

The Effects of Acute Stress on Executive Functioning in a School-Age Population

by

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ABSTRACT

Acute stress appears to impact academic achievement in part by impairing executive functions. Executive functions are cognitive processes that help to control our attention, working memory, planning and organizing skills. Researchers investigated the effect of increased stress during working memory performance in male and female grade 11 students. Participants were randomly assigned to one of two groups: a psychosocial stress (experimental) group and a non-stress (control) group. Attempts to induce acute stress for participants in the experimental group were made via instructions from the Trier Social Stress Test and physiological responses to stress were measured by pulse (beats per minute). Participants completed two tasks measuring their working memory function: Digit Span and Symbol-Digit Modalities Test. Based on the literature, we hypothesized that increased stress would impair working memory performance. No significant differences were found for performance on Digit Span tasks between the control and experimental group. However, a moderate effect size for performance on Digit Span-Backward was noted. Additionally, a moderate effect size was indicated for baseline (pre-test) heart rate. Results indicated significant differences for performance on Digit Span-Forward between males and females. Finally, strong positive correlations were found for participants in the experimental group between trait anxiety and Digit Span-Forward, as well as between state and trait anxiety scores. These findings are consistent with the Yerkes-Dodson Law, indicating students who experience a mild stressor and have higher trait anxiety are more likely to achieve an optimal level of success.

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CHAPTER 1: INTRODUCTION

Students are faced with a number of challenges and stressors each day (i.e., personal stressors – parents/family members, home life; social stressors – classmates, peers; academic stressors – teachers, assignments, exams; external stressors – societal norms and other external expectations). Many students will learn to adapt and/or manage these stressors throughout their school years, but some students will find this more difficult. These difficulties may ultimately affect their academic performance, by putting a strain on their working memory to perform at its optimal level. Working memory is the ability to hold and manipulate information required to complete complex tasks (Baddeley, 1992). Psychologists Yerkes and Dodson set out to explore how stress and anxiety impair performance when they created the Yerkes-Dodson Law. This law states there is an optimal level of stress or anxiety that can increase productivity and/or success. However, if the stress or anxiety exceeds that optimal level, performance can be impaired (Mellifont, Smith-Merry, & Scanlan, 2016). Relatedly, researchers have reported cognitive performance, including verbal and visual memory, to be impaired when under acute psychosocial stress. Specifically, these findings have been reported in populations with both children (De Veld, Riksen-Walraven, & de Weerth, 2014; Quesada, Wiemers, Schoofs, & Wolf, 2012) and adolescents (Slattery, Grieve, Ames, Armstrong, & Essex, 2013).

Executive functioning is an umbrella term that encompasses various processes such as working memory, that is required for all ages to perform daily cognitive tasks (Linares, Bajo, & Pelegrina, 2016). Executive functions are cognitive processes that allow us to perform goal-oriented behaviour and thinking related to attention and inhibition, task management, planning, monitoring, and coding (Starcke, Wiesen, Trotzke, & Brand, 2016). Working memory is an important component of executive functioning that is required for holding and manipulating information in our mind. Two elements of working memory, verbal and nonverbal (visual-

spatial), are integral for executive functions. Working memory is one of the three core functions, also including inhibition and interference control, and cognitive flexibility (Diamond, 2013). Strong working memory skills are linked to success in the academic setting, including test performance, as students are often required to obtain and retain information in temporary storage while working through a number of steps or tasks before providing an answer (Baddeley, 1996; Peng & Fuchs, 2017). Further, poor working memory skills are linked to lower educational outcomes (Owens, Stevenson, Hadwin, & Norgate, 2014). Theories by researchers Eysenck and colleagues suggest that cognitive tasks requiring the use of the central executive, particularly the working memory component, are proven to be much more difficult and require more time and effort to complete, when anxiety effects are present (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007). Support for this was provided by Coy, O'Brien, Tabaczynski, Northern, and Carels' (2011) research, where participants with induced anxiety performed more poorly on the digit span task measuring working memory, compared to a control group with no induced stress. This task required participants to listen to a series of digits and repeat them back in a particular order. Further, researchers have reported that anxiety and acute stress impair working memory in children (Quesada et al., 2012), adolescents (Owens, Stevenson, Hadwin, & Norgate, 2012), and adults (Luethi, Meier, & Sandi, 2009; Oei, Everaerd, Elzinga, van Well., & Bermond, 2006; Schoofs, Preub, & Wolf, 2008).

Stress

Stress was conceptualized by Grant, Compas, Stuhlmacher, Thurm, McMahon, and Halpert in 2003 as “environmental events or chronic conditions that objectively threaten the physical and/or psychological health or well-being of individuals of a particular age in a particular society” (p. 449). The environmental event or condition that threatens the individual is referred to as the stressor and the biological or psychological response that is generated to the

stressor is referred to as the stress response (Schneiderman, Ironson, & Siegel, 2005). These responses can differ based on the individual, depending on how the stressful events or changes are perceived (Hess, Shannon, & Glazier, 2016; Vogel & Schwabe, 2016). Therefore, stress is based on individual perceptions and the body's physiological response. Acute stress is short-term and can be caused by the demands and pressures anticipated in the near future. Once the event passes, the stress is relieved (American Psychological Association, 2017).

Students encounter stress in the classroom quite frequently and while they can interpret and experience stress in different ways (i.e., worry, fear, headache, fatigue, etc.), stress can have wide-spread effects on learning and performance for students who are under pressure to perform (Vogel & Schwabe, 2016; Valizadeh, Farnam, & Farshi, 2012). Research by Vogel and Schwabe (2016) emphasizes the importance for students to recall study material, consolidate curriculum, and integrate new information to previously learned information. Stress largely impairs our abilities to encode, retrieve, and update memories and information. Physical symptoms, mental health issues, and social issues can further influence academic performance (Valizadeh et al., 2012).

The most commonly used protocol to induce a stress response in research is the Trier Social Stress Test (TSST). The TSST was developed as a psychosocial test that is used to induce psychosocial stress in a controlled environment. The TSST requires participants to prepare a speech for a public speaking task and then complete a mental math task in front of a panel of researchers. Schneiderman and colleagues (2005) report acute stressors that require action on the individual's part, such as the TSST, cause myocardial responses to stress, such as increased heart rate and blood flow. The TSST yields consistent results, producing a two-to-three fold increase in stress responses in 70-80% of participants, as measured by stress hormones, produced by the hypothalamic-pituitary-adrenal (HPA) axis (Allen, Kennedy, Dockray, Cryan, Dinan, & Clarke,

2017; von Dawans, Kirschbaum, & Heinrichs, 2011). Upon appraisal of a stressful situation, a stress hormone, cortisol, is secreted by the HPA axis. Slattery and colleagues (2013) report stress effects on cognitive performance are often measured via cortisol levels. Stress appeared to increase cortisol levels and resulted in lower performance levels, particularly on verbal and visual memory tasks. Other researchers have measured stress response by calculating participants' pulse at various points within the procedure (baseline, after TSST instructions or tasks, and post-test) (Kirschbaum, Pirke, & Hellhammer, 1993; Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004).

A study conducted by Luethi and colleagues (2009) investigated the effects of stress, as produced by the TSST, on explicit memory, working memory, and implicit memory. Results indicated an increase in cortisol levels after participants were exposed to the TSST. Performance on verbal working memory was affected after exposure to an acute stressor via the TSST for adult participants in the experimental condition.

The literature suggests conflicting evidence regarding cortisol production between age groups. Some studies indicate no differences in these responses based on age (Kallen, Tulen, Utens, Treffers, De Jong, & Ferdinand, 2008; Hoffman & Absi, 2004) and others suggest there are differences in cortisol secretion (Quesada et al., 2012; Quas, Yim, Edelstein, Cahill, & Rush, 2011; Yim, Quas, Rush, Granger, & Skoluda, 2015). Therefore, the literature regarding cortisol secretion in school-age populations remains unclear.

This stress response induced by the TSST with participants aged 9, 11, 13, and 15 years has also been quantified through the observation of heart rate levels using electrocardiogram (ECG) readings via four electrodes. Gunnar, Wewerka, Frenn, Long, and Griggs (2009a) found the youngest participants to have higher heart rates after being exposed to the TSST and these heart rates were sustained longer than the older participants.

