychiatry Research, 187*(1), 24-29. http://doi:10.1016/j.psychres.2010.12.018

Garnefski, N., & Kraaij, V. (2006). Cognitive emotion regulation questionnaire – development of a short 18-item version (CERQ-short). *Personality and Individual Differences, 41*(6), 1045-1053. https://doi.org/10.1016/j.paid.2006.04.010

Garnefski, N., Kraaij, V., & Spinhoven, Ph. (2002). *Manual for the use of the Cognitive Emotion Regulation Questionnaire.* DATEC.

Garnefski, N., Van Den Kommer, T., Kraaij, V., Teerds, J., Legerstee, J., & Onstein, E. (2002). The relationship between cognitive emotion regulation strategies and emotional problems: Comparison between a clinical and a non-clinical sample. *European Journal of Personality, 16*(5), 403-420. http://doi:10.1002/per.458

Garrison, K. E., & Schmeichel, B. J. (2020). Getting over it: Working memory capacity and affective responses to stressful events in daily life. *Emotion*. https://doi-org.libraryproxy.mic.ul.ie/10.1037/emo0000755.supp

Gathercole, S. E., & Alloway, T. P. (2004). Working memory and classroom learning. *Dyslexia Review, 15*, 4-9.

Gathercole, S. E., & Alloway, T. P. (2006). Practitioner review: Short-term and working memory impairments in neurodevelopmental disorders: Diagnosis and remedial support. *Journal of Child Psychology and Psychiatry, 47*(1), 4-15. http://doi:10.1111/j.1469-7610.2005.01446.x

Gathercole, S. E., Alloway, T. P., Willis, C., & Adams, A. (2006). Working memory in children with reading disabilities. *Journal of Experimental Child Psychology*, *93*(3), 265-281. http://doi:10.1016/j.jecp.2005.08.003

George, E., & Engel, L. (1980). The clinical application of the biopsychosocial model. *American journal of Psychiatry*, *137*(5), 535-544.

Ghisi, M., Bottesi, G., Re, A. M., Cerea, S., & Mammarella, I. C. (2016). Socioemotional features and resilience in Italian university students with and without dyslexia. *Frontiers in Psychology*, *7*, 478-478. doi:10.3389/fpsyg.2016.00478

Gibbs, S., & Elliott, J. (2020). The dyslexia debate: Life without the label. *Oxford Review of Education.*, *46*(4), 487-500. https://doi.org/10.1080/03054985.2020.1747419

Gilger, J. W., Pennington, B. F., & DeFRIES, J. C. (1992). A twin study of the etiology of comorbidity: Attention-deficit hyperactivity disorder and dyslexia. *Journal of the American Academy of Child & Adolescent Psychiatry*, *31*(2), 343-348.

Giofrè, D., Toffalini, E., Provazza, S., Calcagnì, A., Altoè, G., & Roberts, D. J. (2019). Are children with developmental dyslexia all the same? A cluster analysis with more than 300 cases. *Dyslexia*, *25*(3), 284-295. http://doi:10.1002/dys.1629

Glazzard, J. (2013). A critical interrogation of the contemporary discourses associated with inclusive education in England. *Journal of Research in Special Educational Needs*, *13* (3), 182-188. http://doi:10.1111/1471-3802.12018

Goldberg, R. J., Higgins, E. L., Raskind, M. H., & Herman, K. L. (2003). Predictors of success in individuals with learning disabilities: A qualitative analysis of a 20-year longitudinal study. *Learning Disabilities Research and Practice*, *18*(4), 222-236. http://doi:10.1111/1540-5826.00077

Gooch, D., Snowling, M. J., & Hulme, C. (2012). Reaction time variability in children with ADHD symptoms and/or dyslexia. *Developmental Neuropsychology, 37*(5), 453-472. http://doi:10.1080/87565641.2011.650809

Government of Ireland. (1998). *The Education Act 1998*. Government Publications.

Government of Ireland. (2001). *The report of the Task Force on Dyslexia*. Government Publications.

Government of Ireland. (2004). *Education for Persons with Special Educational Needs Act 2004*. Government Publications.

Government of Ireland. (2018). *Well-being policy statement and framework for practice 2018-2023*. Government Publications.

Government of Ireland. (2020). *Learning support guidelines*. Government Publications.

Grady, C. L., Rieck, J. R., Nichol, D., Rodrigue, K. M., & Kennedy, K. M. (2021). Influence of sample size and analytic approach on stability and interpretation of brain-behavior correlations in task-related fMRI data. *Human Brain Mapping, 42*(1), 204-219. https://doi.org/10.1002/hbm.25217

Gray, D. E. (2009). *Doing research in the real world*. Sage.

Gray, S., Fox, A. B., Green, S., Alt, M., Hogan, T. P., Petscher, Y., & Cowan, N. (2019). Working memory profiles of children with dyslexia, developmental language disorder, or both. *Journal of Speech, Language, and Hearing Research*, *62*(6), 1839-1858. http://doi:10.1044/2019_jslhr-l-18-0148

Gray, S. A., Chaban, P., Martinussen, R., Goldberg, R., Gotlieb, H., Kronitz, R., Hockenberry, M., & Tannock, R. (2012). Effects of a computerized working memory training program on working memory, attention, and academics in adolescents with severe LD and comorbid ADHD: A randomized controlled trial. *Journal of Child Psychology and Psychiatry, 53*(12), 1277-1284. https://doi.org/10.1111/j.1469-7610.2012.02592.x

Grigorenko, E. L. (2009). Dynamic assessment and response to intervention two sides of one coin. *Journal of Learning Disabilities, 42*, 111–132.

Grimm, S., Weigand, A., Kazzer, P., Jacobs, A. M., & Bajbouj, M. (2012). Neural mechanisms underlying the integration of emotion and working memory. *NeuroImage*, *61*(4), 1188-1194. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.neuroimage.2012.04.004

Gross, J. J. (2014). *Handbook of Emotion Regulation* (2nd edn.). Guilford.

Gross, J. J., Uusberg, H., & Uusberg, A. (2019). Mental illness and well-being: An affect regulation perspective. *World Psychiatry, 18*(2), 130-139. http://doi:10.1002/wps.20618

Gullone, E., & Taffe, J. (2012). The emotion regulation questionnaire for children and adolescents (ERQ–CA): A psychometric evaluation. *Psychological Assessment*, *24*(2), 409-417. http://doi:10.1037/a0025777

Hachmann, W. M., Bogaerts, L., Szmalec, A., Woumans, E., Duyck, W., & Job, R. (2014). Short-term memory for order but not for item information is impaired in developmental dyslexia. *Annals of Dyslexia*, *64*(2), 121-136. http://doi:10.1007/s11881-013-0089-5

Hachmann, W. M., Cashdollar, N., Postiglione, F., & Job, R. (2020). The relationship of domain-general serial order memory and reading ability in school children with and without dyslexia. *Journal of experimental child psychology*, *193*, 104789.

Haft, S. L., Myers, C. A., & Hoeft, F. (2016). Socio-emotional and cognitive resilience in children with reading disabilities. *Current Opinion in Behavioral Sciences*, *10*, 133-141. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.cobeha.2016.06.005

Hamann, S. (2001). *Cognitive and neural mechanisms of emotional memory*. Elsevier Ltd. http://doi:10.1016/S1364-6613(00)01707-1

Harmon-Jones, E., Price, T. F., & Gable, P. A. (2012). The influence of affective states on cognitive broadening/narrowing: Considering the importance of motivational intensity.

Social and Personality Psychology Compass, *6*(4), 314-327. http://doi:10.1111/j.1751-9004.2012.00432.x

Hawker, D. M., Durkin, J., & Hawker, D. S. J. (2011). To debrief or not to debrief our heroes: That is the question. *Clinical Psychology and Psychotherapy*, *18*(6), 453-463. https://doi.org/10.1002/cpp.730

Hellendoorn, J., & Ruijssenaars, W. (2000). Personal experiences and adjustment of Dutch adults with dyslexia. *Remedial and Special Education*, *21*(4), 227-239. doi:10.1177/074193250002100405

Hoerger, M., Chapman, B. P., Epstein, R. M., & Duberstein, P. R. (2012). Emotional intelligence: A theoretical framework for individual differences in affective forecasting. Emotion, *12*(4), 716-725. http://doi:10.1037/a0026724

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*(2), 165-179. http://doi:10.1177/001440290507100203

Horowitz-Kraus, T., Holland, S. K., Versace, A. L., Bertocci, M. A., Bebko, G., Almeida, J. R. C., & Phillips, M. L. (2017). Reading-related white matter structures in adolescents are influenced more by dysregulation of emotion than behavior. *NeuroImage Clinical*, *15*, 732-740. http://doi:10.1016/j.nicl.2017.06.020

Hulme, C., & Snowling, M. J. (2011). Children's reading comprehension difficulties: Nature, causes, and treatments. *Current Directions in Psychological Science: A Journal of the American Psychological Society*, *20*(3), 139-142. http://doi:10.1177/0963721411408673

Humphrey, N., & Mullins, P. M. (2002). Personal constructs and attribution for academic success and failure in dyslexia. *British Journal of Special Education*, *29*(4), 196-203. http://doi:10.1111/1467-8527.00269

Hunter, A., Hunter, A., Eastwood, J. D., & Eastwood, J. D. (2018). Does state boredom cause failures of attention? Examining the relations between trait boredom, state boredom, and sustained attention. *Experimental Brain Research, 236*(9), 2483-2492. https://doi.org/10.1007/s00221-016-4749-7

Hur, J., Iordan, A. D., Dolcos, F., & Berenbaum, H. (2017). Emotional influences on perception and working memory. *Cognition and Emotion, 31*(6), 1294-1302. http://doi:10.1080/02699931.2016.1213703

Ingesson, S. G. (2007). Growing up with dyslexia: Interviews with teenagers and young adults. *School Psychology International, 28*(5), 574-591. http://doi:10.1177/0143034307085659

International Dyslexia Association (IDA). (2018, July 16). *Definition of dyslexia*. International Dyslexia Association. https://dyslexiaida.org/definition-of-dyslexia/

Iuculano, T., Moro, R., & Butterworth, B. (2011). Updating working memory and arithmetical attainment in school. *Learning and Individual Differences, 21*(6), 655-661.

Jeffries, S., & Everatt, J. (2004). Working memory: Its role in dyslexia and other specific learning difficulties. Dyslexia: *An International Journal of Research and Practice, 10*(3), 196-214. https://doi-org.libraryproxy.mic.ul.ie/10.1002/dys.278

Jiboc, A. M. (2019). Coping mechanisms in children with specific learning difficulties. *Romanian Journal of School Psychology*, *12*(24), 18-26.

Johnson, R. B. (2009). Toward a more inclusive "scientific research in education". *Educational Researcher, 38*(6), 449-457. http://doi:10.3102/0013189X09344429

Juszczak, L., & Sadler, L. (1999). Adolescent development: Setting the stage for influencing health behaviours. *Adolescent Medicine, 10*(1), 1.

Kahan, B. C., Jairath, V., Doré, C. J., & Morris, T. P. (2014). The risks and rewards of covariate adjustment in randomized trials: An assessment of 12 outcomes from 8 studies. *Trials, 15*(1), 139-139. https://doi.org/10.1186/1745-6215-15-139

Kalka, D., & Lockiewicz, M. (2018). Happiness, life satisfaction, resiliency and social support in students with dyslexia. *International Journal of Disability, Development and Education*, *65*(5), 493-508. http://doi:10.1080/1034912X.2017.1411582

Kannangara, C. S., Carson, J., Puttaraju, S., & Allen, R. E. (2018). Not all those who wander are lost: Examining the character strengths of dyslexia. *Global Journal of Intellectual and Developmental Disabilities*, *4*(5), 555-648.

Kauschke, C., Bahn, D., Vesker, M., & Schwarzer, G. (2019). The role of emotional valence for the processing of facial and verbal stimuli-positivity or negativity bias? *Frontiers in Psychology, 10*, 1654-1654. https://doi.org/10.3389/fpsyg.2019.01654

Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory & Cognition*, *31*(8), 1169-1180. http://doi:10.3758/bf03195800

Kershner, J. R. (2016). Network dynamics in dyslexia: Review and implications for remediation. *Research in Developmental Disabilities, 59*, 24-34. https://doi.org/10.1016/j.ridd.2016.07.014

Kershner, J. R. (2020). Dyslexia as an adaptation to cortico-limbic stress system reactivity. *Neurobiology of Stress, 12*, 100223-100223. http://doi:10.1016/j.ynstr.2020.100223

Kershner, J. R. (2021). An evolutionary perspective of dyslexia, stress, and brain network homeostasis. *Frontiers in Human Neuroscience*. http://doi:10.3389/fnhum.2020.575546

Kibby, M. Y., Marks, W., Morgan, S., & Long, C. J. (2004). Specific impairment in developmental reading disabilities: A working memory approach. *Journal of Learning Disabilities, 37*(4), 349-363. https://doi-org.libraryproxy.mic.ul.ie/10.1177/00222194040370040601

Kim, S. (2009). Effects of sample size on robustness and prediction accuracy of a prognostic gene signature. *BMC Bioinformatics, 10*(1), 147-147. https://doi.org/10.1186/1471-2105-10-147

Kimppa, L., Shtyrov, Y., Partanen, E., & Kujala, T. (2018). Impaired neural mechanism for online novel word acquisition in dyslexic children. *Scientific Reports, 8*(1), 12779-12. http://doi:10.1038/s41598-018-31211-0

Knight, C. (2018). What is dyslexia? An exploration of the relationship between teachers' understandings of dyslexia and their training experiences. *Dyslexia, 24*(3), 207-219. http://doi:10.1002/dys.1593

Knoop, van C., Segers, E., Verhoeven, L., & Knoop-van Campen, C. (2018). How phonological awareness mediates the relation between working memory and word reading efficiency in children with dyslexia. *Dyslexia, 24*(2), 156-169. https://doi-org.libraryproxy.mic.ul.ie/10.1002/dys.1583

Kobylińska, D., & Kusev, P. (2019). Flexible emotion regulation: How situational demands and individual differences influence the effectiveness of regulatory strategies. *Frontiers in Psychology, 10*, 72. http://doi:10.3389/fpsyg.2019.00072

Krathwohl, D. R. (1993). *Methods of educational and social science research: An integrated approach*. Longman.