Many researchers have used the TSST to induce psychosocial stress before measuring executive functioning, however until recently, it was only applied in individualized data-collection settings, where participants entered the testing environment one-by-one to complete the tasks in front of a panel of researchers (de Veld et al., 2014; Zandara, Garcia-Lluch, Pulpulos, Hidalgo, Villada, & Salvador, 2016; Schoofs et al., 2008; Schoofs, Pabst, Brand, & Wolf, 2013). In response to this limitation, a group TSST (TSST-G) has been created, where participants enter the testing environment in groups of four or five and complete the TSST tasks in front of their group members and the investigators. The TSST-G was validated in a randomized controlled study by researchers von Dawans and colleagues in 2011. Results of this study showed the experimental group to have up to three times the increase in cortisol levels, and significant increases in heart rate after completion of the TSST-G, than those in the control group. Overall, participants reported increases in strain, challenge, and stress on the TSST tasks, as opposed to those in the control group, providing evidence to support a group TSST to effectively generate acute psychosocial stress.

The TSST has been used across a wide-range of age groups (children, adolescents, and adults). One study by Yim and colleagues (2015) found adults to secrete higher levels of cortisol following completion of the TSST, relative to a sample of participants under 16 years of age. Further, their second study found adolescents to secrete higher levels of cortisol than the younger groups. Adults were not included in their second sample. Other researchers have found children and adolescents, aged 7-18, to produce significant levels of cortisol after participating in the TSST and therefore have found this method to successfully induce psychosocial stress across a range of age groups (Quas et al., 2011; Quesada et al., 2012; Slattery et al., 2013).

Anxiety

Anxiety is another common factor that can reduce or impair the ability to perform tasks requiring executive functioning at an optimal level. Stress is characterized as a normal response to a threatening event or condition, while anxiety differs because it is characterized by worry and often persists beyond the typical response for the particular situation. Anxiety is defined in the DSM-5 as a fear or worry response to a particular situation, persisting beyond the typical response for the individual's developmentally-appropriate period. There are many types of anxiety disorders that differ based on the object(s) or situation(s) that induce fear, anxiety, or avoidance behavior and the thoughts associated with them (American Psychiatric Association, 2013). Anxiety symptoms include emotional, cognitive, physiological, and behavioural components. These symptoms can manifest as distress, fear, worry, helplessness, muscle tension, increased heart rate, and avoidance (Vallance & Fernandez, 2016).

Beesdo, Knappe and Pine, (2009) report the lifetime prevalence of any anxiety disorder in children and adolescents is 15-20%, with females experiencing higher rates of any anxiety disorder than males (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Headley & Campbell, 2013; Layne, Berstein, & March, 2006). Anxiety disorders are among the most common diagnoses for children and adolescents (Mazzone, Ducci, Scoto, Passaniti, D'Arrigo, & Vitiello, 2007). Furthermore, symptoms of anxiety disorders appear to present earlier than any other mental health disorder (Beesdo et al., 2009). Due to anxiety's persistent and impairing symptoms, its presence is known to have a negative effect on academic performance (Voltas, Hernández-Martínez, Aparicio, Arija, & Canals, 2014).

Spielberger, Gorsuch, Lushene, Vagg, and Jacobs created the State-Trait Anxiety Inventory (STAI; 1983) to assess two types of anxiety: state anxiety and trait anxiety. State anxiety increases as the level of threat or danger increases and is measured as to how the

individual would feel “in the moment”. The anxiety that rises is related to the situation or stimuli presented in the environment. In environments where there is no perceived threat or a threat is present but is not perceived as such, state anxiety levels should be low. Trait anxiety is considered to vary based on individual differences and reflects a stable personality characteristic. Further, trait anxiety varies based on the attitudes and strategies of the individual (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010). Clinically anxious individuals often have both high state and trait anxiety (Bishop, 2009).

Prior research showed that individuals with low trait anxiety had less success when they were under pressure to score as many soccer goals as possible while experiencing a high level of verbal instructional pressure, compared to a control group with no verbal instructional pressure. However, their state anxiety scores did not show an increase when under pressure (Horikawa & Yagi, 2012). These changes reflect individual differences and vary based on the individual’s appraisal of the threat. According to the Processing Efficiency Theory, individuals with low trait anxiety interpret anxiety as less threatening, compared to high trait anxiety individuals who construe a more negative appraisal (Eysenck & Calvo, 1992; Eysenck et al., 2007).

Eysenck and Calvo’s Processing Efficiency Theory (PET, 1992) infers that worry uses some of the cognitive resources required to process and store information, as part of our working memory, therefore hindering task performance due to limited remaining resources. Some individuals cope by taking advantage of additional resources (i.e., strategies) in an effort to compensate. Similarly, the Attentional Control Theory (ACT) aims to understand and explain the connection between anxiety, cognitive performance, and attention. ACT builds on the assumptions addressed in the processing efficiency theory, with a stronger focus on attention’s role in impaired performance. Researchers believe this understanding of attention is integral to investigating the effects of anxiety on cognitive performance (Eysenck et al., 2007). ACT states

that anxiety impairs working memory abilities, causing performance difficulties with response accuracy and efficiency when completing timed-tasks (Owens et al., 2014). ACT considers both effectiveness and efficiency important pieces for this process. Effectiveness refers to the quality and accuracy of the responses and efficiency refers to the cognitive effort, such as the time and resources allocated to the task. However, while in the presence of a threatening stimulus, a comparison of brain activation indicated that individuals used a shifting resource by continuously re-directing their attention from the task at hand to the perceived threat. This creates an inefficient approach to task completion and provides evidence that worry impairs efficiency more than effectiveness, particularly for individuals with high state anxiety, on tasks requiring use of the central executive. It is believed that individuals with anxiety allocate many of their resources by attending to external threats and other stimuli, making it difficult to attend to the task at hand. However, many studies fail to explicitly measure anxiety levels of the participants and instead, only measure worry retrospectively (Eysenck et al., 2007).

Another assumption of ACT states that the greater the dependence on the central executive, the greater the effects of worry and anxiety on performance. The central executive functions that were examined in Eysenck and colleagues' 2007 research were inhibition and shifting. Attention is critical for shifting our focus between tasks and inhibiting irrelevant information/stimuli. These findings are more often observed during high load working memory tasks (Najmi, Amir, Frosio, & Ayers, 2014), however researchers have failed to identify the particular central executive functions that are impaired, other than working memory. The connection between attention and anxiety was further investigated in Pacheco-Unguetti and colleague's 2010 research, by referring to state anxiety as increasing "the threat value assigned to a stimulus or situation" (p.298) and trait anxiety as a "tendency to constantly direct attention toward the source of the threat" (p.298). A high negative correlation was found as trait anxiety

scores increased, self-reports of attentional control decreased. In sum, both the processing efficiency theory and the attentional control theory agree that worrying compromises the central executive component, responsible for attentional control in Baddeley's working memory model (Baddeley, 1996; Eysenck et al., 2007).

Consistent with the Yerkes-Dodson Law, experiencing anxiety can make students more alert and aware of details and deadlines, pushing them to spend more time and pay more attention to their work than others (Eysenck et al., 2007). However, excessive levels of anxiety on a regular basis can be harmful by disrupting daily functioning (Jarrett, Black, Rapport, Grills-Taquechel, & Ollendick, 2015) and in the academic setting, anxiety symptoms have been associated with poor academic performance (Grover, Ginsburg, & Idalongo, 2007). Researchers have found those with higher levels of general anxiety to perform poorly on a variety of tasks from the Wechsler Adult Intelligence Scale (WAIS), including digit span, as well as motor tasks (Barnard, Broman-Fulks, Michael, Webb, & Zawilinski, 2011).

Executive Functions

Although researchers have yet to come to an agreement as to what the individual cognitive processes that make up executive functions should be named, they tend to agree on the operations that best represent each function (i.e., selective-attention, inhibition, task management, planning, monitoring, and coding) (Starcke et al., 2016). Executive functioning has also been described by Blakemore and Choudhury (2006) as the ability to control and coordinate our thoughts and behaviours. Previous findings have suggested that stress can lead to poorer academic performance (Grover et al., 2007; Mazzone et al., 2007) and can also have a negative effect on executive functioning (Owens et al., 2012; Voltas et al., 2014). Indeed, it has been suggested that these functions are the first to suffer during times of distress (Diamond, 2013). Furthermore, putting a time limit on tasks can increase anxiety and further impair executive

functioning (Diamond, Kirkham, & Amso, 2002). Baddeley (1996) has described that attentional resources required during the performance of working memory tasks are controlled by the central executive component. However, while the executive functions are often grouped together, factor analyses (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), neuroimaging (Smolker, Depue, Reineberg, Orr, & Banich, 2015) and brain lesion studies (Tsuchida & Fellows, 2013) suggest that these functions are distinct. Therefore, consistent with the fine grain, systematic approach endorsed by Shields, Sazma, and Yonelinas (2016), the effects of stress should not necessarily be considered on executive functioning as a whole, but rather in the context of the individual components of executive functions.