Lallier, M., Donnadieu, S., Berger, C., & Valdois, S. (2010). A case study of developmental phonological dyslexia: Is the attentional deficit in the perception of rapid stimuli sequences amodal? *Cortex, 46*(2), 231-241.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International affective picture system (IAPS): Technical manual and affective ratings. *NIMH Center for the Study of Emotion and Attention*, *1*, 39-58.

Leahy, R. L., Tirch, D., & Napolitano, L. A. (2011). *Emotion regulation in psychotherapy: A practitioner's guide.* Guilford Press.

Lee, T. W., & Xue, S. W. (2018). Functional connectivity maps based on hippocampal and thalamic dynamics may account for the default-mode network. *European Journal of Neuroscience*, *47*(5), 388-398. https://doi.org/10.1111/ejn.13828

Lieder, I., Adam, V., Frenkel, O., Jaffe-Dax, S., Sahani, M., & Ahissar, M. (2019). Perceptual bias reveals slow-updating in autism and fast-forgetting in dyslexia. *Nature Neuroscience*, *22*(2), 256-264. https://doi.org/10.1038/s41593-018-0308-9

Livingston, E. M., Siegel, L. S., & Ribary, U. (2018). Developmental dyslexia: Emotional impact and consequences. *Australian Journal of Learning Difficulties*, *23*(2), 107-135. http://doi:10.1080/19404158.2018.1479975

Lo, S., & Andrews, S. (2015). To transform or not to transform: Using generalized linear mixed models to analyse reaction time data. *Frontiers in Psychology*, *6*, 1171-1171. https://doi.org/10.3389/fpsyg.2015.01171

Łockiewicz, M., Bogdanowicz, K. M., & Bogdanowicz, M. (2014). Psychological resources of adults with developmental dyslexia. *Journal of Learning Disabilities*, *47*(6), 543-555. http://doi:10.1177/0022219413478663

Lombardino, L. J., & Gauger, L. M. (2014). Dyslexia: Why is this diagnosis so challenging? *Perspectives on Language Learning and Education*, *21*(3), 98-113. http://doi:10.1044/lle21.3.98

Long, L., MacBlain, S., & MacBlain, M. (2007). Supporting students with dyslexia at the secondary level: An emotional model of literacy. *Journal of Adolescent & Adult Literacy*, *51*(2), 124–134. http://doi:10.1598/JAAL.51.2.4

Lukkahatai, N., & Saligan, L. N. (2013). Association of catastrophizing and fatigue: A systematic review. *Journal of Psychosomatic Research*, *74*(2), 100-109. https://doi.org/10.1016/j.jpsychores.2012.11.006

Maehler, C., & Schuchardt, K. (2011). Working memory in children with learning disabilities: Rethinking the criterion of discrepancy. *International Journal of Disability, Development & Education*, *58*(1), 5-17. https://doi-org.libraryproxy.mic.ul.ie/10.1080/1034912X.2011.547335

Maehler C., & Schuchardt K. (2016). Working memory deficits in children with specific learning disorders and/or attention deficits. *Learning and Individual Differences, 49*, 341-347. http://doi:10.1016/j.lindif.2016.05.007

Malagoli, C., & Usai, M. C. (2018). WM in adolescence: What is the relationship with emotional regulation and behavioral outcomes? *Frontiers in Psychology*, *9*: 844. http://doi:10.3389/fpsyg.2018.00844

Mammarella, N., Fairfield, B., De Leonardis, V., Carretti, B., Borella, E., Frisullo, E., & Di Domenico, A. (2012). Is there an affective working memory deficit in patients with chronic schizophrenia? *Schizophrenia Research*, *138*(1), 99-101. http://doi:10.1016/j.schres.2012.03.028

Marques, O. (2011). *Practical image and video processing using MATLAB*. Wiley-IEEE Press. http://doi:10.1002/9781118093467

Marusak, H., Zundel, C., Brown, S., & Rabinak, C. (2017). Convergent behavioral and corticolimbic connectivity evidence of a negativity bias in children and

adolescents. *Social Cognitive and Affective Neuroscience., 12*(4), 517-525. https://doi.org/10.1093/scan/nsw182

MATLAB. (2010). *Version 7.10.0 (R2010a)*. The MathWorks Inc.

McCambridge, J., Witton, J., & Elbourne, D. R. (2014). Systematic review of the Hawthorne effect: New concepts are needed to study research participation effects. *Journal of Clinical Epidemiology, 67*(3), 267-277. https://doi.org/10.1016/j.jclinepi.2013.08.015

McCrae, N., Gettings, S., & Purssell, E. (2017). Social media and depressive symptoms in childhood and adolescence: A systematic review. *Adolescent Research Review, 2*(4), 315-330. https://doi.org/10.1007/s40894-017-0053-4

McGaugh, J. L. (2004). the amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience, 27*(1), 1-28. http://doi:10.1146/annurev.neuro.27.070203.144157

McGrath, L. M., Pennington, B. F., Shanahan, M. A., Santerre-Lemmon, L. E., Barnard, H. D., Willcutt, E. G., DeFries, J. C., & Olson, R. K. (2011). A multiple deficit model of reading disability and attention-deficit/hyperactivity disorder: Searching for shared cognitive deficits. *Journal of Child Psychology and Psychiatry, 52*(5), 547-557. https://doi.org/10.1111/j.1469-7610.2010.02346.x

McGrew, K. S. (2005). The Cattell-Horn-Carroll theory of cognitive abilities: Past, present, and future. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (pp. 136-181). The Guilford Press.

MacKay, T. (2006). *The West Dunbartonshire Literacy Initiative: The Design, Implementation and Evaluation of an Intervention Strategy to Raise Achievement and Eradicate Illiteracy. Phase I Research Report.* West Dunbartonshire Council.

McNulty, M. A. (2016). Dyslexia and the life course. *Journal of Learning Disabilities*, *36*(4), 363-381. http://doi:10.1177/00222194030360040701

McPhillips, T., Hazzard, D., Beck, G., Casserly, A. M., & Tiernan, B. (2015). *Dyslexia in Ireland, north and south – perspectives on developments since publication of the dyslexia reports (2002).* SCoTENS.

McPhillips, T., Hazzard, D., Beck, G. J., Casserly, A. & Tiernan, B. (2017). Dyslexia policy and practice: Cross-professional and parental perspectives on the Northern Ireland context. *British Journal of Special Education*, *44*(2), 144-164. http://doi:10.1111/1467-8578.12172

McRae, K., Jacobs, S. E., Ray, R. D., John, O. P., & Gross, J. J. (2012). Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. *Journal of Research in Personality*, *46*(1), 2-7. http://doi:10.1016/j.jrp.2011.10.003

Memosyne. (2007). *Jungle memory (on-line training package).* Memosyne. http://www.junglememory.com

Menghini, D., Finzi, A., Carlesimo, G. A., & Vicari, S. (2011). Working memory impairment in children with developmental dyslexia: Is it just a phonological deficit. *Developmental Neuropsychology*, *36*(2), 199-213. http://doi:10.1080/87565641.2010.549868

Mertens, D. M. (2015). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods* (4th ed.). SAGE Publications.

Meule, A. (2017). Reporting and interpreting working memory performance in n-back tasks. *Frontiers in Psychology*, *8*, 352-352. http://doi:10.3389/fpsyg.2017.00352

Miciak J, Fletcher JM. (2020). The critical role of instructional response for identifying dyslexia and other learning disabilities. *Journal of Learning Disabilities*, *53*(5), 343-353. http://doi:10.1177/0022219420906801

Mikels, J. A., Larkin, G. R., Reuter-Lorenz, P. A., & Carstensen, L. L. (2005). Divergent trajectories in the aging mind: Changes in working memory for affective versus visual information with age. *Psychology and Aging*, *20*(4), 542-553. http://doi:10.1037/0882-7974.20.4.542

Mikels, J. A., & Reuter-Lorenz, P. A. (2019). Affective working memory: An integrative psychological construct. *Perspectives on Psychological Science*, *14*(4), 543-559. http://doi.org/10.1177/1745691619837597

Mikels, J. A., Reuter-Lorenz, P. A., Beyer, J. A., & Fredrickson, B. L. (2008). Emotion and working memory: Evidence for domain-specific processes for affective maintenance. *Emotion, 8*(2), 256–266. https://doi-org.libraryproxy.mic.ul.ie/10.1037/1528-3542.8.2.256

Miller, M. (2002). Resilience elements in students with learning disabilities. *Journal of Clinical Psychology*, *58*(3), 291-298. http://doi:10.1002/jclp.10018

Mirabolfathi, V., Schweizer, S., Moradi, A., & Jobson, L. (2020). Affective working memory capacity in refugee adolescents. *Psychological Trauma*. http://doi:10.1037/tra0000552

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, *4*(1). http://doi:10.1136/bmj.g7647

Moon, J. A. (2013). *Reflection in learning & professional development: Theory & practice*. RoutledgeFalmer. https://doi.org/10.4324/9780203822296

Morgan, E. & Klein, C. (2000) *The dyslexic Adult in a non-dyslexic world.* Whurr.

Mortari, L. (2015). Reflectivity in research practice: An overview of different perspectives. *International Journal of Qualitative Methods, 14*(5), 160940691561804. https://doi.org/10.1177/1609406915618045

Mourad, M., Bousleiman, S., Wapner, R., & Gyamfi-Bannerman, C. (2020). Conducting research during the COVID-19 pandemic. *Seminars in Perinatology, 44*(7), 151287-151287. https://doi.org/10.1016/j.semperi.2020.151287

Nachshon, O., & Horowitz, K. T. (2019). Cognitive and emotional challenges in children with reading difficulties. *Acta Paediatrica, 108*(6), 1110-1114. https://doi-org.libraryproxy.mic.ul.ie/10.1111/apa.14672

Nalavany, B. A., Logan, J. M., & Carawan, L. W. (2018). The relationship between emotional experience with dyslexia and work self-efficacy among adults with dyslexia. *Dyslexia (10769242), 24*(1), 17-32. https://doi-org.libraryproxy.mic.ul.ie/10.1002/dys.1575

NCCA. (2017). Junior Cycle well-being guidelines. http://www.juniorcycle.ie/NCCA_JuniorCycle/media/NCCA/Curriculum/Well-being/Well-being-Guidelines-for-Junior-Cycle.pdf.

Nejati, V., Salehinejad, M. A., & Nitsche, M. A. (2018). Interaction of the left dorsolateral prefrontal cortex (l-DLPFC) and right orbitofrontal cortex (OFC) in hot and cold executive functions: Evidence from transcranial direct current stimulation (tDCS). *Neuroscience, 369*, 109-123. http://doi:10.1016/j.neuroscience.2017.10.042

Nelson, J. M., & Harwood, H. (2010). Learning disabilities and anxiety: A meta-analysis. *Journal of Learning Disabilities, 44*(1), 3-17. http://doi:10.1177/0022219409359939

Nelson, J. M., Lindstrom, W., & Foels, P. A. (2015). Test anxiety among college students with specific reading disability (dyslexia): Nonverbal ability and working memory as predictors. *Journal of Learning Disabilities, 48*(4), 422-432. https://doi-org.libraryproxy.mic.ul.ie/10.1177/0022219413507604

NEPS (National Educational Psychological Service). (2007). *Special educational needs – A continuum of support guidelines for teachers*. Stationery Office.

NEPS (National Educational Psychological Service). (2007). *Special Educational Needs – A Continuum of Support Guidelines for Teachers.* Dublin: Stationery Office.

Neta, M., Davis, F. C., & Whalen, P. J. (2011). Valence resolution of ambiguous facial expressions using an emotional oddball task. *Emotion, 11*(6), 1425-1433. http://doi:10.1037/a0022993

Nicolaou, E., Quach, J., Lum, J., Roberts, G., Spencer-Smith, M., Gathercole, S., Wake, M. (2018). Changes in verbal and visuospatial working memory from Grade 1 to Grade 3 of primary school: Population longitudinal study. *Child Care, Health & Development*, *44*(3), 392-400. http://doi:10.1111/cch.12543

Nicholson, E., Murphy, T., Larkin, P., Normand, C., & Guerin, S. (2016). Protocol for a thematic synthesis to identify key themes and messages from a palliative care research network. *BMC Research Notes*, *9*(1), 478-478. https://doi.org/10.1186/s13104-0162282-1

Nicolson, R. I., Fawcett, A. J., & Dean, P. (2001). Developmental dyslexia: The cerebellar deficit hypothesis. *Trends in Neurosciences, 24*(9), 508-511. http://doi:10.1016/s0166-2236(00)01896-8

Nouwens, S., Groen, M. A., & Verhoeven, L. T. W. (2017). How working memory relates to children's reading comprehension: The importance of domain-specificity in storage and processing. *Reading & Writing, 30*(1), 105-120. http://doi:10.1007/s11145-016-96655

Novita, S. (2016). Secondary symptoms of dyslexia: A comparison of self-esteem and anxiety profiles of children with and without dyslexia. *European Journal of Special Needs Education*, *31*(2), 279-288.