Brain development research indicates that there is a steady increase in white matter during childhood and adolescence, but grey matter follows a stage-specific development pattern. Blakemore and Choudhury (2006) state the development of brain regions responsible for executive functioning varies and that the areas of the brain responsible for the many tasks included under this broad term may develop at different stages. For example, improvement on selective attention, working memory, and problem-solving tasks was observed in adolescent participants. However, performance on tasks measuring strategic behaviour indicated that this skill was developed earlier in childhood (Shallice, 1982).

The Symbol-Digit Modalities Test (SDMT) is a measure of executive function that assesses attention, visual scanning, and motor speed (Sheridan, Fitzgerald, Adams, Nigg, Martel, Puttler, Wong, & Zucker, 2006). SDMT codes nine symbols with the single digits 1-9. This test requires participants to write the number that is paired with the respective codes. It is not to be confused with the Coding subtest of the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V; Wechsler, 2014) and the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) (Wechsler, 2008), where the participant is responsible for writing the symbol paired with

their respective numbers. The symbols are presented below with empty boxes and the participants are asked to write as many correct numbers in the boxes as quickly as they can in 90 seconds. This test offers both written and oral administrations and was originally designed to identify individuals with cerebral dysfunction, particularly patients with Multiple Sclerosis (Sheridan et al., 2006). Further, it has also been used to measure attention and information processing speed. Information processing speed is integral to cognitive functions such as attention and working memory (Forn, Ripollés, Cruz-Gómez, Belenguer, González-Torre, & Ávila, 2013). The SDMT can be and has been used with participants both male and female, ranging from 6-17 years old and above (Smerbeck, Parrish, Yeh, Hoogs, Krupp, Weinstock-Guttman, & Benedict, 2011). SDMT was chosen as a task of cognitive abilities due its' measures of fine motor control, processing speed, and attention. These functions all play a diverse and important role in executive functioning.

Working Memory

Working memory is a component of executive functioning conceptualized as a capacity-limited system for storing and manipulating information for short time periods (up to ~30 s), in order to carry out complex cognitive operations such as planning, reasoning, and problem solving. The contents of working memory not only include the specific stimuli required for later use, but also the goals driving the current behaviour (Baddeley, 1992; Cohen, Perlstein, Braver, Nystrom, Noll, Jonides, & Smith, 1997; Deiber, Missonnier, Bertrand, Gold, Fazio-Costa, Ibañez, & Giannakopoulos, 2007). Working memory is most commonly measured using span tasks for children and adults, such as the Digit Span task used on the WISC-V and WAIS-IV (Colbert & Bo, 2017).

Baddeley and Hitch proposed working memory as a tripartite system consisting of the central executive, an attentional controller, as well as two short-term stores: a visuospatial

sketchpad and phonological loop (Baddeley, 1996). Baddeley considered the central executive to be a crucial component due to its control function that determines which cognitive resources to expend and which to inhibit by integrating information from other sources (Baddeley, 1986). In his 2002 paper, he further highlighted the importance of the central executive by explaining the three attentional characteristics it is responsible for: focusing attention, dividing attention, and switching attention (Baddeley, 2002). The visuospatial sketchpad, previously known as the visuospatial scratchpad, functions to hold and manipulate visual images and is crucial for visual working memory. The phonological loop, previously referred to as the articulatory loop, is based on sound and language, and caters specifically to verbal information (Baddeley, 1996). Both of these working memory components are limited in capacity and are believed to hold information in memory for only a few seconds before fading, unless it can be rehearsed (Baddeley, 2003). Working memory processes verbal information differently than visual information as it relies more heavily on the left hemisphere of the brain (Hill, Laird, & Robinson, 2014). It is believed that worry is more damaging to the phonological loop than the visuospatial sketchpad, as these thoughts are verbalized and not processed based on imagery. This assumption is supported by evidence that anxiety is more closely related to the phonological loop component of working memory than the visuospatial sketchpad. A research study including 50 students, ages 11 and 12, found verbal working memory performance to be impaired for students with higher trait anxiety but did not find significant results between trait anxiety and spatial working memory (Owens, Stevenson, Norgate, & Hadwin, 2008).

Working memory begins to develop in early childhood and continues throughout adolescence, improving with age (Owens et al., 2014; Huizinga, Dolan, & van der Molen, 2006; Linares et al., 2016; Span, Ridderinkhof, & van der Molen, 2004; Colbert & Bo, 2017). Linares and colleagues (2016) expected to see quicker response times and more correct answers during a

working memory task with their older age groups, and their hypothesis was confirmed. During a retrieval task, they found accuracy was lowest in their youngest age group (8 years of age), compared to participants ages 11, 14, and 21. Additionally, research by Conklin, Luciana, Hooper, and Yarger (2007) reported working memory improvements were shown in adolescents compared to their younger participants (9-12 years of age), providing support to Huizinga and colleagues (2006) who suggested adult levels of performance for various tasks could be reached by the ages of 13-15. These studies support theories of working memory becoming stronger with age. Verbal working memory is believed to improve until the age of 26 and then begins to gradually decline (Swanson, 2017).

To assess verbal working memory, span tasks comprised of digits, letters, and/or words are often used as an index of phonological loop performance (Baddeley, 2003; Coy et al., 2011). Digit Span tasks consist of verbally-presented numbers and require participants to recite them back in simple (Digit Span-Forward) and complex (Digit Span-Backward) forms. Digit Span-Forward requires participants to recite the numbers back in the same order they were presented to them and Digit Span-Backward requires participants to recite them back to the examiner in the reverse order, therefore requiring participants to manipulate the numbers in their mind. Digit Span-Forward is considered to be an excellent and reliable measure of attention and immediate memory, while Digit Span-Backward measures working memory. Opportunities for item rehearsal are reduced by the examiner reading the digits aloud at a rate of one digit per second. Digit span tasks utilizing both the forward and backward component, showed performance on the forward task to stabilize earlier in both age groups (ages 13-15 and 11-12), than performance on the backward task (ages 16-17 and 13-15). Overall, the younger participants had demonstrated a shorter span than the older participants (Conklin et al., 2007). As seen in Conklin and colleagues' findings, age-related gain has been reported in children's working memory, meaning students

appear to process information faster, as they grow older. However, a declining effect has been reported for older adults and seniors, causing slower processing responses (Span et al., 2004). Some researchers have questioned the reliability of the digit span task to produce adverse effects for participants under stressful conditions (Oei et al., 2006; Schoofs et al., 2008). Other researchers have found stress to impair performance on digit span tasks (Coy et al., 2011; Schoofs et al., 2008; Elzinga, Bakker, & Bremner, 2005; Hood, Pulvers, Spady, Kliebenstein, & Bachand, 2015). These researchers have found stress to impair working memory, when assessing working memory performance using both Digit Span tasks, while other researchers have found stress to impair performance on the Digit Span-Backward task, but not on the Forward task (de Veld et al., 2014; Quesada et al., 2012). This can be explained as the task requirements differ due to the manipulation requirement in Digit Span-Backward. Barnard and colleagues (2011) found individuals with higher sensitivity to events that could be perceived as anxiety-provoking, to have more difficulty completing the Digit Span tasks than those with lower anxiety levels, with the low anxiety participants responding with more correct digits.

Researchers Eysenck and colleagues (2007), by way of the Attentional Control Theory, have identified working memory as the component of executive functioning to be most adversely affected by anxiety. Owens and colleagues (2014) reported decreases in performance on working memory tasks when trait anxiety increased in participants with low working memory capacities, as measured by the Cambridge Neuropsychological Test Automated Battery (CANTAB).

Research shows strong negative relationships; as stress and anxiety increases, working memory and academic performance decreases (Owens et al., 2008; Owens et al., 2012; Christopher & MacDonald, 2005; Quesada et al., 2012). Calvo and Ramos found that high-anxiety participants required more time to read text, as demands increased, compared to low-anxiety individuals (Eysenck & Calvo, 1992).

Gender

The literature indicates females appear to have higher functioning in some cognitive areas compared to males. Mittal, Verma, Jain, Khatter, and Juyal (2012) had 100 healthy male and female participants, ages 17-20, complete the Montreal Cognition Assessment Test to measure a wide range of their cognitive abilities. Specific measures of attention included Digit Span-Forward and Digit Span-Backward. Results indicate that gender differences were observed in cognitive functioning where female adolescents had overall higher cognitive functioning, particularly in visuospatial skills and memory. Attention scores were higher for the group of female participants, but the differences were not statistically significant. Another study had male and female participants between the ages of 5 and 19 complete a series of memory tasks, including Digit Span-Forward and Digit Span-Backward. Results indicated females were relatively stronger on verbal tasks and males were relatively stronger on spatial tasks and these differences were found to be statistically significance. Small mean differences were noted between genders on these tasks, where females had slightly higher mean scores on Digit Span-Forward and Digit Span-Backward than males (Lowe et al., 2003).

Research by Speck, Ernst, Braun, Koch, Miller, and Chang (2000) found several gender differences that suggested males and females used different problem-solving strategies and found men to have faster response times but women to have higher accuracy with slower response times during verbal working memory tasks. Further, gender differences were reported in a review by Gunnar, Talge, and Herrera (2009b), as found in cortisol levels. They found elevated stress levels, measured by cortisol secretions, in 13-year old females, in addition to male and female participants at age 15, but no significant elevations in the younger age groups of males. Similar evidence has been reported in Quesada and colleagues (2012) research reporting higher cortisol levels in females, ages 8 and 13, compared to males. In their own research, they found

significant increases in cortisol levels in children aged 8-10 after exposure to the TSST-C, but no gender differences were reported. These results were consistent with previous research indicating females experience higher rates of anxiety (Costello et al., 2003; Headley & Campbell, 2013; Layne et al., 2006).

CHAPTER 2: PRESENT STUDY

Students experience a variation of stressors every day, both inside and outside the classroom. These stressors can have a negative effect on student learning and academic performance. Studies indicate that cognitive performance is impaired for children (De Veld et al., 2014; Quesada et al., 2012) and adolescents (Slattery et al., 2013) when they are under stress. These challenges can lead to increased difficulty in the academic setting. A research study showed participants had more difficulty remembering important information learned the previous day, after they were exposed to a mild stress procedure, compared to participants in the control group (Vogel & Schwabe, 2016).

Executive Functions

Cognitive performance is in part, controlled through the development of executive functions. These functions are important for goal-oriented behaviour such as planning, organizing, problem-solving, and attention. Executive functions are integral for student success and it is believed that the development of these skills is critical for students entering school. These skills are indicative of student achievement and academic success (Wagner, Cepeda, Krieger, Maggi, D'Angiulli, Weinberg, & Grunau, 2016).

Working Memory

One executive function that is impaired by acute stress is working memory. Working memory is critical for daily functioning through tasks that require mental math, organizing, and planning (Diamond, 2013). This cognitive process begins developing very early in life (i.e., during childhood) and is a slow progression (Owens et al., 2014; Linares et al., 2016; Diamond, 2013). However, some researchers argue that adult-levels of working memory performance may be achieved during early adolescence (Huizinga et al., 2006; Conklin et al., 2007). Neuroimaging shows a reduction of activity in the area of the prefrontal cortex that is associated with working

memory, while experiencing acute stress (Otto, Raio, Chiang, Phelps, & Daw, 2013). Working memory deficits can make it difficult for students to hold important information in mind to complete tasks. For example, students are asked and expected to hold a series of instructions in their mind while they carry out the requested tasks in school every day. These deficits could mean that these students could forget some of the instructions before completing all of the steps. Some students will develop strategies, such as asking a peer or their teacher. However, other students may not develop any strategies, and this will cause them additional difficulties. Researchers Passareli-Carrazzoni and colleagues (2018) found that there are several variables that contribute to the development of skills that are essential to cognitive performance. Their research has indicated monthly family income, maternal depression, and fluid intelligence of the child are all factors that can lead to difficulties with working memory.

Researchers have used a variety of tasks to measure working memory. Digit span is one of the popular tasks used to measure working memory. Participants are asked to recite a series of digits in a specific order, using their working memory to hold the information in mind and complete the task. Many researchers have found that performance on this task is impaired when participants are experiencing stress (Barnard et al., 2011; Coy et al., 2011; Elzinga et al., 2005; Hood et al., 2015; Schoofs et al., 2008).

Symbol Digit Modalities Test (SDMT) is a timed measure of processing, attention and inhibition. It requires participants to scan and hold numbers and geometric figures in their mind while pairing them one-by-one and writing them down on paper. The task was developed by Smith in 1973 (Smith, 1982) and has been supported in the literature for measuring cognitive performance.

Acute Stress

Acute stress has most commonly been induced in a laboratory setting using the Trier Social Stress Test (TSST). This task was developed with intended purpose to induce acute psychosocial stress for groups of students having to perform various tasks in front of researchers and peers. Tasks requiring preparation, public speaking, and mental math are all included in the protocol. Instructions are given to each group of participants and each task is explained. This protocol has been very successful, producing elevated stress responses for many participants across various studies (Allen et al., 2017; Slattery et al., 2013; von Dawans et al., 2011). Due to the TSST's psychosocial stress component and the presence of a socially evaluative audience, research suggests that adolescent's perception to and awareness of their own social images will be an important stressor (Birkett, 2011). Researchers report that while we consider social relationships to often be beneficial for our well-being, negative social interactions are connected to psychological distress (Geiger, Sabik, Lupis, Rene, & Wolf, 2014). One study has reported the relationship between stress and self-image, the quality and nature of social relationships, and the quality of relationships with classmates among adolescents (Bacchini & Magliulo, 2003). Another paper reports that individuals with the need for social approval are more concerned with the impression they make on others, and thus are more likely to conform to others' opinions and actions to fit-in with their colleagues or peers (Twenge & Campbell, 2008). Presumably, the social aspect of the TSST is the mechanism by which it produces its acute stress effects. Researchers Koval and Kuppens (2012) investigated the effects of anticipatory social stress using experimental manipulation. Initially, participants were led to believe they would be completing the TSST later in the day during the same testing session. It wasn't until the next day that they were introduced to the TSST and the instructions. Next, they were informed of the upcoming TSST and were given a copy of the instructions to read. Additionally, participants were

completing an Experience Sampling Method (ESM) measure simultaneously to determine their feelings (i.e., rating their anxiety and stress levels on a continuous scale from 1-100) at various time points throughout the study, often immediately following mention of the TSST. Finally, at the end of the testing session on the second day, participants completed the TSST tasks. Results indicated an increase in threat emotion was found after experimental manipulation of anticipatory social stress, induced via the TSST instruction anticipation. Therefore, we speculated the presence of the social evaluation component that awaits participants after the instructions are provided would be sufficient to induce acute stress. Furthermore, research showed females to be more concerned with social cues and stressors, such as perception of rejection (Lenroot & Giedd, 2010).

Anxiety

While most students experience and understand stress, students also experience anxiety. Many students experience healthy levels of anxiety and this can help students to better prepare for assignments, tests, and oral presentations (Eysenck et al., 2007). However, some students also experience significant levels of anxiety that have the ability to impair their functioning (Jarrett et al., 2015). The State-Trait Anxiety Inventory (STAI) was created by Charles Spielberger and colleagues in 1983 and is still used today to measure trait and state anxiety. Trait anxiety reflects an individual's personality characteristic and varies based on individual differences. Example items include, "I lack self-confidence" and "I am a steady person". State anxiety reflects how the individual feels in the moment. Example items include, "I feel at ease" and "I feel upset".

Researchers surveyed students across 26 colleges and universities between 2007 and 2009. They found that 10% of students met screening criteria for an anxiety disorder and 12% met DSM-IV diagnostic criteria for an anxiety disorder. Overall, female students were more

likely to screen positive for an anxiety disorder (Hunt & Eisenberg, 2010; Pearson, Teresa, & Jennifer, 2013). The Ontario Student Drug Use and Health Survey (2015) found 34% of students indicated a moderate-to-serious level of psychological distress, classified by symptoms of anxiety and depression. Further, 14% of university students indicated a serious level of psychological distress (Boak, Hamilton, Adlaf, Henderson, & Mann, 2016).