Nugent, M. (2007). Comparing inclusive and segregated settings for children with dyslexia – Parental perspectives from Ireland. *Support for Learning*, *22*(2), 52-59. http://doi:10.1111/j.1467-9604.2007.00447.x

Nugent, M. (2008). Services for children with dyslexia – The child's experience. *Educational Psychology in Practice*, *24*(3), 189-206. http://doi:10.1080/02667360802256741

Oberauer, K. (2019). Working memory and attention – A conceptual analysis and review. *Journal of Cognition*, *2*(1).

Oberst, U., Wegmann, E., Stodt, B., Brand, M., & Chamarro, A. (2017). Negative consequences from heavy social networking in adolescents: The mediating role of fear of missing out. *Journal of Adolescence*, *55*, 51-60. http://doi:10.1016/j.adolescence.2016.12.008

OECD (Organisation for Economic Co-operation and Development). (2009). *PISA 2009 assessment framework: Key competencies in reading, mathematics and science*. Author.

Palmer, S. (2000). Phonological recoding deficit in working memory of dyslexic teenagers. *Journal of Research in Reading*, *23*(1), 28-40. http://doi:10.1111/1467-9817.00100

Panhwar, A. H., Ansari, S., & Shah, A. A. (2017). Post-positivism: An effective paradigm for social and educational research. *International Research Journal of Arts & Humanities (IRJAH)*, *45*(45), 253-259.

Paré, C., Thibault, P., Côté, P., Pimentel, S. D., Shen, S., Yakobov, E., & Sullivan, M. J. L. (2019). The relationship between level of catastrophizing and mental health comorbidity in individuals with whiplash injuries. *The Clinical Journal of Pain*, *35*(11), 880-886. https://doi.org/10.1097/AJP.0000000000000749

Patael, S. Z., Farris, E. A., Black, J. M., Hancock, R., Gabrieli, J. D. E., Cutting, L. E., & Hoeft, F. (2018). Brain basis of cognitive resilience: Prefrontal cortex predicts better reading

comprehension in relation to decoding. *PloS One, 13(*6), e0198791-e0198791. http://doi:10.1371/0198791

Paulus, M. P., Squeglia, L. M., Bagot, K., Jacobus, J., Kuplicki, R., Breslin, F. J., Tapert, S. F. (2019). Screen media activity and brain structure in youth: Evidence for diverse structural correlation networks from the ABCD study. *NeuroImage, 185,* 140-153. http://doi:10.1016/j.neuroimage.2018.10.040

Pe, M. L., Raes, F., & Kuppens, P. (2013). The cognitive building blocks of emotion regulation: Ability to update working memory moderates the efficacy of rumination and reappraisal on emotion. *PloS One, 8*(7), e69071-e69071. http://doi:10.1371/journal.pone.0069071

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods, 51*(1), 195-203. https://doi.org/10.3758/s13428-018-01193-y

Peirce, J. W., Gray, J. R., Simpson, S., MacAskill, M. R., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods.* http://doi:10.3758/s13428-018-01193-y

Peng P., Barnes M., Wang C., Wang W., Li S., Swanson H. L., & Tao S. (2018). A meta-analysis on the relation between reading and working memory. *Psychological Bulletin, 144*, 48-76.

Peng, P., & Fuchs, D. (2016). A Meta-analysis of working memory deficits in children with learning difficulties: Is there a difference between verbal domain and numerical domain? *Journal of Learning Disabilities, 49*(1), 3-20. http://doi:10.1177/0022219414521667

Perlstein, W. M., Elbert, T., & Stenger, V. A. (2002). Dissociation in human prefrontal cortex of affective influences on working memory-related activity. *Proceedings of the National Academy of Sciences, 99*(3), 1736-17410. http://doi:10.1073/pnas.241650598

Perry, C., Willison, A. T., Walker, M. K., Nankivell, M. C., Lawrence, L. M., & Thomas, A. (2019). Working memory load affects early affective responses to concrete and abstract words differently: Evidence from ERPs. *Cognitive, Affective & Behavioral Neuroscience*, *19*(2), 377-391. https://doi-org.libraryproxy.mic.ul.ie/10.3758/s13415-018-00686-9

Phillips, D. C., & Burbules, N. C. (2000). *Postpositivism and educational research*. Rowman & Littlefield Publishers.

Pino, M., & Mortari, L. (2014). The inclusion of students with dyslexia in higher education: A systematic review using narrative synthesis. *Dyslexia, 20*(4), 346-369. http://doi:10.1002/dys.1484

Psychological Society of Ireland. (2011). *Code of professional ethics.* https://www.psychologicalsociety.ie/footer/PSI-Code-of-Professional-Ethics-3

Putwain, D. W. (2008). Examination stress and test anxiety. *Psychologist*, *21*(12), 1026-1029.

Quartana, P. J., Campbell, C. M., & Edwards, R. R. (2009). Pain catastrophizing: A critical review. *Expert Review of Neurotherapeutics*, *9*(5), 745-758. https://doi.org/10.1586/ern.09.34

Rączy, K., & Orzechowski, J. (2019). When working memory is in a mood: Combined effects of induced affect and processing of emotional words. *Current Psychology*, 1-10. https://doi.org/10.1007/s12144-019-00208-x

Ramus, F. (2014). Neuroimaging sheds new light on the phonological deficit in dyslexia. *Trends in Cognitive Sciences*, *18*(6), 274-275. http://doi:10.1016/j.tics.2014.01.009

Rappolt-Schlichtmann, G., Boucher, A. R., & Evans, M. (2018). From deficit remediation to capacity building: Learning to enable rather than disable students with dyslexia. *Language, Speech & Hearing Services in Schools, 49*(4), 864-874. http://doi:10.1044/2018_LSHSS-DYSLC-18-0031

Rasamimanana, M., Barbaroux, M., Colé, P., & Besson, M. (2020). Semantic compensation and novel word learning in university students with dyslexia. *Neuropsychologia, 139*, 107358-107358. http://doi:10.1016/j.neuropsychologia.2020.107358

Redick, T. S., & Lindsey, D. R. B. (2013). Complex span and n-back measures of working memory: A meta-analysis. *Psychonomic Bulletin & Review, 20*(6), 1102-1113. https://doi.org/10.3758/s13423-013-0453-9

Reid, G., Strnadová, I., & Cumming, T. (2013). Expanding horizons for students with dyslexia in the 21st century: universal design and mobile technology. *Journal of Research in Special Educational Needs, 13*(3), 175-181.

Reed, A. E., Chan, L., & Mikels, J. A. (2014). Meta-analysis of the age-related positivity effect: Age differences in preferences for positive over negative information. *Psychology and Aging*, *29*(1), 1-15. https://doi.org/10.1037/a0035194

Reymen, I. M. M. J., Hammer, D. K., Kroes, P. A., Aken van, J. E., Dorst, C. H., Bax, M. F. T., & Basten, T. (2006). A domain-independent descriptive design model and its application to structured reflection on design processes. *Research in Engineering Design*, *16*(4), 147-173.

Reynolds, L., & Wu, S. (2018, June). "I'm never happy with what I write": Challenges and strategies of people with dyslexia on social media. In *Proceedings of the International AAAI Conference on Web and Social Media*, *12*(1).

Riddick, B. (2003). Experiences of teachers and trainee teachers who are dyslexic. *International Journal of Inclusive Education, 7(*4), 389-402. http://doi:10.1080/1360311032000110945

Riddick, B. (2010). Living with dyslexia: The social and emotional consequences of specific learning difficulties/disabilities (2nd edn.). Routledge. http://doi:10.4324/9780203864579

Romani, C., Tsouknida, E., & Olson, A. (2015). Encoding order and developmental dyslexia: A family of skills predicting different orthographic components. *Quarterly Journal of Experimental Psychology (2006), 68*(1), 99-128. https://doi.org/10.1080/17470218.2014.938666

Rose, J. (2009). *Identifying and teaching children and young people with dyslexia and literacy difficulties (The Rose Report).* DCSF Publications.

Rose, L. T., & Rouhani, P. (2012). Influence of verbal working memory depends on vocabulary: Oral reading fluency in adolescents with dyslexia. *Mind, Brain & Education*, *6*(1), 1-9. https://doi-org.libraryproxy.mic.ul.ie/10.1111/j.1751-228X.2011.01135.x

Rosen, V. M., & Engle, R. W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology*. *126*(3), 211-227. http://doi:10.1037/0096-3445.126.3.211

Ryder, D., and B. Norwich. 2018. "What's in a Name? Perspectives of Dyslexia Assessors Working with Students in the UK Higher Education Sector." *Dyslexia* 24: 109–127.

Sako, E. (2016). The emotional and social effects of dyslexia. *European Journal of Interdisciplinary Studies, 4*(2), 233. https://doi.org/10.26417/ejis.v4i2.p233-241

Savage, R., Lavers, N., & Pillay, V. (2006). Working memory and reading difficulties: What we know and what we don't know about the relationship. *Educational Psychology Review*, *19*(2), 185-221. http://doi:10.1007/s10648-006-9024-1

Schmeichel, B. J., & Demaree, H. A. (2010). Working memory capacity and spontaneous emotion regulation: High capacity predicts self-enhancement in response to negative feedback. *Emotion*, *10*(5), 739-744. http://doi:10.1037/a0019355

Schmeichel, B. J., & Tang, D. (2014). *The relationship between individual differences in executive functioning and emotion regulation: A comprehensive review.* In J. P. Forgas

& E. Harmon-Jones (Eds.), *Sydney symposium of social psychology. Motivation and its regulation: The control within* (p. 133–151). Psychology Press.

Schmeichel, B. J., Volokhov, R. N., & Demaree, H. A. (2008). Working memory capacity and the self-regulation of emotional expression and experience. *Journal of Personality and Social Psychology*, *95*(6), 1526-1540. http://doi:10.1037/a0013345

Schneider, W. J., & McGrew, K. S. (2018). The Cattell-Horn-Carroll theory of cognitive abilities. In D. P. Flanagan & E. M. McDonough (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (pp. 73-163). The Guilford Press.

Schønning, V., Hjetland, G. J., Aarø, L. E., & Skogen, J. C. (2020). Social media use and mental health and well-being among adolescents – A scoping review. *Frontiers in Psychology*, *11*, 1949-1949. https://doi.org/10.3389/fpsyg.2020.01949

Schweizer, S., Grahn, J., Hampshire, A., Mobbs, D., & Dalgleish, T. (2013). Training the emotional brain: improving affective control through emotional working memory training. *Journal of Neuroscience*, *33*(12), 5301-5311.

Schweizer, S., Navrady, L., Breakwell, L., Howard, R. M., Golden, A.-M., Werner-Seidler, A., & Dalgleish, T. (2018). Affective enhancement of working memory is maintained in depression. *Emotion*, *18*(1), 127-137. https://doi-org.libraryproxy.mic.ul.ie/10.1037/emo0000306.supp

Schweizer, S., Satpute, A. B., Atzil, S., Field, A. P., Hitchcock, C., Black, M., & Dalgleish, T. (2019). The impact of affective information on working memory: A pair of meta-analytic reviews of behavioral and neuroimaging evidence. *Psychological Bulletin*, *145*(6), 566-609. http://doi:10.1037/bul0000193

SERC (Special Education Review Committee), & Ireland. Department of Education. (1993). *Report of the special education review committee: Tuairisc an choiste athbreithnithe ar an oideachas speisialta.* Stationery Office.

Smith-Spark, J., & Fisk, J. (2007). Working memory functioning in developmental dyslexia. *Memory*, *15*(1), 34–56. https://doi-org.libraryproxy.mic.ul.ie/10.1080/09658210601043384

Snowling, M. (2015). *The dyslexia debate*. Wiley Subscription Services, Inc. http://doi:10.1111/camh.12097

Snowling, M. J. (2012). Changing concepts of dyslexia: Nature, treatment and comorbidity. *Journal of Child Psychology and Psychiatry, 53*(9), e1-e3. http://doi:10.1111/j.1469-7610.2009.02197.x

Snowling, M. J., & Hulme, C. (2012). Annual research review: The nature and classification of reading disorders – Commentary on proposals for DSM-5. *Journal of Child Psychology and Psychiatry*, *53*, 593-607.

Snowling, M. J., Hulme, C., & Nation, K. (2020). Defining and understanding dyslexia: Past, present and future. *Oxford Review of Education, 46*(4), 501-513. https://doi.org/10.1080/03054985.2020.1765756

Snowling, M. J., & Melby-Lervåg, M. (2016). Oral language deficits in familial dyslexia: A meta-analysis and review. *Psychological Bulletin, 142*(5), 498-545. http://doi:10.1037/bul0000037

Spencer, M. B. (2007). *Phenomenology and ecological systems theory: Development of diverse groups. Handbook of child psychology*. Wiley, American Cancer Society.