Researchers Vogel and Schwabe completed a review of learning and memory under stress in 2016. They reported that stress affects a range of memory systems, leading to an unbalanced operating system that is responsible for cementing memories or facts in our minds. This makes it difficult for students to recall important information and can result in an underestimation of their abilities. The purpose of this research was to measure the extent to which acute stress impairs working memory performance in a school-aged population. We hypothesized that working memory performance would be impaired in the experimental group compared to the control group. Researchers expected the experimental group to have more difficulty with working memory after being exposed to the psychosocial stressor induced via the TSST. The control group was not exposed to a stressor. An exploratory analysis was completed to examine whether trait anxiety would moderate the impact of stress on working memory performance in these students. Finally, we completed another exploratory analysis on working memory performance between genders after the TSST. We have aimed to highlight the importance of stress and its impact on school functioning. It is important to understand the effect stress has on students' academic performance. Understanding their own strengths and challenges can help them to succeed. In addition, this research has attempted to offer further knowledge to help improve understanding of the stress effects on academic performance and we hope this study will lead to strategies to help reduce stress associated with poor student performance. It can also be used to help parents, school psychologists and teachers identify, manage and reduce the

implication of students' stress levels. By identifying information about any effects associated with an increase of stress and anxiety symptoms on students, it is hoped that this research would contribute to ongoing efforts aimed at helping students manage and reduce their own stress and anxiety levels by developing strategies to help them complete difficult tasks. Previous research has not included both the digit span and SDMT together as measures of executive functioning. We have included these cognitive measures in the present study because they both measure different operations that are integral for executive functioning. Additionally, looking at the differences between stress and anxiety while indexing them both separately through the heart rate data and STAI was important to determine the differences as to how these two variables affect academic performance.

Methodology

Participants

The study population includes 24 participants, both male (n=11) and female (n=13), aged 16-17 years. Participants were recruited, and all were in grade 11 at the time of study through the Cape Breton-Victoria Regional Centre for Education (CBVRCE) in Nova Scotia. Researchers obtained demographic information during the data collection session, such as age and gender, and whether the individual had received a Learning Disability diagnosis. Participants were excluded if they reported receiving a diagnosis of a Learning Disability.

Test Batteries

Two cognitive tests were used to measure participants' executive functioning: Digit Span and Symbol Digit Modalities Test. These tests were chosen because they are non-invasive, short in duration, and applicable to the age group involved.

Digit Span

Participants were administered the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) Digit Span-Forward and Digit Span-Backward subtests (Wechsler, 2014) as a relatively quick measure of working memory ability. Both forms of Digit Span were administered orally, with the participant asked to repeat the list of digits after the examiner had completed delivering it at a rate of one digit per second. For the Digit Span-Forward task, the participant repeated the digits in the same order they were presented, while in the Digit Span-Backward task, the participant repeated the digits in reverse order. Participants had two attempts at each set to successfully move on to the next set. However, if a participant received a score of 0 on both trials, the task was complete and the total number of digits before that trial was used as the participant's highest score.

Symbol Digit Modalities Test

The Symbol Digit Modalities Test (SDMT) is commonly used to assess cognitive function in both children (8 years and older) and adults. The SDMT involves a simple pairing task that children and adults can easily perform. Using a reference key, the examinee pairs specific numbers with given geometric figures. The written form of the test was used; administration time was 90 seconds. As the SDMT uses only geometric figures and numbers, the SDMT is relatively culture-free. SDMT was chosen because it is a measure of attention, coding, and processing speed. These three components play a key role in executive functioning. Finally, the SDMT has demonstrated sensitivity in detecting changes in cognitive functioning over time and in response to treatment. Raw scores were collected by summing the total number of correct items within the 90 second time-limit and using this data for the analysis.

State Trait Anxiety Inventory for Adults

The State-Trait Anxiety Inventory for Adults is a commonly used measure of trait and state anxiety (STAI; Spielberger et al., 1983). While the STAI has declined in popularity in clinical settings to diagnose anxiety, it is commonly used in research, as it separately indexes both state and trait anxiety (Seligman, Ollendick, Langley, & Baldacci, 2004). Raw scores were calculated by reverse-scoring, as provided with the STAI manual, and then calculating the sum of all items to obtain overall raw scores.

Study Design and Procedure

On the day of the study, participants were asked to bring their signed consent form to the lab, indicating parental permission to participate. Participants were briefed on the study and assent from the students via written signature was obtained, prior to beginning. This study took place in their school during school hours. Participants were randomized to a psychosocial stress (experimental) group or a non-stress (control) group. Researchers collected heart rate levels via radial pulse from each participant by counting and recording beats per minute, as the baseline measure (HR1). Pulse measurements provided an indirect index of physiological stress response. Next, instructions were given and participants in the psychosocial stress group were told they would be completing a series of tasks, as part of the Trier Social Stress Test (TSST). Participants were told the TSST would include a 5-minute preparatory time for a public speaking task, the public speaking task required the participants to introduce themselves to everyone in the room (i.e., peers and investigators), and a mental math task requiring them to continually subtract a number during a timed two-minute period. Following the explanation of the TSST, pulse was taken again (HR2) for the experimental group only, and then participants began the cognitive test batteries, Digit Span and Symbol-Digit Modalities Test. Researchers used the TSST to induce acute stress and felt that the instructions alone would be sufficient to induce a stress response. At

the completion of the cognitive test batteries, participants were debriefed and pulse was taken for the third and final time (HR3). For the non-stress (control) group, participants completed the same cognitive test batteries without any mention of the TSST. Pulse was collected both before (HR1) and after the completion of the tests (HR3).

Participants in the psychosocial stress group were asked not to reveal the deception component to other students, who may be future participants in this research study. However, they were informed they could discuss any part of the study, including the deception component, with the researchers, their parents, and their teachers. All testing and data was collected following ethics clearance from Mount Saint Vincent University's Research Ethics Board.

Analysis

Data was analyzed using IBM's SPSS software. Independent t-tests were run to determine group differences on measures of demographic variables (experimental vs control group, state vs trait anxiety), executive functioning (SDMT), working memory (Digit Span), and heart rate. A p-value of .05 was used to determine significant results. Additionally, effect sizes (Hedges' *g*) were calculated. Next, heart rate differences were computed and analyzed using a paired samples t-test to measure change in heart rate from pre-test (HR1) to following the TSST instructions (HR2). Finally, Spearman correlations were run to observe relationships among these variables.

Results

Group Demographics

Independent samples t-tests were run to compare the means of the control group (no stress) and the experimental group (psychosocial stress) for demographic variables including gender, state anxiety, and trait anxiety. The results of these independent t-tests indicated there were no significant differences between the control group and the experimental group on

measures of state and trait anxiety. See Table 1 for group means (M) and standard deviations (SD).

Heart Rate

There were no significant differences on the independent samples t-tests between groups for post-test heart rate (HR3); $t(22) = -.528, p = .603, Hedges' g = .23$. However, a moderate effect size was indicated for pre-test heart rate (HR1); $t(22) = -1.144, p = .265, Hedges' g = .47$ for participants in the experimental group. A paired samples t-test was run to analyze the changes from heart rate 1 (HR1) to heart rate 2 (HR2) for participants in the experimental group but no significant differences were observed; $t(12) = -1.15, p = .273, Hedges' g = .21$.

SDMT

An independent samples t-test was run to compare group mean differences in performance on the SDMT and Hedges' g was calculated to determine effect size. No significant results were found: $t(20) = .337, p = .740, Hedges' g = .14$.

Digit Span

Independent samples t-tests were run to determine group mean differences on the digit span tasks. Separate analyses for Digit Span-Forward and Digit Span-Backward were run. No significant differences were found for performance on the Digit Span-Forward task: $t(22) = .045, p = .964, Hedges' g = .018$ or Digit Span-Backward task, $t(22) = 1.23, p = .233, Hedges' g = .50$. Interestingly, a moderate effect size was observed for Digit Span-Backward. The psychosocial stress (experimental) group performed more poorly (see Figure 1 for a visual representation of group performance on the Digit Span tasks). A significant difference was found between males (n=5) and females (n=8) in the experimental group for performance on Digit Span-Forward; $t(11) = -7.836, p < .001, Hedges' g = 4.47$, with females showing more success for their

performance on this task. No significant gender differences were found in this group on the other cognitive measures.

Correlations

A significant positive correlation was indicated for participants in the psychosocial stress (experimental) group between trait anxiety and performance on the Digit Span-Forward task; $r = .769, p = .003$. See Figure 2 for a visual representation of this strong correlation. This significant correlation remained consistent when results from all participants in both groups were analyzed; $r = .683, p < .001$. There was also a moderate positive correlation between Digit Span-Forward and state anxiety; $r = .439, p = .032$. Additionally, a strong positive correlation between state and trait anxiety scores for participants in the psychosocial stress group was also observed; $r = .827, p = .001$. This significant relationship remained consistent when run again with participants in the entire sample; $r = .635, p = .036$. Lastly, there was a moderate positive correlation between trait anxiety and performance on the SDMT; $r = .518, p = .016$.

Discussion

Our results are mixed and have supported some of our hypotheses. Our results partially support our hypothesis that participants under stress in the experimental group will have lower performance scores on the cognitive tasks measuring their executive functioning. No significant group differences were found on the Digit Span tasks or SDMT. Although the result of this analysis was not significant, a moderate effect size was detected for Digit Span-Backward. This effect size indicates there is some difference between the control and experimental groups on the Digit Span-Backward task. In sum, this finding indicates participants had more difficulty on Digit Span-Backward, compared to Digit Span-Forward. Our finding conflicts with much of the literature, where researchers have explored the effects of stress on performance (Grover et al., 2007; Mazzone et al., 2007; Luethi et al., 2009; Vogel & Schwabe, 2016; Devilbiss, Jenison, &

Berridge, 2012) and provides weak support for these studies. Although this moderate effect size was found, there was not enough power to obtain statistical significance. Therefore, future studies should consider this limitation and a larger sample size is recommended.

Next, we explored whether trait anxiety moderates the impact of stress on cognitive performance, particularly on the digit span tasks. A strong positive relationship was indicated between trait anxiety and Digit Span-Forward for participants in the experimental group. Therefore, students who reported higher trait anxiety and were experiencing acute stress, had more success completing Digit Span-Forward. The significant result remained consistent when performance on the Digit Span-Forward task in both groups was considered however, only a moderate positive relationship was observed, compared to a strong relationship. Consistent with the Yerkes-Dodson Law, it appears that students who had a higher trait disposition, were paired with a mild stressor and experienced an optimal level of performance (Mellifont et al., 2016; Chaby, Sheriff, Hirrlinger, & Braithwaite, 2015). Also, this was only seen with Digit Span-Forward, which was an easier cognitive task than the others. Similar results may not be seen with more difficult tasks. Eysenck and colleagues (2007) explain that individuals who are experiencing anxiety surrounding a particular task often focus on developing strategies to complete the task effectively. These theories help to explain why participants with higher trait anxiety in the stress condition had success on this cognitive task measuring working memory, but the strength of the relationship decreased when participants from the non-stress group were included. Another moderate positive relationship appears with trait anxiety and performance on the SDMT. Therefore, students who were feeling more anxious in the moment, during the tasks, were more likely to have success completing the SDMT. This result was seen for participants in both groups. Therefore, participation in either group was equally likely to have this result. A

positive relationship between state and trait anxiety for participants was observed and is not uncommon, as reported in Kennedy, Schwab, Morris, and Beldia's 2001 study.

As an exploratory measure, we examined if there were differences in performance on the cognitive tasks based on gender in the stress condition. Our hypothesis was partially supported. We found a significant gender difference and a strong effect size for performance on Digit Span-Forward but no significant differences for performance on Digit Span-Backward or SDMT. Females had more success on this task than males. Research has found females to have higher scores on the Digit Span tasks, but these differences were not significant (Mittal et al, 2012; Lowe et al., 2003). Therefore, our findings are consistent with the literature.

Lastly, we explored if any group differences were present for heart rate scores. First, we explored differences in HR3 but found no significant group differences. The same result was found for HR1, although a moderate effect size was found. Further, there were no significant results to indicate heart rate correlated with state or trait anxiety. Finally, there were no significant differences between HR1 and HR2 for participants in the stress group. Overall, this suggests that there were no increases in heart rate after TSST instructions were given. It is possible that participation in this study and entering the testing environment alone had increased participants' heart rates (HR1) enough to notice some differences however, we are unsure why this finding would be true for the experimental condition but not the control condition. Researchers had expected that by providing the TSST instructions, participants would automatically experience an acute stress response, even without performing the tasks included in the TSST. These results indicate that it is possible this was not enough of a stressor to induce the desired level of stress for the experimental group and may have influenced our findings regarding task performance.

Limitations

Unfortunately, we had difficulty obtaining the two age groups desired for this study. We intended to consider the effects of stress on cognitive functioning in two age groups and hypothesized that the older participants in the stress group would have more difficulty completing the cognitive tasks. However, our attempts to obtain an additional age group to incorporate into the sample size was met with much difficulty. The goal was to compare performance between children and adolescents however, obtaining signed consent forms and time constraints limited the ability to do so. This was due to time of year, where consent forms were sent home towards the end of the school year, difficulty obtaining returned signed consent forms from parents and guardians, and a small school population for the desired sample age. Additionally, the small overall sample size was a limitation for this study. The sample size was further reduced by splitting participants into two smaller groups to obtain data for the control and experimental groups. In the future, it is recommended that data be collected over a longer period of time, targeting larger school and grade populations. The two groups did not have equal sample sizes and while this is not a disadvantage, it was important to keep this in mind during data analysis and future research should be mindful of this.

Additionally, the TSST instructions alone did not induce the level of acute stress that we had intended or expected. Researchers anticipated that due to the TSST's socially evaluative component and adolescents' awareness and perception of social image would be sufficient to induce an acute stress response. However, the results of this study indicate that simple exposure to instructions is insufficient to create an acute stress response and disrupt working memory. Therefore, future studies aiming to induce acute stress using the TSST should have participants complete the tasks involved in the TSST and then test after. Additionally, given the size of the school, it would have been possible that the students in each group were known to each other and

had already formed relationships prior to participating in this research therefore, it could be helpful to have less familiar observers come into the testing session to act as a judging panel during the TSST tasks. Additionally, it is possible that students had discussed the study procedure with their peers upon leaving the testing environment. Therefore, future participants in this study may have been aware of the deception component prior to beginning. This could help explain why there was no change in heart rate scores. In the future, we recommend asking students if they have any prior knowledge about this study, prior to beginning.

Finally, heart rate was collected by researchers manually using radial pulse. This could be a limitation to the study's methodology, as it could be interpreted as a subjective method of collection based on lack of formal medical training to obtain radial pulse. However, radial pulse is a valid and reliable measure of heart rate and is often used in many health care settings to obtain a measurement of pulse.

Conclusions and Future Directions

Stress has various implications on student functioning. There is an abundance of literature focusing on the relationship between stress, executive functioning, and working memory. Additionally, differences between ages and gender have been considered. Future research should aim to explore the effects on different age groups and more widespread cognitive and social functioning such as memory, processing abilities, and verbal expression.

Table 1

Means and Standard Deviations of each group for performance on each task.

	No stress (control) group	Psychosocial stress (experimental) group
SDMT	40.80(8.68)	39.58(8.23)
Digit Span-Forward	11.27(2.15)	11.23(2.35)
Digit Span-Backward	7.27(1.19)	6.46(1.90)
HR1	73.82(8.83)	79.08(12.87)
HR2	-----	81.85(14.11)
HR3	73.78(15.76)	77.54(16.86)

Note. [M(SD)] Standard Deviations are reported in parentheses.