Staal, M. A., Bolton, A. E., Yaroush, R. A., & Bourne, L. E. (2008). Cognitive performance and resilience to stress. In B. J. Lukey & V. Tepe (Eds.), *Biobehavioral resilience to stress* (pp. 259-348). Taylor & Francis Group, LLC.

Stanovich, K. E. (2020). *Are discrepancy-based definitions of dyslexia empirically defensible?. In Current directions in dyslexia research (pp. 15-30)*. Garland Science.

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology, 86*(1), 24-53. https://doi.org/10.1037/0022-0663.86.1.24

Stein, J., & Walsh, V. (1997). To see but not to read: The magnocellular theory of dyslexia. *Trends in Neurosciences, 20*(4), 147-152. http://doi:10.1016/S0166-2236(96)01005-3

Stothard, J., Woods, K., & Innoue, A. (2018). An exploration of practitioner educational psychologists' understandings and practice in relation to dyslexia. *Educational and Child Psychology*, *35*(1), 13-26.

Svetaz, M. V., Ireland, M., & Blum, R. (2000). Adolescents with learning disabilities: Risk and protective factors associated with emotional well-being: Findings from the national longitudinal study of adolescent health. *Journal of Adolescent Health*, *27*(5), 340-348. http://doi:10.1016/s1054-139x(00)00170-1

Swanson, H. L. (1989). Strategy instruction: Overview of principles and procedures for effective use. *Learning Disability Quarterly*, *12*(1), 3-14. http://doi:10.2307/1510248

Swanson, H. L., & Sachse-Lee, C. (2001). A subgroup analysis of working memory in children with reading disabilities: Domain-general or domain-specific deficiency? *Journal of Learning Disabilities, 34*(3), 249-263. http://doi:10.1177/002221940103400305

Swanson, H. L., Zheng, X., & Jerman, O. (2009). Working memory, short-term memory, and reading disabilities: A selective meta-analysis of the literature. *Journal of Learning Disabilities*, *42*(3), 260-287. http://doi:10.1177/0022219409331958

Swanson, L. H., (2003). Age-related differences in learning disabled and skilled readers' working memory. *Journal of Experimental Child Psychology*, *85*(1), 1. https://doi-org.libraryproxy.mic.ul.ie/10.1016/S0022-0965(03)00043-2

Swanson, L. H. (2011). Dynamic testing, working memory, and reading comprehension growth in children with reading disabilities. *Journal of Learning Disabilities*, *44*(4), 358-371. https://doi-org.libraryproxy.mic.ul.ie/10.1177/0022219411407866

Talepasand, S., Eskandaripour, M., & Taghinezhad, A. (2018). Comparison of working and visual memory in children with and without dyslexia. *Zahedan Journal of Research in Medical Sciences*, *20*(9), 1-6. https://doi-org.libraryproxy.mic.ul.ie/10.5812/zjrms.70701

Terras, M. M., Thompson, L. C., & Minnis, H. (2009). Dyslexia and psycho-social functioning: An exploratory study of the role of self-esteem and understanding. *Dyslexia*, *15*(4), 304-327. http://doi:10.1002/dys.386

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 45-45. http://doi:10.1186/1471-2288-8-45

Tiernan, B., & Casserly, A. M. (2018). The impact and the implications of policy regarding the organisation of support for pupils with dyslexia in Irish primary mainstream schools. *Irish Educational Studies*, *37*(1), 51-67. https://doi-org.libraryproxy.mic.ul.ie/10.1080/03323315.2017.1421089

Toffalini, E., Marsura, M., Garcia, R. B., & Cornoldi, C. (2019). A cross-modal working memory binding span deficit in reading disability. *Journal of Learning Disabilities*, *52*(2), 99-108. https://doiorg.libraryproxy.mic.ul.ie/10.1177/0022219418786691

Townsend, E., Nielsen, E., Allister, R., & Cassidy, S. A. (2020). Key ethical questions for research during the COVID-19 pandemic. *The Lancet. Psychiatry*, *7*(5), 381-383. https://doi.org/10.1016/S2215-0366(20)30150-4

Trilla, I., Weigand, A., & Dziobek, I. (2020). Affective states influence emotion perception: evidence for emotional egocentricity. *Psychological Research*, 1-11. http://doi:10.1007/s00426-020-01314-3

UNESCO. (2014). *Education for all global monitoring report 2013/14: Teaching and learning- achieving quality for all.* Author.

Vasic, N., Lohr, C., Steinbrink, C., Martin, C., & Wolf, R. C. (2008). Neural correlates of working memory performance in adolescents and young adults with dyslexia. *Neuropsychologia, 46*(2), 640-648. http://doi:10.1016/j.neuropsychologia.2007.09.002

Vellutino, F. R. (1981). *Dyslexia: Theory and research.* MIT Press.

Vidyasagar, T. R., & Pammer, K. (2010). Dyslexia: A deficit in visuo-spatial attention, not in phonological processing. *Trends in Cognitive Sciences*, *14*(2), 57-63.

Wang, Y., Zhang, Y., Liu, L., Cui, J., Wang, J., Shum, D. H. K., van Amelsvoort, T., & Chan, R. C. K. (2017). A meta-analysis of working memory impairments in autism spectrum disorders. *Neuropsychology Review, 27*(1), 46-61. https://doi.org/10.1007/s11065-016-9336-y

Weems, C. F., Berman, S. L., Silverman, W. K., & Saavedre, L. M. (2001). Cognitive errors in youth with anxiety disorders. *Cognitive Therapy and Research*, *25*(5), 559-575.

Whelan, R. (2008). Effective analysis of reaction time data. *The Psychological Record*, *58*(3), 475-482. http://doi:10.1007/BF03395630

Witkin, J. E., Zanesco, A. P., Denkova, E., & Jha, A. P. (2020). Dynamic adjustments in working memory in the face of affective interference. *Memory & Cognition*, *48*(1), 16-31. https://doi-org.libraryproxy.mic.ul.ie/10.3758/s13421-019-00958-w

Wolf, R. C., Sambataro, F., Lohr, C., Steinbrink, C., Martin, C., & Vasic, N. (2010). Functional brain network abnormalities during verbal working memory performance in

adolescents and young adults with dyslexia. *Neuropsychologia*, *48*(1), 309-318. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.neuropsychologia.2009.09.020

Wood, J. V., Heimpel, S. A., & Michela, J. L. (2003). Savoring versus dampening: Self-esteem differences in regulating positive affect. *Journal of Personality and Social Psychology*, *85*(3), 566-580. http://doi:10.1037/0022-3514.85.3.566

Woods, D. L., Wyma, J. M., Yund, E. W., Herron, T. J., & Reed, B. (2015). Factors influencing the latency of simple reaction time. *Frontiers in Human Neuroscience*, *9*, 131-131. http://doi:10.3389/fnhum.2015.00131

World Health Organization. (2019). *The WHO special initiative for mental health (2019-2023): Universal health coverage for mental health*. World Health Organization. https://apps.who.int/iris/handle/10665/310981

Xiu, L., Wu, J., Chang, L., & Zhou, R. (2018). Working memory training improves emotion regulation ability. *Scientific Reports*, *8*(1), 15012. https://doi.org/10.1038/s41598-018-31495-2

Young, B. (2001). Postpositivism and educational research. *International Journal of Educational Management*, *15*(4), 206-206. https://doi.org/10.1108/ijem.2001.15.4.206.1

Young, K., Sandman, C., & Craske, M. (2019). Positive and negative emotion regulation in adolescence: Links to anxiety and depression. *Brain Sciences*, *9*(4), 76. http://doi:10.3390/brainsci9040076

Yüvrük, E., Kapucu, A., & Amado, S. (2020). The effects of emotion on working memory: Valence versus motivation. *Acta Psychologica*, *202*, 102983. http://doi:10.1016/j.actpsy.2019.102983

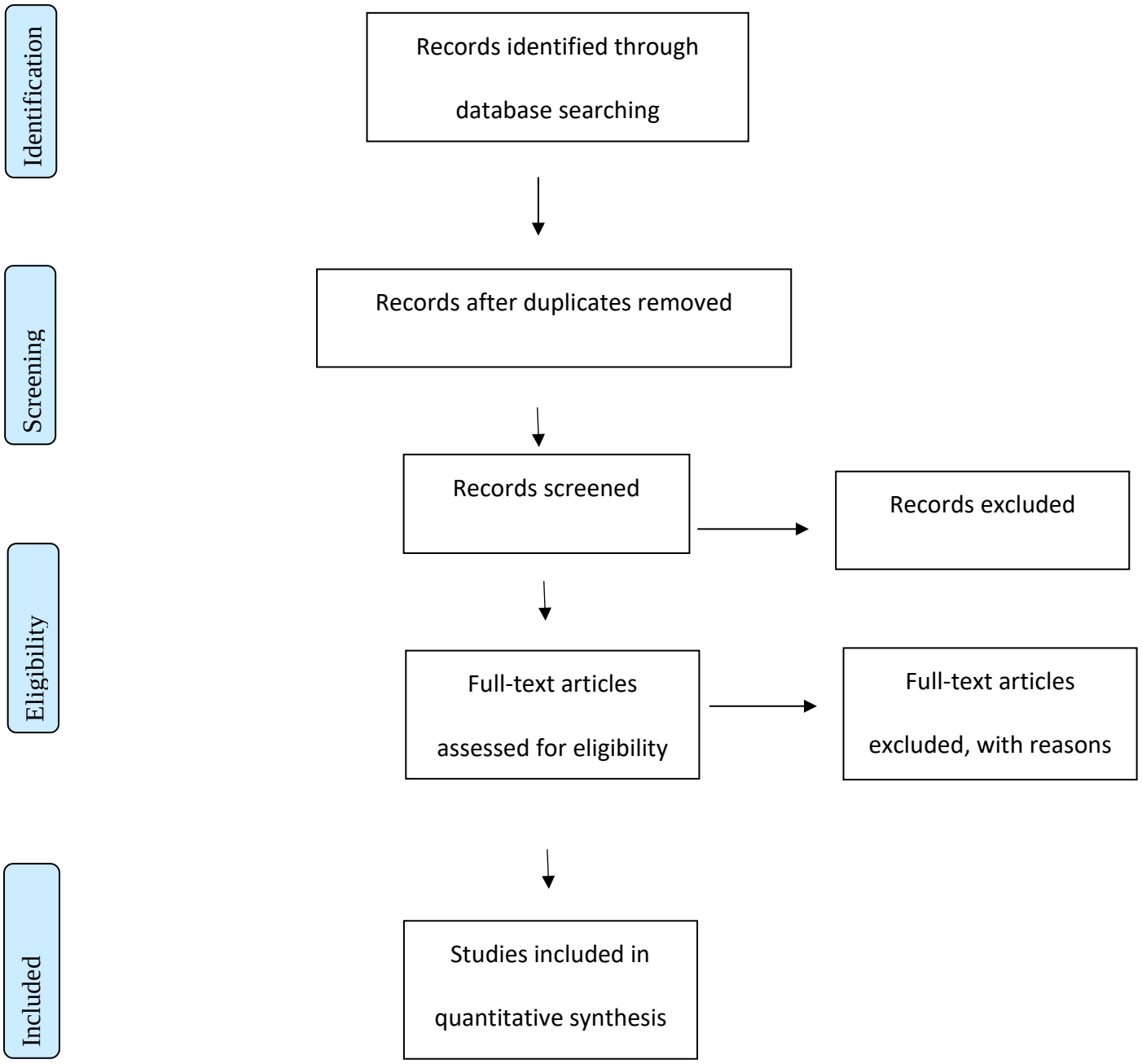
Zaehringer, J., Falquez, R., Schubert, A. L., Nees, F., & Barnow, S. (2018). Neural correlates of reappraisal considering working memory capacity and cognitive flexibility. *Brain Imaging and Behaviour, 12*(6), 1529-1543. http://doi:10.1007/s11682-017-9788-6

Zeidner, M., & Mathews, G. (2005). *Evaluation anxiety: Current theory and research.* In A. J. Elliot, & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 141-163). Guildford Press.