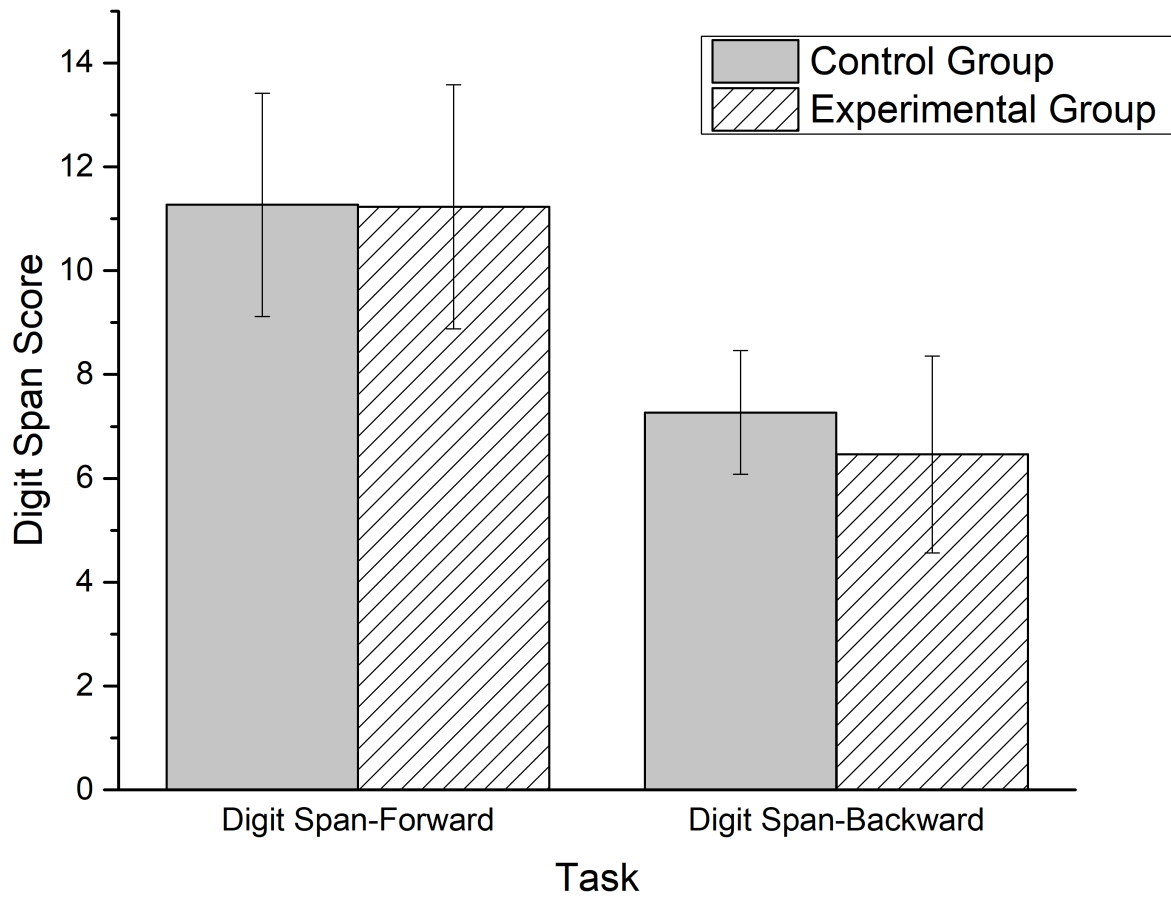


Figure 1. Group differences on digit span tasks.

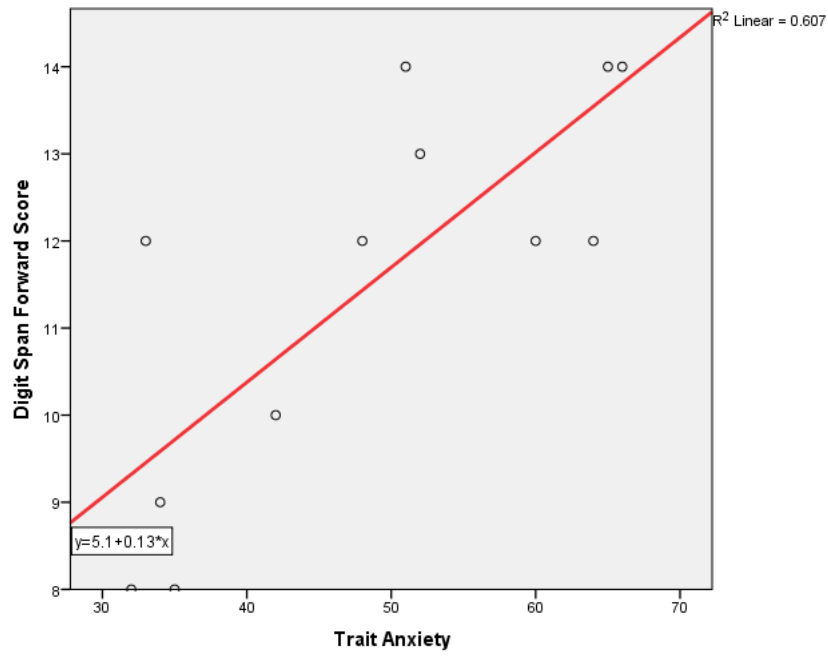


Figure 2. Significant positive correlation between trait anxiety and performance on the Digit Span-Forward task.

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Appendices

Appendix A**PRINCIPAL INFORMATION SHEET**

STUDY TITLE: The Effects of Acute Stress on Executive Functioning in School-Age Populations

INTRODUCTION

My name is Christina Ferguson and I am a student in the Master of Arts in School Psychology program at Mount Saint Vincent University, in Halifax. A requirement of the program is for each student to complete a Master's level thesis before graduating. I have chosen to focus on school-age students within schoolboards across Nova Scotia. I am asking for your approval to collect data within your school from students in grades 6 and 11. Upon approval, we will decide on a mutually-agreed upon date for the research team to come to the school to collect data.

This information sheet describes the purpose and procedures and the possible risks and benefits of the proposed research. You are encouraged to discuss any questions with the principal investigator or supervising investigator.

BACKGROUND

Acute stress appears to impact academic achievement in part by impairing executive functions. Executive functions are mental processes that allow us to perform goal-oriented behaviour and thinking by helping to control our attention, working memory, and planning and organizing skills. Working memory involves temporarily holding and manipulating information in our conscious awareness to help us learn or complete a task. Strong working memory skills are linked to success in the academic setting, including test performance. We are interested in looking at how increased stress affects working memory abilities in school children of two age groups (grade 6 and grade 11). This project has been funded by an Internal Grant through Mount Saint Vincent University.

PROCEDURES

If you agree for your school to participate, we will send information letters and consent forms home to parents in grades 6 and 11. The parents must sign the consent form. The student must then bring this form to school on the day testing will occur. Prior to testing, we will verify that each student is eligible to participate. Unfortunately, any student with a diagnosed learning disability, neurological disorder or anxiety disorder may not participate in this study. On the test day, we ask that you have a room available (i.e., a classroom or other closed room within the school) where the data collection can take place. Participants will be brought to this room by the Principal Investigator and a research assistant. In the test session, students in participating classes will be randomly divided into groups of four and led to a study room where they will be asked to complete two cognitive tasks measuring their performance; half of the students will complete

these tasks while under a stressful situation (being told they will have to deliver a speech and perform math problems in front of the rest of the group). The other half will simply complete the tasks with no stress component added. Pulse will be measured at various times to assess any change(s). Participants will also be asked to complete a questionnaire indicating how anxious they feel in certain situations at the beginning of the study. Each participant has a right to skip any questions they do not wish to answer. The entire procedure should take no more than 30 minutes.

HOW WILL THIS DATA BE USED?

The data will be analyzed by the study investigators and will form the basis for the Principal Investigator's Master's thesis within the School Psychology program at Mount Saint Vincent University. Additionally, data may be used in future published manuscripts and conference presentations. Any resulting publications or presentations will only use group data; the students will never be personally identified.

CONFIDENTIALITY

Information will be kept confidential and the student's privacy will be protected by assigning participant numbers to the students. Only the research team will have access to the names associated with the participant numbers. Any scientific publication or presentation resulting from this work will be presented so that the students cannot be identified as test participants and will only use group data (not individual responses). Information collected from the study will be stored in a password-protected secure server housed at Mount Saint Vincent University (electronic data for cognitive tasks) and in a locked filing cabinet within the Supervising investigator's laboratory (consent forms, study questionnaires) at Mount Saint Vincent University. Data will be kept for 5 years following the final test session (until approximately Spring 2023), after which point it will be destroyed by physical or digital shredding. At all times, only the principal investigator (Ferguson), supervising investigator (Fisher), associate investigator (Champod) and research assistants currently working in the lab will have access to this information.

CONTACT INFORMATION

If you have any specific questions about this study, you should contact the principal investigator, Christina Ferguson (christina.ferguson@msvu.ca) or the supervising investigator, Derek Fisher, Ph.D. (902.457.5503; derek.fisher@msvu.ca)

If you are interested in having your school participate in this research study, please contact myself (Principal Investigator) or Dr. Derek Fisher (Supervising Investigator) via the email addresses or telephone number listed above.

I look forward to hearing from you!