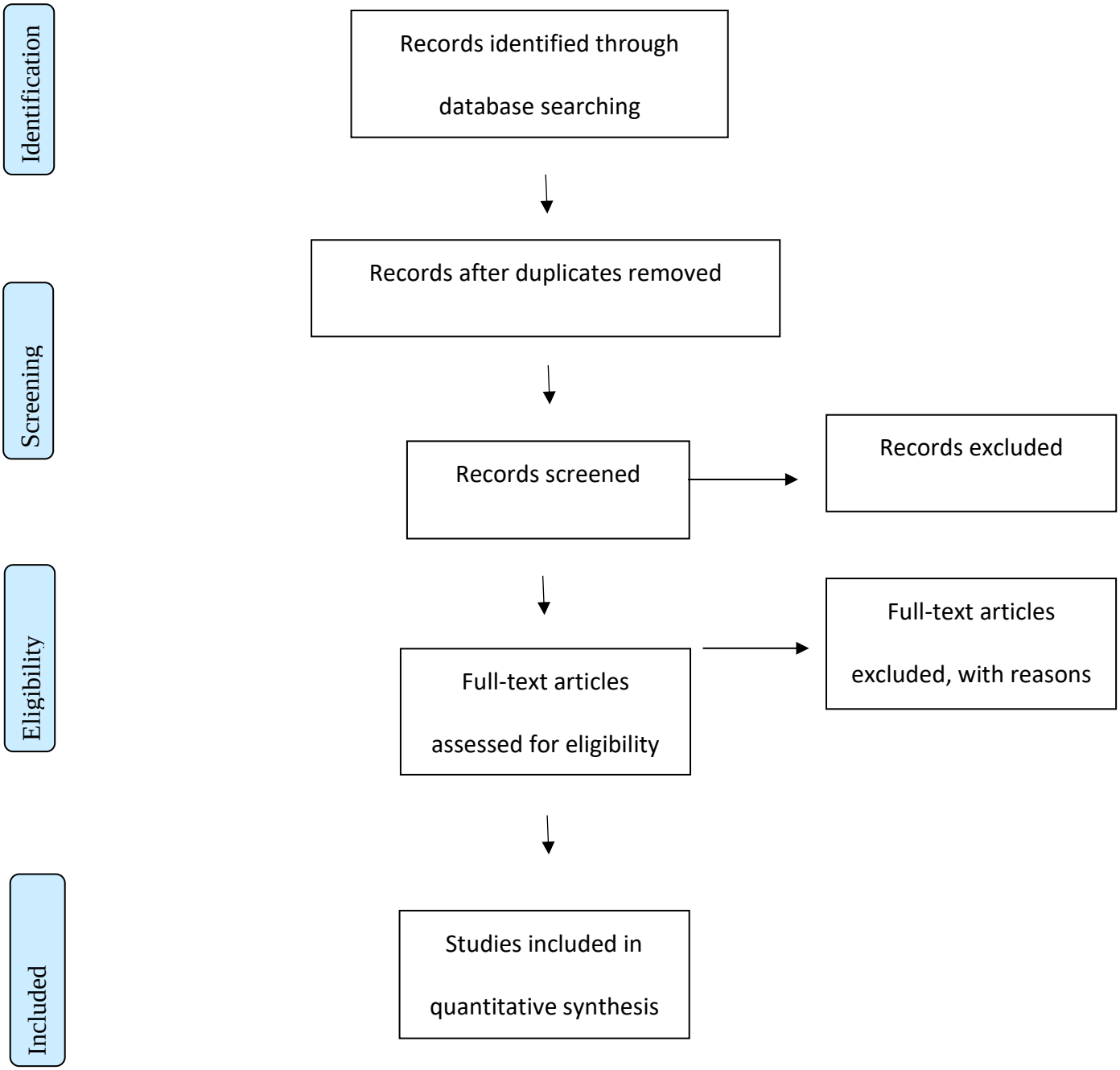
Appendices

Appendix A: Prisma flow diagrams for each of the four review themes

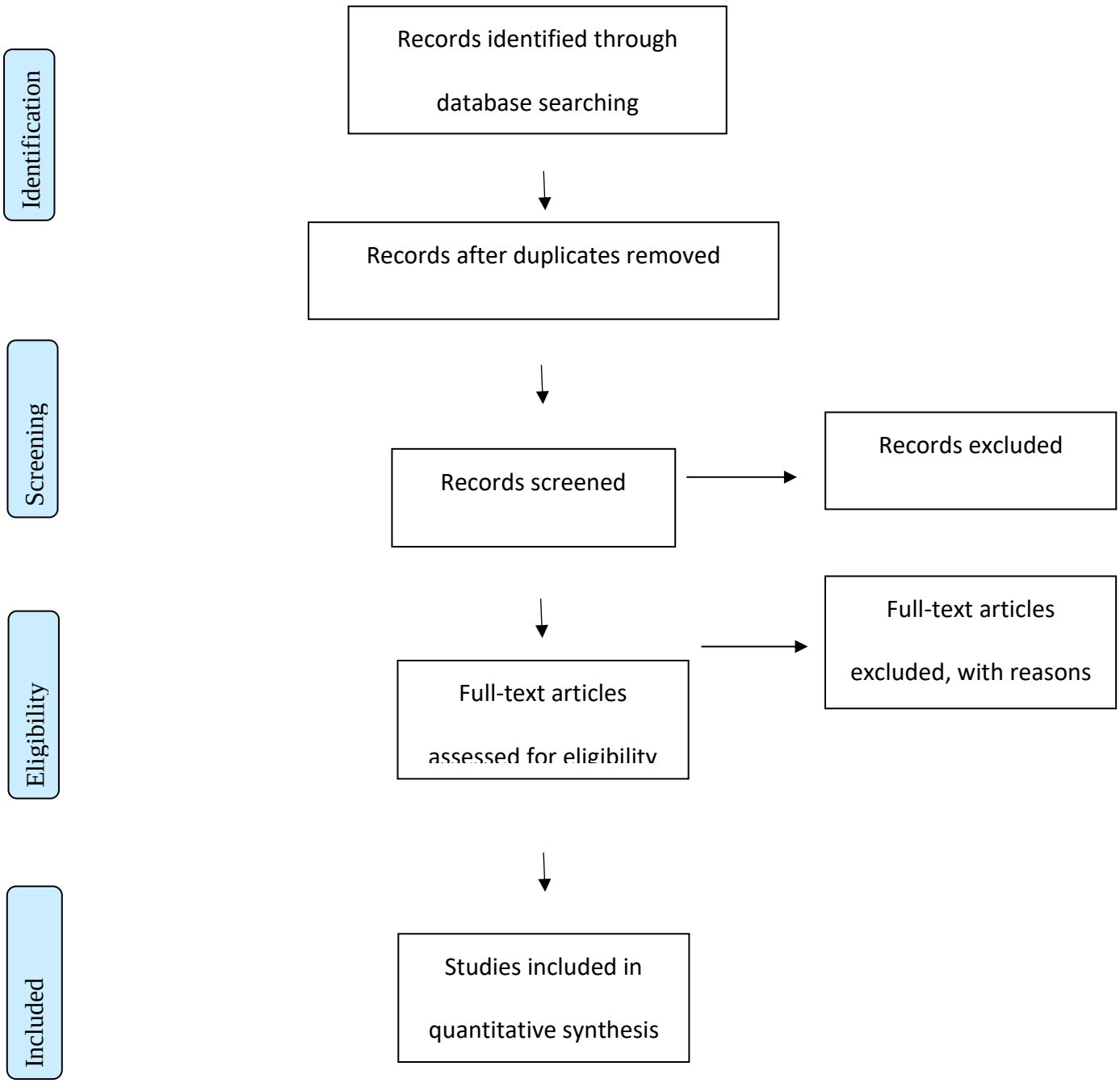
PRISMA Flow Diagram for Theme 1: The working memory of adolescents with dyslexia



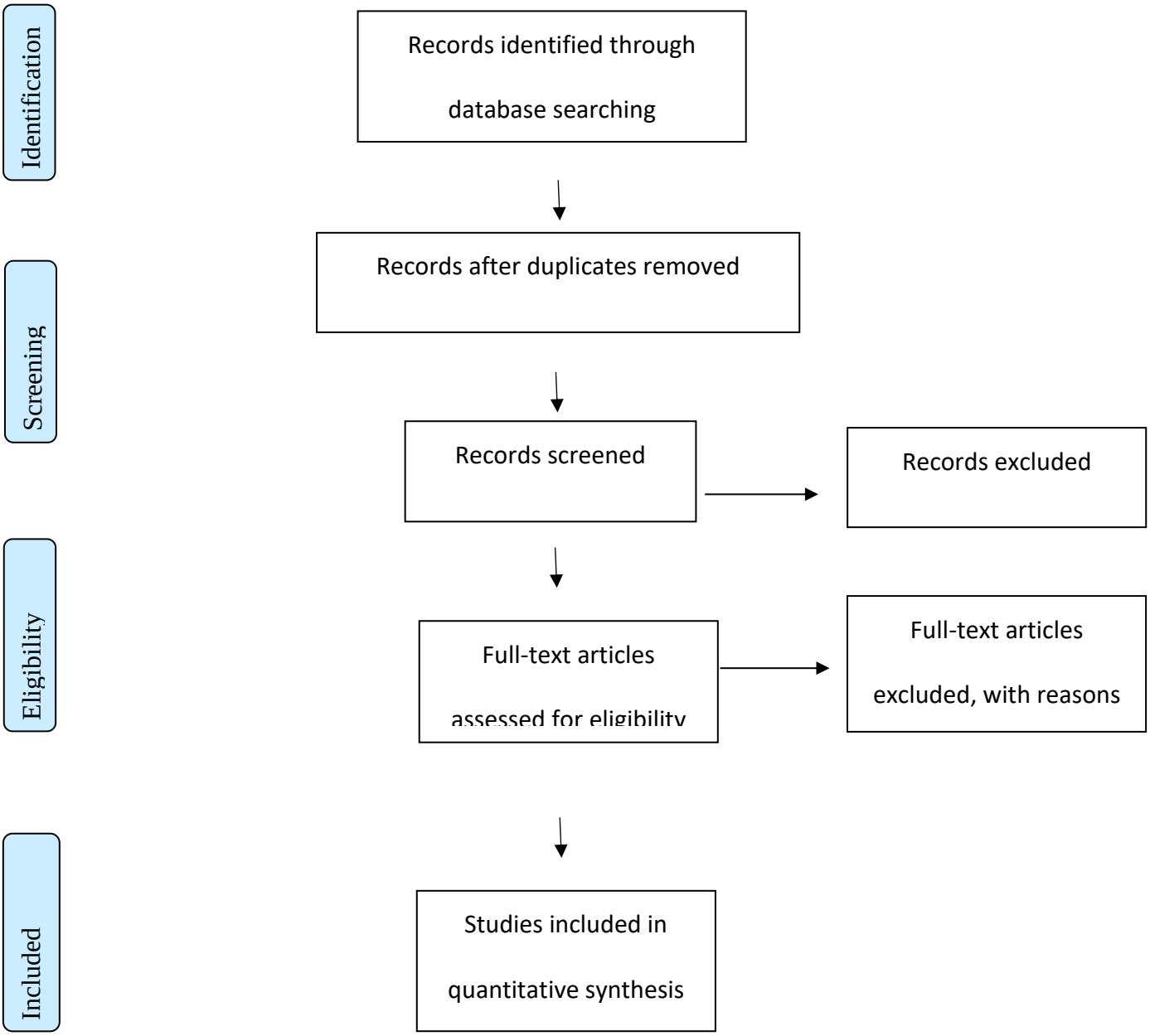
PRISMA Flow Diagram for Theme 2: Affect related working memory



PRISMA Flow Diagram for Theme 3: Emotional regulation and working memory



PRISMA Flow Diagram for Theme 4: Affect and literacy learning



Appendix B Inclusionary/Exclusionary criteria and rationale for the four themes featured in the systematic review

		Inclusionary	Exclusionary	Rationale
1	**Participants**	Adolescents (11-15 years old) were part of the sample population for theme 3 and 4. Due to a lack of studies with adolescents alone, this preference was not always possible.	All participants in primary school or an adult. <11 or >15	Adolescence is specifically chosen due to cognitive, neurological, social, and developmental changes mentioned above. Studies in theme one and two did not supply enough papers that included only adolescent participants.
2	**Study design**	-Empirical studies using appropriate quantitative measures to assess Theme 1: the working memory of adolescents with dyslexia Theme 2: affect and working memory Theme 3: emotional regulation and dyslexia or working	-Qualitative studies that did not give quantitative evidence of (affective) working memory functioning. Study not based on students with dyslexia or a SLD specifically for theme	Studies need to be specific to dyslexia and accurately measuring working memory, socio-emotional or literacy outcomes, and emotional regulation and must not incorporate a systematic review of previous literature. Mixed method approaches were partially included.

		memory Theme 4: Socio-emotional factors and literacy	1.Secondary data such as systematic reviews/ a meta-analysis	
3	**Geographic Context**	Studies from OECD countries such as the UK, Australia and America.	Studies not from OECD countries.	OECD countries are more similar to Ireland in relation to educational, social and financial factors. Studies were not conducted in Ireland, but should generalizable to an Irish population.
4	**Outcome variables**	Studies that made reference to some working memory, socio-emotional factors, or literacy factors.	Outcome variables were not specific to WM/AWM functioning, ER, or socio-emotional effects on literacy.	To gather data relating to the review questions on working memory and socio-emotional factors of adolescents with dyslexia. Research should focus on emotion maintenance rather than how emotion affects cognition or cognition affects emotion.
5	**Publication language**	Publication in the English language. Articles in English language but research done through a different	Publication not in the English language and from a very different orthography.	For the author to be able to understand and review text, it must be in English. The orthography of another language would be different to English and results may not be as

		language with different orthography.		comparable to an Irish population but it will give a variety of experiences internationally.
6	**Publication date**	From January 2010 to July 2020	Before January 2010	The study will have met certain academic and quality standards. Some studies done prior to 2000 on WM required further study and corroboration (e.g. Swanson, 1999; Swanson, 2001).ER strategies must be relevant to current adolescent generation.
7	**Type of publication**	Peer-reviewed journal	Non-peer-reviewed journal	Higher credibility and a comprehensive assessment process

Appendix C.1: Sample Coding protocol for Quality of Validity for Theme 1

Paper Reference: Kibby, M. Y., Marks, W., Morgan, S., & Long, C. J. (2004). Specific Impairment in Developmental Reading Disabilities: A Working Memory Approach. *Journal of Learning Disabilities*, *37*(4), 349-363. https://doiorg.libraryproxy.mic.ul.ie/10.1177/00222194040370040601

Quality indicators within single subject research to identify evidence-based practice in special education (Horner et al., 2005)

Description of Participants and Setting	
Participants are described with sufficient detail to allow others to select individuals with similar characteristics (e.g., age, gender, disability, diagnosis).	√
The process for selecting participants is described with replicable precision.	√
Critical features of the physical setting are described with sufficient precision to allow replication.	√
Dependent Variable	
Dependent variables are described with operational precision.	√
Each dependent variable is measured with a procedure that generates a quantifiable index.	√
Measurement of the dependent variable is valid and described with replicable precision.	√
Dependent variables are measured repeatedly over time.	
Data are collected on the reliability or interobserver agreement associated with each dependent variable, and	

IOA levels meet minimal standards {e.g., lOA = 80%; Kappa = 60%).

Independent Variable

Independent variable is described with replicable precision. √

Independent variable is systematically manipulated and under the control of the experimenter. √

Overt measurement of the fidelity of implementation for the independent variable is highly desirable.

Baseline

The majority of single-subject research studies will include a baseline phase that provides repeated measurement of a dependent variable and establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable did not occur.

Baseline conditions are described with replicable precision.

Experimental Control/internal Validity

The design provides at least three demonstrations of experimental effect at three different points in time.

The design controls for common threats to internal validity (e.g., permits elimination of rival hypotheses). √

The results document a pattern that demonstrates experimental control. √

External Validity

Experimental effects are replicated across participants, settings, or materials to establish external validity. √

Social Validity

The dependent variable is socially important. √

The magnitude of change in the dependent variable resulting from the intervention is socially important.

Implementation of the independent variable is practical and cost-effective.

Social validity is enhanced by implementing the independent variable over extended periods, by typical intervention agents, in typical physical and social contexts.

Appendix C.2: Sample Coding protocol for Quality of Validity for Theme 2

Paper Reference: Mikels, J. A., Reuter-Lorenz, P. A., Beyer, J. A., & Fredrickson, B. L. (2008). Emotion and working memory: Evidence for domain-specific processes for affective maintenance. *Emotion*, *8*(2), 256-266. https://doi-org.libraryproxy.mic.ul.ie/10.1037/1528-3542.8.2.256

Quality indicators within single subject research to identify evidence-based practice in special education (Horner et al., 2005)

Description of Participants and Setting	
Participants are described with sufficient detail to allow others to select individuals with similar characteristics (e.g., age, gender, disability, diagnosis).	√
The process for selecting participants is described with replicable precision.	
Critical features of the physical setting are described with sufficient precision to allow replication.	√
Dependent Variable	
Dependent variables are described with operational precision.	√
Each dependent variable is measured with a procedure that generates a quantifiable index.	√
Measurement of the dependent variable is valid and described with replicable precision.	√
Dependent variables are measured repeatedly over time.	√
Data are collected on the reliability or interobserver agreement associated with each dependent variable, and	

IOA levels meet minimal standards {e.g., lOA = 80%; Kappa = 60%).

Independent Variable

Independent variable is described with replicable precision. √

Independent variable is systematically manipulated and under the control of the experimenter. √

Overt measurement of the fidelity of implementation for the independent variable is highly desirable.

Baseline

The majority of single-subject research studies will include a baseline phase that provides repeated measurement of a dependent variable and establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable did not occur. √

Baseline conditions are described with replicable precision. √

Experimental Control/internal Validity

The design provides at least three demonstrations of experimental effect at three different points in time. √

The design controls for common threats to internal validity (e.g., permits elimination of rival hypotheses). √

The results document a pattern that demonstrates experimental control. √

External Validity

Experimental effects are replicated across participants, settings, or materials to establish external validity. √

Social Validity

The dependent variable is socially important. √

The magnitude of change in the dependent variable resulting from the intervention is socially important.	
Implementation of the independent variable is practical and cost effective.	√
Social validity is enhanced by implementation of the independent variable over extended time periods, by typical intervention agents, in typical physical and social contexts.	√

Appendix C.3: Sample Coding protocol for Quality of Validity for Theme 3

Paper Reference: Garrison, K. E., & Schmeichel, B. J. (2020). Getting over it: Working memory capacity and affective responses to stressful events in daily life. *Emotion*. Advance online publication. https:// doi.org/10.1037/emo0000755

Quality indicators within single subject research to identify evidence-based practice in special education (Horner et al., 2005)

Description of Participants and Setting	
Participants are described with sufficient detail to allow others to select individuals with similar characteristics (e.g., age, gender, disability, diagnosis).	√
The process for selecting participants is described with replicable precision.	√
Critical features of the physical setting are described with sufficient precision to allow replication.	√
Dependent Variable	
Dependent variables are described with operational precision.	√
Each dependent variable is measured with a procedure that generates a quantifiable index.	√
Measurement of the dependent variable is valid and described with replicable precision.	√
Dependent variables are measured repeatedly over time.	√
Data are collected on the reliability or interobserver agreement associated with each dependent variable, and	√
IOA levels meet minimal standards {e.g., lOA = 80%; Kappa = 60%).	

Independent Variable

Independent variable is described with replicable precision. √

Independent variable is systematically manipulated and under the control of the experimenter. √

Overt measurement of the fidelity of implementation for the independent variable is highly desirable.

Baseline

The majority of single-subject research studies will include a baseline phase that provides repeated measurement of a dependent variable and establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable did not occur. √

Baseline conditions are described with replicable precision. √

Experimental Control/internal Validity

The design provides at least three demonstrations of experimental effect at three different points in time. √

The design controls for common threats to internal validity (e.g., permits elimination of rival hypotheses). √

The results document a pattern that demonstrates experimental control. √

External Validity

Experimental effects are replicated across participants, settings, or materials to establish external validity. √

Social Validity

The dependent variable is socially important. √

The magnitude of change in the dependent variable resulting from the intervention is socially important. √

Implementation of the independent variable is practical and cost effective.	√
Social validity is enhanced by implementation of the independent variable over extended time periods, by typical intervention agents, in typical physical and social contexts.	√

Appendix C.4: Sample Coding protocol for Quality of Validity for Theme 4

Paper Reference: Rączy, K., & Orzechowski, J. (2019). When working memory is in a mood: Combined effects of induced affect and processing of emotional words. Current Psychology: *A Journal for Diverse Perspectives on Diverse Psychological Issues*. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s12144-019-00208-x

Quality indicators within single subject research to identify evidence-based practice in special education (Horner et al., 2005)

Description of Participants and Setting	
Participants are described with sufficient detail to allow others to select individuals with similar characteristics (e.g., age, gender, disability, diagnosis).	√
The process for selecting participants is described with replicable precision.	√
Critical features of the physical setting are described with sufficient precision to allow replication.	√
Dependent Variable	
Dependent variables are described with operational precision.	√
Each dependent variable is measured with a procedure that generates a quantifiable index.	√
Measurement of the dependent variable is valid and described with replicable precision.	√
Dependent variables are measured repeatedly over time.	√
Data are collected on the reliability or interobserver agreement associated with each dependent variable, and	

IOA levels meet minimal standards {e.g., lOA = 80%; Kappa = 60%).

Independent Variable

Independent variable is described with replicable precision. √

Independent variable is systematically manipulated and under the control of the experimenter. √

Overt measurement of the fidelity of implementation for the independent variable is highly desirable.

Baseline

The majority of single-subject research studies will include a baseline phase that provides repeated measurement of a dependent variable and establishes a pattern of responding that can be used to predict the pattern of future performance, if introduction or manipulation of the independent variable did not occur. √

Baseline conditions are described with replicable precision. √

Experimental Control/internal Validity

The design provides at least three demonstrations of experimental effect at three different points in time.

The design controls for common threats to internal validity (e.g., permits elimination of rival hypotheses). √

The results document a pattern that demonstrates experimental control. √

External Validity

Experimental effects are replicated across participants, settings, or materials to establish external validity. √

Social Validity

The dependent variable is socially important. √

The magnitude of change in the dependent variable resulting from the intervention is socially important.	√
Implementation of the independent variable is practical and cost effective.	√
Social validity is enhanced by implementation of the independent variable over extended time periods, by typical intervention agents, in typical physical and social contexts.	√

Appendix D: High and low sources of weighting

High Weighting Indicators for Theme 1 (2 or more)	**Low Weighting Indicators for Theme 1 (2 or more)**
Measured more than two domains in WM (i.e. visuospatial processing, phonological processing, or central executive processing)	Measures one domain in WM(i.e. just visual spatial processing, or phonological processing, or central executive processing
High validity and reliability measures used	Validity and reliability not recorded
Study mentions WM differences with typically developing peers	Study does not mention WM differences with typically developing peers
Sample population checked for co-morbidities, e.g. ADHD	Uncertainty if sample population may have co-morbidities, e.g. attentional difficulties
Sample population includes post-primary students or mean age of participants 12-14 years	Mean age of population greater than 15 or less than 11
High Weighting Indicators for Theme 2 (2 or more)	**Low Weighting Indicators for Theme 2 (2 or more)**
Large sample (i.e. 23 or more)	Low Sample size (i.e. 22 or less)
Measures affect maintenance	Mainly measures affective distractors or affective content rather than affect maintenance
Includes adolescents	
Includes more than 1 experiment testing aspects of AWM or tests	

additional variables with a relationship to AWM	
High Weighting Indicators for Theme 3 (3 or more)	**Low Weighting Indicators for Theme 3 (3 or more)**
Two or more studies within the article testing different aspects of the relationship between ER and WM **ER performance measured, not just trait ER with questionnaires** **Uses multiple measures and sample population over 200 participants** **Incorporated literacy components to the investigation**	Article tests one aspect of relationship between ER and WM ER trait questionnaires used only Uses only one measure of ER or WM and sample population under 200 participants Did not incorporate literacy aspects to the investigation Measures affective responses and does not distinguish between emotional reactivity and emotional regulation
High Weighting Indicators for Theme 4 (2 or more)	**Low Weighting Indicators for Theme 4 (2 or more)**
Study investigated the relationship between affective literacy content and working memory using positive and negative words **FMRI and behavioural data** **Includes male and females in sample population**	Study investigated the relationship between affective literacy content and working memory but only negative words were used Includes only one gender in the sample population and/or low sample population (under 25)

Appendix E.1: Excluded Studies and Rationale for Exclusion from Theme 1

Study Number	Study Reference	Rationale for Exclusion
1	Swanson, H. L., & Sachse-Lee, C. (2001). A subgroup analysis of working memory in children with reading disabilities: Domain-general or domain-specific deficiency? *Journal of Learning Disabilities, 34*(3), 249-263. https://doiorg.libraryproxy.mic.ul.ie/10.1177/002221940103400305	Included in Meta-analysis by Swanson
2	Swanson, H. L., Howard, C. B., & Sáez, L. (2006). Do Different Components of Working Memory Underlie Different Subgroups of Reading Disabilities? *Journal of Learning Disabilities, 39*(3), 252-269. https://doi-org.libraryproxy.mic.ul.ie/10.1177/00222194060390030501	Included in Meta-analysis by Swanson
3	Fostick, L., & Revah, H. (2018). Dyslexia as a multi-deficit disorder: Working memory and auditory temporal processing. *Acta Psychologica, 183*, 19-28. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.actpsy.2017.12.010	4
4	Maehler, C., & Schuchardt, K. (2016). Working memory in children with specific learning disorders and/or attention deficits. *Learning and Individual Differences, 49*, 341-347. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.lindif.2016.05.007	1
5	Moll, K., Göbel, S. M., Gooch, D., Landerl, K., & Snowling, M. J. (2016). Cognitive risk factors for specific learning disorder: Processing speed, temporal processing, and working memory.	4

Journal of Learning Disabilities, *49*(3), 272-281. https://doi-org.libraryproxy.mic.ul.ie/10.1177/0022219414547221

6 Savage, R., Lavers, N., & Pillay, V. (2007). Working memory and reading difficulties: What we know and what we don't know about the relationship. *Educational Psychology Review*, *19*(2), 185-221. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s10648-006-9024-1 2

7 Dawes, E., Leitão, S., Claessen, M., & Nayton, M. (2015). A profile of working memory ability in poor readers. *Australian Psychologist*, *50*(5), 362–371. https://doi-org.libraryproxy.mic.ul.ie/10.1111/ap.12120 4

8 Fischbach, A., Könen, T., Rietz, C., & Hasselhorn, M. (2014). What is not working in working memory of children with literacy disorders? Evidence from a three-year-longitudinal study. *Reading & Writing*, *27*(2), 267–286. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s11145-013-9444-5 1

9 Schuchardt, K., Bockmann, A.-K., Bornemann, G., & Maehler, C. (2013). Working Memory Functioning in Children With Learning Disorders and Specific Language Impairment. *Topics in Language Disorders*, *33*(4), 298–312. https://doi-org.libraryproxy.mic.ul.ie/10.1097/01.TLD.0000437943.41140.36 4

10 Wang, S., & Gathercole, S. E. (2013). Working memory deficits in children with reading difficulties: Memory span and dual task coordination. *Journal of Experimental Child Psychology*, *115*(1), 188–197. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.jecp.2012.11.015 1