Thank you,



Christina Ferguson



NOTICE OF RESEARCH STUDY

Dear Parent(s)/Guardian(s),

My name is Christina Ferguson and I am a graduate student in the Master of Arts in School Psychology program at Mount Saint Vincent University. This program requires students to complete a research study in order to be eligible to graduate. I was born and raised in Cape Breton and have decided to focus part of my research on the student population within the Cape Breton Victoria Regional School Board to study the effects of stress on academic performance.

The purpose of this research is to investigate the extent to which acute stress impairs working memory performance in two age groups of students. (Acute stress is short-term stress caused by the anticipation of an event and stops once the event passes). After speaking with the administration at Sydney Academy, they have agreed to allow the grade 11 classes to participate in this study. You are receiving this information sheet because your child is a grade 11 student. Participation in this study will occur on a date chosen with the school and will take place during school hours. It will take approximately 10-20 minutes to complete.

Participation in this research study is voluntary and participant data will remain confidential. The students will be given a participant number and this will never be connected to their names or any other identifying information. Detailed information about what your child will be asked to do can be found in the accompanying consent package.

If you and your child are interested in learning more about this research study, please see the attached information letter and consent form!

If you have any questions, please do not hesitate to contact me at Christina.Ferguson@msvu.ca.

Thank you,

Christina Ferguson

Christina Ferguson



INFORMATION SHEET

STUDY TITLE: The Effects of Acute Stress on Executive Functioning in School-Age Populations

PRINCIPAL INVESTIGATOR: Christina Ferguson, M.A. (cand.)
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ASSOCIATE INVESTIGATOR: Anne Sophie Champod, Ph.D.
Department of Psychology, Acadia University

INTRODUCTION

Please read and carefully consider the following information before you give your consent to participate in this study. This information sheet describes the purpose and procedures and the possible risks and benefits of the proposed research. You are encouraged to discuss any questions with the principal investigator or supervising investigator before signing this consent form. You may keep this information sheet for your records if you consent to participate. You are asked to send the signed consent page (at the back of this package) in to school with your child if you agree for them to participate. The test session at your child's school will take place on: _____

BACKGROUND

Acute stress appears to impact academic achievement in part by impairing executive functions. Executive functions are cognitive processes that allow us to perform goal-oriented behaviour and thinking by helping to control our attention, working memory, and planning and organizing skills. Working memory involves temporarily holding and manipulating information in our conscious awareness to help us learn or complete a task. Strong working memory skills are linked to success in the academic setting, including test performance. We are interested in looking at how increased stress affects working memory abilities in school children of two age groups (grade 5 and grade 11). This project has been funded by an Internal Grant through Mount Saint Vincent University.

PROCEDURES

If you agree for your child to participate, you must sign the consent form. Your child must then bring this form to school on the day testing will occur. Prior to testing, we will verify that your child is eligible to participate. *Unfortunately, any student with a diagnosed learning disability, neurological disorder or anxiety disorder may not participate in this study.* On the test day, which is listed on the front page of this information package for your school, participants will be brought to a classroom or other closed room within the school by the Principal Investigator and a research assistant in groups of 4-5. In the test session, students in participating classes will be randomly divided into groups of four and led to a study room where they will be asked to complete two cognitive tasks measuring their performance; half of the students will complete these tasks while under a stressful situation (being told they will have to deliver a speech and perform math problems in front of the rest of the group). The other half will simply complete the tasks with no stress component added. Pulse will be measured at various times to assess any change(s). Participants will also be asked to complete a questionnaire indicating how anxious they feel in certain situations at the beginning of the study. Each participant has a right to skip any questions they do not wish to answer. The entire procedure should take no more than 30 minutes.

PARTICIPATION

Your child's participation is voluntary; if you do not want your child to participate, simply do not sign and return this form. If you agree for your child to participate, they may withdraw from the study at any time without penalty during the study day. Furthermore, if at any point within one (1) month of the test session, either you or your child may withdraw their data from the study by directly contacting either the Principal Investigator or the Supervising Investigator.

RISKS

There are risks with this, or any study. To give you the most complete information available, we have listed some *possible* risks. We want to make sure that if you allow your child to participate in the study, you and your child have had a chance to think about the risks carefully. The risks presented in this study do not exceed those that may be expected in everyday life.

Participants may find the questionnaires, tasks and (if applicable) stress situation presented during the course of the study upsetting or distressing. Participants may not like all of the questions that are asked. Any participant may skip those questions they do not wish to answer and/or may withdraw participation at any point during the test session.

BENEFITS

There are no immediate benefits for participating in this study, however your child's participation will contribute to a better understanding of how stress impacts cognitive function.

HOW WILL THIS DATA BE USED?

The data will be analyzed by the study investigators and will form the basis for the Principal Investigator's Master's thesis within the School Psychology program at Mount Saint Vincent University. Additionally, data may be used in future published manuscripts and conference presentations. Any resulting publications or presentations will only use group data; your child will never be personally identified.

CONFIDENTIALITY

Information will be coded and your child's privacy will be protected. Any scientific publication or presentation resulting from this work will be presented so that your child cannot be identified as a test participant and will only use group data (not individual responses). Information collected from the study will be stored in a password-protected secure server housed at Mount Saint Vincent University (electronic data) and in a locked filing cabinet within the Principal investigator's laboratory (study questionnaires) at Mount Saint Vincent University. Data will be kept for 5 years following the final test session (until approximately Spring 2023), after which point it will be destroyed by physical or digital shredding. At all times, only the principal investigator (Ferguson), supervising investigator (Fisher), associate investigator (Champod) and research assistants currently working in the lab will have access to this information.

INFORMATION

If you have any specific questions about this study, you should contact the principal investigator, Christina Ferguson (christina.ferguson@msvu.ca) or the supervising investigator, Derek Fisher (902.457.5503; derek.fisher@msvu.ca)

If you have any questions regarding the conduct of this study and/or wish to speak to someone at arm's length from this study, you may contact the Research Office at Mount Saint Vincent University (research@msvu.ca; 902.457.6350).

If you feel distressed after participating in this study, you may contact the study investigators. If you can't reach anyone by telephone or email and you are experiencing a crisis that calls for immediate attention, phone the Mental Health Mobile Crisis Team at 902.429.8167 or 1.888.429.8167 for assistance.



CONSENT FORM

Title of Proposal: The Effects of Acute Stress on Executive Functioning in School-Age Populations

Principal Investigator: Christina Ferguson, M.A. (cand.)

Principal Investigator: Derek Fisher, Ph.D.

Associate Investigator: Anne Sophie Champod, Ph.D.

Statement: I, _____, agree for my child to participate in the above described research project, the nature and possible complications of which have been explained to me as outlined in the attached Information Letter of which I have received a copy.

I understand the risks and benefits of the study that have been explained to me.

My child will not be identified in any scientific presentation or publication.

I understand I may withdraw my consent for my child to participate at any time up to one month after the test session.

Name of Parent (printed)

Signature of Parent

Date

Participant Assent

I agree to participate in this research project.

I understand the risks and benefits of the study that have been explained to me.

I understand that I may skip any questions I do not wish to answer and may stop the study at any time.

Name of Participant (printed)

Signature of Participant

Date

Appendix C



FOLLOW-UP NOTICE OF RESEARCH STUDY

Dear Parent/Guardian,

A few weeks ago, your son/daughter received a consent package to participate in a research study titled, *The Effects of Acute Stress on Executive Functioning in School-Age Populations*.

We're still running this study and looking for participants! If your child is interested in participating in this research study, please find a consent form online at <http://www.msvu.ca/en/home/research/ECNSconference/ferguson.aspx> . Please print this form and return it to the guidance counsellor by **Monday, June 4th, 2018**.

The purpose of this research is to investigate the extent to which acute stress impairs working memory performance in two age groups of students. Acute stress is short-term stress caused by the anticipation of an event and stops once the event passes. After speaking with the administration at *Sydney Academy*, they have agreed to allow the grade 11 students to participate in this study. You are receiving this information sheet because your child is a grade 11 student. Participation in this study will occur on a date chosen with the school and will take place during school hours. It will take approximately 10-20 minutes to complete.

Participation in this research study is voluntary and participant data will remain confidential. The students will be given a participant number and this will never be connected to their names or any other identifying information. Detailed information about what your child will be asked to do can be found in the accompanying consent package.

If you have any questions, please do not hesitate to contact me at Christina.Ferguson@msvu.ca.

Thank you,

Christina Ferguson

Christina Ferguson