11	Malstädt, N., Hasselhorn, M., & Lehmann, M. (2012). Free recall behaviour in children with and without spelling impairment: The impact of working memory subcapacities. *Dyslexia: An International Journal of Research and Practice*, *18*(4), 187–198. https://doi-org.libraryproxy.mic.ul.ie/10.1002/dys.1446	4
12	Maehler, C., & Schuchardt, K. (2011). Working Memory in Children with Learning Disabilities: Rethinking the Criterion of Discrepancy. *International Journal of Disability, Development and Education*, *58*(1), 5–17.	4
13	Beneventi, H., Tønnessen, F. E., Ersland, L., & Hugdahl, K. (2010). Executive working memory processes in dyslexia: Behavioral and fMRI evidence. *Scandinavian Journal of Psychology*, *51*(3), 192–202. https://doi-org.libraryproxy.mic.ul.ie/10.1111/j.1467-9450.2010.00808.x	4
14	Swanson, H. L., Zheng, X., & Jerman, O. (2009). Working memory, short-term memory, and reading disabilities: A selective meta-analysis of the literature. *Journal of Learning Disabilities*, *42*(3), 260–287. https://doi-org.libraryproxy.mic.ul.ie/10.1177/0022219409331958	2

Appendix E.2: Excluded Studies and Rationale for Exclusion from Theme 2

Study Number	Study Reference	Rationale for Exclusion
1	Schweizer, S., Satpute, A. B., Atzil, S., Field, A. P., Hitchcock, C., Black, M., Barrett, L. F., & Dalgleish, T. (2019). The impact of affective information on working memory: A pair of meta-analytic reviews of behavioral and neuroimaging evidence. Psychological Bulletin, 145(6), 566–609. https://doi-org.libraryproxy.mic.ul.ie/10.1037/bul0000193.supp	Systematic Review
2	Mikels, J. A., & Reuter-Lorenz, P. A. (2019). Affective Working Memory: An Integrative Psychological Construct. Perspectives on Psychological Science, 14(4), 543–559. https://doi-org.libraryproxy.mic.ul.ie/10.1177/1745691619837597	Review of literature
3	Donolato, E., Giofrè, D., & Mammarella, I. C. (2019). Working memory, negative affect and personal assets: How do they relate to mathematics and reading literacy? *PLoS ONE*, *14*(6), 1–17. https://doi-org.libraryproxy.mic.ul.ie/10.1371/journal.pone.0218921	4
4	Wante, L., Braet, C., & Mueller, S. C. (2018). Altered Working Memory Processing of Emotion in Adolescents with Dysphoric Symptomatology: An Eye Tracking Study. *Child Psychiatry & Human Development*, *49*(6), 875–887. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s10578-018-0803-y	4
5	Artuso, C., Bellelli, F., & Belacchi, C. (2020). Developmental dyslexia: How taxonomic and thematic organization affect	4

working memory recall. *Child Neuropsychology*, *26*(2), 242–256. https://doi-org.libraryproxy.mic.ul.ie/10.1080/09297049.2019.1640869

Appendix E.3: Excluded Studies and Rationale for Exclusion from Theme 3

Study Number	Study Reference	Rationale for Exclusion
1	Lee, T., & Xue, S. (2018). Does emotion regulation engage the same neural circuit as working memory? A meta-analytical comparison between cognitive reappraisal of negative emotion and 2-back working memory task. PloS One, 13(9), e0203753. doi:10.1371/journal.pone.0203753	Meta-analysis
2	Schmeichel, B. J., & Tang, D. (2015). Individual differences in executive functioning and their relationship to emotional processes and responses. *Current Directions in Psychological Science*, *24*(2), 93-98.	Review
3	Hitchcock C, & Westwell MS. (2017) A cluster-randomised, controlled trial of the impact of Cogmed Working Memory Training on both academic performance and regulation of social, emotional and behavioural challenges. *Journal of Child Psychology & Psychiatry*. *58*(2):140-150. doi:10.1111/jcpp.12638	4
4	Ribeiro, F. S., Santos, F. H., & Albuquerque, P. B. (2019). How Does Allocation of Emotional Stimuli Impact Working Memory Tasks? An Overview. *Advances in Cognitive Psychology*, *15*(2), 155–168. https://doi-org.libraryproxy.mic.ul.ie/10.5709/acp-0265-y	Review
5	Michaud Dumont, F., Tarabulsy, G. M., Sylvestre, A., & Voisin, J. (2019). Children's Emotional Self-Regulation in the Context of	4

Adversity and the Association with Academic Functioning. *Child Psychiatry & Human Development, 50*(5), 856–867. https://doi-org.libraryproxy.mic.ul.ie/10.1007/s10578-019-00888-3

6 Basso, J. C., McHale, A., Ende, V., Oberlin, D. J., & Suzuki, W. A. (2019). Brief, daily meditation enhances attention, memory, mood, and emotional regulation in non-experienced meditators. *Behavioural Brain Research, 356*, 208–220. https://doi-org.libraryproxy.mic.ul.ie/10.1016/j.bbr.2018.08.023 1,4

7 Music, G. (2014). Top down and bottom up: trauma, executive functioning, emotional regulation, the brain and child psychotherapy. *Journal of Child Psychotherapy, 40*(1), 3–19. https://doi-org.libraryproxy.mic.ul.ie/10.1080/0075417X.2014.883125 4

8 Evrard, D., Charollais, A., Marret, S., Radi, S., Rezrazi, A., & Mellier, D. (2011). Cognitive and emotional regulation developmental issues in preterm infants 12 and 24 months after birth. *European Journal of Developmental Psychology, 8*(2), 171–184. https://doi-org.libraryproxy.mic.ul.ie/10.1080/17405620903504538 1

9 Liu, W., Peeters, N., Fernández, G., & Kohn, N. (2020). Common neural and transcriptional correlates of inhibitory control underlie emotion regulation and memory control. *Social Cognitive & Affective Neuroscience, 15*(5), 523–536. https://doi-org.libraryproxy.mic.ul.ie/10.1093/scan/nsaa073 Review

10 Hendricks, M. A., & Buchanan, T. W. (2016). Individual differences in cognitive control processes and their relationship to emotion regulation. *Cognition & Emotion*, *30*(5), 912–924. https://doi-org.libraryproxy.mic.ul.ie/10.1080/02699931.2015.1032893

Appendix E.4: Excluded Studies and Rationale for Exclusion from Theme 4

Study Number	Study Reference	Rationale for Exclusion
1	Ehret, C., Boegel, J., & Manuel, N. R. (2018). The Role of Affect in Adolescents' Online Literacies: Participatory Pressures in BookTube Culture. *Journal of Adolescent & Adult Literacy*, *62*(2), 151–161. https://doi-org.libraryproxy.mic.ul.ie/10.1002/jaal.881	4
2	Duff, C., McPherson, A. C., & King, G. (2020). Residential Immersive Life Skills Programs: A Catalyst for Facilitating Emotional Literacy Development for Youth with Disabilities. *Developmental Neurorehabilitation*, *23*(5), 294–301. https://doi-org.libraryproxy.mic.ul.ie/10.1080/17518423.2019.1657198	2,4
3	Tornare, E., Cuisinier, F., Czajkowski, N. O., & Pons, F. (2017). Impact of induced joy on literacy in children: does the nature of the task make a difference? *Cognition & Emotion*, *31*(3), 500–510. https://doi-org.libraryproxy.mic.ul.ie/10.1080/02699931.2015.1132682	1,4
4	Fisher, D., Frey, N., Marsh, J. P., & Gonzalez, D. (2019). The Links Between Social and Emotional Learning and Literacy. *Journal of Adolescent & Adult Literacy*, *63*(1), 115–117. https://doi-org.libraryproxy.mic.ul.ie/10.1002/jaal.963	4
5	Nikolajeva, M. (2013). Picture books and Emotional Literacy. *Reading Teacher*, *67*(4), 249–254. https://doi-org.libraryproxy.mic.ul.ie/10.1002/trtr.1229	2,4

6	Haddon, A., Goodman, H., Park, J., Crick, R. D., & McLaughlin, C. (2005). Evaluating Emotional Literacy in Schools: The Development of the School Emotional Environment for Learning Survey. *Pastoral Care in Education, 23*(4), 5–16. https://doi-org.libraryproxy.mic.ul.ie/10.1111/j.1468-0122.2005.00346.x	4
7	Swank, H. (2011). A Wanderer in a Distant Place: Tibetan Exile Youth, Literacy, and Emotion. *International Migration, 49*(6), 50–73. https://doi-org.libraryproxy.mic.ul.ie/10.1111/j.1468-2435.2011.00703.x	3
8	Matteson, M. L. (2014). The Whole Student: Cognition, Emotion, and Information Literacy. *College & Research Libraries, 75*(6), 862–877. https://doi-org.libraryproxy.mic.ul.ie/10.5860/crl.75.6.862	4
9	Zaccoletti, S., Altoè, G., & Mason, L. (2019;2020;). The interplay of reading-related emotions and updating in reading comprehension performance. *British Journal of Educational Psychology, 90*(3), 663-682. doi:10.1111/bjep.12324	3
10	Long, L., MacBlain, S., & MacBlain, M. (2007). Supporting students with dyslexia at the secondary level: An emotional model of literacy. *Journal of Adolescent & Adult Literacy, 51*(2), 124-134. doi:10.1598/JAAL.51.2.4	4

Appendix F: Ethical Approval

MARY IMMACULATE COLLEGE
COLÁISTE MHUIRE GAN SMÁL

Mary Immaculate College
Research Ethics Committee
MIREC-4: MIREC Chair Decision Form

APPLICATION NO. A20-021

1. PROJECT TITLE

An investigation into the working memory of adolescents with and without dyslexia for affective stimuli

2. APPLICANT

Name:	Claire Donnelly
Department / Centre / Other:	EPISE
Position:	Postgraduate Researcher

3. DECISION OF MIREC CHAIR

☐	Ethical clearance through MIREC is required.
☐	Ethical clearance through MIREC is not required and therefore the researcher need take no further action in this regard.
✓	Ethical clearance is required and granted. Referral to MIREC is not necessary.
☐	Ethical clearance is required but the full MIREC process is not. Ethical clearance is therefore granted if required for external funding applications and the researcher need take no further action in this regard.
☐	Insufficient information provided by applicant / Amendments required.

4. REASON(S) FOR DECISION

A20-021 - Claire Donnelly - An investigation into the working memory of adolescents with and without dyslexia for affective stimuli
I have reviewed this application and I believe it satisfies MIREC requirements. It is, therefore, approved in full
Suggestions:

- **Parental/Legal Guardian Consent Form**
  For ease of identification, Claire might include the child's name on the Consent Form

5. DECLARATION (MIREC CHAIR)

Name (Print):	Dr Áine Lawlor
Signature:	Áine Lawlor
Date:	15th April 2020

MIREC-4 Rev 3 Page 1 of 1

Appendix G: Covering Letter to the Board of Management/ School Principal School

Mary Immaculate College,

South Circular Road,

Limerick V94 VN26.

Tel: +353 61 204300

Date

Principal Name,

Principal Address,

Date

Dear _____,

My name is Claire Donnelly. I am currently undertaking postgraduate training on the Doctorate in Educational and Child Psychology programme at Mary Immaculate College, Limerick. I am researching how adolescents with dyslexia process affective information such as feelings, moods, and attitudes. This research is being conducted under the supervision of Dr Therese Brophy, Programme Coordinator, Doctorate in Educational Psychology, and Dr Paul Mulcahy, Lecturer in Psychology, Department of Psychology.

The proposed title of the research is: an investigation into the working memory of adolescents with and without dyslexia for affective stimuli.

The collection of data will require 20 minutes. If you would like your school to participate in this research project, please feel free to contact me by email at 09005128@micstudent.mic.ul.ie, or by phone 086-207 2920. For more detailed information about this research project, please refer to the enclosed information sheet. If you have any questions about this research, please do not hesitate to contact me. Alternatively, you may contact my first

supervisor, Dr Therese Brophy at therese.brophy@mic.ul.ie or my second supervisor, Dr Paul Mulcahy, at paul.mulcahy@mic.ul.ie

If you have any concerns about this study and wish to contact someone independently, you may contact: Mary Collins, MIREC Administrator, Research and Graduate School, Mary Immaculate College, South Circular Road, Limerick. Telephone: 06-204980 / Email: mirec@mic.ul.ie

Kind regards,

_____

Claire Donnelly

Appendix H: Informational Letter for School

An investigation into the working memory of adolescents with and without dyslexia for affective stimuli

School Information Letter

What is the project about?

Working memory helps us to store, sort, and recall information in school and everyday life. There is evidence to believe that we may store information relating to our feelings, moods, and attitudes differently. We do not know if this could be a strength or a challenge for adolescents with dyslexia, and the role emotional regulation plays in supporting this process for adolescents with and without dyslexia.

Who is undertaking it?

My name is Claire Donnelly, and I am a postgraduate student attending Mary Immaculate College, Limerick. I am presently completing the Professional Doctorate in Educational and Child Psychology in the Department of Educational Psychology, Inclusive & Special Education, under the supervision of Dr Therese Brophy and Dr Paul Mulcahy. The current study will form part of my thesis.

Why is it being undertaken?

This project seeks to better understand how affect or emotions can impact learning positively or negatively, which may help to develop further assessment and teaching methodologies that particularly suit children and adolescents with dyslexia.

What are the benefits of this research?

There may be benefits to the education and psychology community. Firstly, the study will clarify if adolescents with dyslexia process affective material differently to adolescents without dyslexia. Secondly, this knowledge will

not only add to the psychological understanding of dyslexia but may support future educational practices of young people with dyslexia at school.

What are the risks of this research?

This research will use age-appropriate positive and negative pictures and words, and discuss how they manage emotions. All tasks will be outlined in the participant information sheet. However, if activities evoke strong feelings for them, participants can withdraw at any stage during the research.

Exactly what is involved for the participant

Participants will be asked to take part in approximately 20 minutes of activities on a computer. Participants will receive instructions on the computer, where they will be required to look at pictures and make a decision about them. Next, participants will complete a short questionnaire on their emotional regulation (how participants manage their emotional experience).

Right to withdraw

Students are free to withdraw from the research project at any time without giving a reason and without consequence.

How will the information be used/disseminated?

The data collected will be combined with that of other participants from different schools to form the results section of my thesis. Summary data only will appear in the thesis; individual participant data will not be shown.

How will confidentiality be kept?

All information gathered will remain confidential and will not be released to any third party. A random ID number will be generated for each participant, and it is this number rather than the participant's name, which will be held with their data to maintain their anonymity.

What will happen to the data after research has been completed?

In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

Contact details

If at any time you have any queries/issues with regard to this study, my contact details are as follows:

- Principal investigator name: Claire Donnelly 09005128@micstudent.mic.ul.ie
- Principal investigator contact number: to be provided following participant recruitment.
- First supervisor: Dr Therese Brophy therese.brophy@mic.ul.ie
- Second supervisor: Dr Paul Mulcahy paul.mulcahy@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:

Mary Collins, MIREC Administrator, Research and Graduate School, Mary Immaculate College, South Circular Road, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie

Appendix I: Informational Letter for Parent/Legal Guardian

An investigation into the working memory of adolescents with and without dyslexia for affective stimuli

Parent/Legal Guardian Information Letter

What is the project about?

Working memory helps us to store, sort, and recall information in school and everyday life. There is evidence to suggest that we may sort, store, and recall affective information (e.g. relating to our feelings, moods and attitudes) differently. We do not know if this could be a strength or a challenge for adolescents with or without dyslexia, and the skills and strategies youths use to manage the thoughts and emotions experienced. It will investigate the working memory of 12-14 year old post-primary students who have or have not a diagnosis of dyslexia, but do not have any other learning, or developmental difficulties.

Who is undertaking it?

My name is Claire Donnelly, and I am a postgraduate student attending Mary Immaculate College, Limerick. I am presently completing the Professional Doctorate in Educational and Child Psychology in the Department of Educational Psychology, Inclusive & Special Education, under the supervision of Dr Therese Brophy and Dr Paul Mulcahy. The current study will form part of my thesis.

Why is it being undertaken?

This project seeks to better understand how affect or emotions can impact learning positively or negatively. This may help to develop further assessments and teaching methodologies that particularly suit children and adolescents with and without dyslexia.

What are the benefits of this research?

Firstly, the study will clarify if adolescents with dyslexia sort, store and recall information relating to emotions differently to adolescents without dyslexia. Secondly, this knowledge will not only add to the understanding of dyslexia but may support future educational practices when supporting young people with dyslexia at school.

What are the risks of this research?

This research will use age appropriate positive and negative pictures and words, and discuss how they manage emotions. All tasks will be outlined in the participant information sheet. However, if activities evoke strong feelings for them, participants can withdraw at any stage during the research.

Exactly what is involved for the participant

Participants will be invited to participate in approximately 20 minutes of activities on a computer. Participants will receive instructions and complete working memory activities, where they will be required to look at pictures and make a decision about them. Students will rate their experiences completing the tasks. Finally, participants will complete a short questionnaire on their emotional regulation (how participants manage their emotional experiences). It is important that participants wear their glasses if they have difficulties with vision.

Right to withdraw

Your son/daughter is free to withdraw from the research project at any time without giving a reason and without consequence.

How will the information be used/disseminated?

The data collected will be combined with that of other participants from different schools to form the results section of my thesis. Summary data only will appear in the thesis; individual participant data will not be shown.

How will confidentiality be kept?

All information gathered will remain confidential and will not be released to any third party. A random ID number will be generated for each participant, and it is this number rather than the participant's name, which will be held with their data to maintain their anonymity.

What will happen to the data after research has been completed?

In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

Contact details

If at any time you have any queries/issues with regard to this study, my contact details are as follows:

- Principal investigator name: Claire Donnelly 09005128@micstudent.mic.ul.ie
- Principal investigator contact number: to be provided following participant recruitment.
- First supervisor: Dr Therese Brophy therese.brophy@mic.ul.ie
- Second supervisor: Dr Paul Mulcahy paul.mulcahy@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:

Mary Collins, MIREC Administrator, Research and Graduate School, Mary Immaculate College, South Circular Road, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie

Appendix J: Parent/Legal Guardian Informed Consent Letter

An investigation into the working memory of adolescents with and without dyslexia for affective stimuli

Parental/Legal Guardian Consent Form

Dear parent/guardian,

As outlined in the **Participant Information Letter,** the current study will investigate how adolescents (12-14 years old) with and without dyslexia process information that pertains to feelings, moods, and attitudes. The parent/legal guardian information letter should be read before consenting to your son or daughter taking part in this research study.

Participants' information will be kept strictly confidential, and they are free to withdraw from the research investigation at any time. All information gathered will remain confidential and will not be released to any third party. In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

- Please tick if your adolescent has a diagnosis of dyslexia ☐
- Please tick if your adolescent does not have a diagnosis of dyslexia ☐
- Please tick if your son/daughter is between 12-14 years old, attends post-primary school, and has not any other learning or developmental difficulties. ☐

Please read the following statements before signing the consent form.

- I have read and understood the **Participant Information Letter.**
- I understand that, as part of the study, data regarding my son/daughter's working memory, and emotional regulation will be recorded.
- I understand what the project is about and what the results will be used for.

- I am fully aware of **all** of the procedures involving my child and of any **risks and benefits** associated with the study.

- I know that participation is voluntary and that my child can withdraw from the study at any stage without giving any reason.

- I am aware that the results will be kept confidential.

- Participation is greatly appreciated. If you are happy for your son/daughter to participate, please return this signed consent form along with your son/daughter's assent form to 09005128@micstudent.mic.ul.ie. Alternatively, you can email the researcher, Claire Donnelly, to arrange alternative consent.

Name (PRINTED): _____

Name (signature): _____

Date: _____

Appendix K: Participant Informational Letter

An investigation into the working memory of adolescents with and without dyslexia for affective stimuli

Participant Information Letter

What is the project about?

Working memory helps us to store, sort, and recall information in school and everyday life. We may store information that relates to emotions differently. We do not know if this could be a strength or a challenge for adolescents with and without dyslexia.

Who is undertaking it?

My name is Claire Donnelly, and I am a postgraduate student attending Mary Immaculate College, Limerick. I am presently completing the Professional Doctorate in Educational and Child Psychology in the Department of Educational Psychology, Inclusive & Special Education, under the supervision of Dr Therese Brophy and Dr Paul Mulcahy. The current study will form part of my thesis.

Why is it being undertaken?

This project seeks to better understand how you store, sort, and remember information. Young people have a range of learning styles, and this project will help psychologists and teachers understand the type of information that is easier or more difficult for you to learn.

What are the benefits of this research?

This research may help to discover new ways of making learning easier.

What are the risks of this research?

You will be working with images that will be positive and negative. You will know in advance what you will be asked about (see paragraph below) and can withdraw at any point during the project.

Exactly what is involved for the participant

You will receive instructions on the computer and complete 20 minutes of activities. This will involve working memory activities, where you will be required to look at pictures and make a decision about them. You will need your glasses if you normally wear them. You will rate your experiences completing the tasks. Finally, you will complete a short questionnaire on your emotional regulation skills (how you manage your emotional experiences).

Right to withdraw

Your details and results will be kept strictly confidential, and you are free to withdraw from the research project at any time without giving a reason and without consequence.

How will the information be used/disseminated?

The data collected will be combined with that of other participants from different schools to form the results section of my thesis. Summary data only will appear in the thesis; individual participant data will not be shown.

How will confidentiality be kept?

All information will remain anonymous. A random ID number will be used instead of your name.

What will happen to the data after research has been completed?

In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

Contact details

If at any time you have any queries/issues with regard to this study, my contact details are as follows:

- Principal investigator name: Claire Donnelly 09005128@micstudent.mic.ul.ie
- Principal investigator contact number: to be provided following participant recruitment.
- First supervisor: Dr Therese Brophy therese.brophy@mic.ul.ie
- Second supervisor: Dr Paul Mulcahy paul.mulcahy@mic.ul.ie

If you have concerns about this study and wish to contact someone independent, you may contact:

Mary Collins, MIREC Administrator, Research and Graduate School, Mary Immaculate College, South Circular Road, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie

Appendix L: Participant Assent

An investigation into the working memory of adolescents with and without dyslexia for affective stimuli

Participant Assent Form

Dear participant,

As outlined in the **Participant Information Letter,** the current study will investigate if young people store information that relates to feelings, moods and attitudes differently. The participant information letter should be read before consenting to take part in the project.

Your details will be kept anonymous, and you are free to withdraw from the project at any time. All information gathered will remain confidential and will not be released to any third party. In accordance with the MIC Record Retention Schedule, all anonymised data may be stored indefinitely.

Please read the following statements before signing the consent form.

- I have read and understood the **Participant Information Letter**.
- I will wear my glasses during the project, if I need them to read.

- I understand that, as part of the study, data regarding my working memory and how I manage my emotions may be recorded.
- I understand what the project is about and what the results will be used for.
- I am fully aware of **all** of the procedures involved, and of any **risks and benefits** associated with the study.
- I know that participation is voluntary and that I can withdraw from the study at any stage without giving any reason.
- I am aware that the results will be kept confidential.

I have difficulty with reading and writing. ☐

I do not have difficulty with reading and writing. ☐

Name (PRINTED): _____

Name (signature): _____

Date: _____

Appendix M: Additional Preliminary Checks and Calculating Luminance Scores

Firstly, the data collected from phase one and phase two were analysed and compared to check for any carryover effects. There was a statistically significant decrease in reaction time from Phase 1 maintenance tasks (M = 2.6212, SD = 1.12822) to Phase 2 (M = 2.3611, SD = 1.30879), F (1,67) = 4.241, p = .043, partial η^2 = .060. There was a non-significant decrease in reaction time from Phase 1 N-back tasks (M = 0.5802, SD = 0.07210) to Phase 2 N-back tasks (M =0.5732, SD = 0.07797), F (1,67) = 0.621, p = .433, partial η^2 = 0.009. These quicker reaction times demonstrate some practice effects for these novel tasks, in particular for the maintenance tasks.

Secondly, the order of the tasks were investigated, i.e. whether there were effects depending on if brightness maintenance or affect maintenance appeared first and also if neutral words or more affective words appeared first. No significant difference for maintenance tasks F (1, 66) = .238, p > .05, partial η2 = .004 or N-back tasks F (1, 66) = .533, p > .05, partial η2 = .008 were noted. This was expected, given that tasks were counter-balanced to eliminate task order effects.

Thirdly, the reaction times when tasks were congruent (e.g. affective maintenance and affective n-back), or incongruent (e.g. affective maintenance and neutral words) were examined. A mixed ANOVA concluded that congruency between tasks did not have a significant impact on maintenance phase reaction times F (1, 66) = 2.619, p > .05, partial η2 = 0.038, or N-back phase reaction time, F (1, 66) = .493, p > .05, partial η2 =.007.

Fourthly, a three-way interaction effect was then investigated between the phases, congruency, and order of the affective and more neutral tasks. The first and second N-back phases showed an interaction with the order, i.e. affective or neutral words first, and congruency with maintenance type tasks, F (1, 64) = 9.069, p = .004, partial η2 = .12. Participants in phase one who completed the brightness maintenance tasks first along with the

incongruent affective n-back task took the longest reaction times (*M* = .6010, *SD* = .05734), but in phase two, participants who completed the affective maintenance tasks and had incongruent neutral n-back tasks had the quickest responses (*M* = .5485, *SD* = .09982). This may indicate that participants were differently affected by the interaction between phase, congruency and sequence in which they performed the tasks.

Calculating luminance scores

A code algorithm was used in Matlab (2010) for calculating image luminance values for each image. Measuring luminance by this software is important to ascertain an objective measurement tool (Cai, 2016). The human visual system is more sensitive to some parts of the visible spectrum than others, therefore computing a measurement of perceived lightness/luminance with objective software is more accurate.

Appendix N: Study Finding Handout for Youths with Dyslexia

Study Findings

What can help me learn?

- Practice new skills often.

- Use one method of learning at a time, e.g. use visuals or oral information, but not both together. Switching between tasks can be difficult!

- Use visual organisers to help remember information.

- Watch out for thoughts that predict the worst-case scenario, e.g. 'I'm going to fail', and try to use more helpful thoughts such as 'I can give this a try'.

- Look for a positive way to think about things that are challenging

- Focus on your progress rather than your results. Effort, good strategies, and sometimes help from others are what lead to success.