

THE INFLUENCE OF STABLE AND FLUCTUATING INDIVIDUAL  
DIFFERENCES ON EXECUTIVE FUNCTIONING

by

Kathryn E. Flood

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Supervisor: Lisa Best, Ph.D, Department of Psychology

Examining Board: Mary Ann Campbell Ph.D Department of Psychology, Chair.  
Enrico DiTommaso, Ph.D, Department of Psychology  
Lucy Wilson, Ph.D, Geology, Department of Biological Sciences

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## **Abstract**

Executive functioning (EF) refers to the higher order cognitive processes that allow individuals to engage in goal-setting behaviours. These processes are relatively complex and individual differences on EF engagement vary. The current study examined the relationship between situational (i.e., loneliness) and dispositional (i.e., personality) factors and EF. Eighty-two participants completed performance-based tasks and self-report questionnaires to assess EF and related psychosocial variables. Results indicated surprising similarities between the EF and the personality factors of Neuroticism and Conscientiousness. Furthermore, hypothesized subscales of self-report EF were not related to family, social and romantic loneliness when these factors were statistically controlled. Finally two competing models outlining the association of EF and loneliness were tested, with null findings. Supplementary analyses indicated that it may be beneficial to measure the overarching construct of loneliness and that additional EF performance-based tests are necessary to fully examine the link between loneliness and EF.

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## List of Abbreviations

A	Agreeableness
BAS	Behavioural activation system
BRI	Behavioural Regulation Index
BRIEF-A	Behaviour rating inventory of executive function-adult
C	Conscientiousness
D-KEFS	Delis Kaplan Executive Function System
DLPFC	Dorsolateral prefrontal cortex
E	Extraversion
EF	Executive function
FFM	Five factor model of personality
fMRI	Functional magnetic resonance imaging
GEC	Global executive composite
IWM	Internal working models
LB	Loneliness burden
M <sub>age</sub>	Mean age
MCI	Metacognition Index
N	Neuroticism
NEO-PI-R	Neuroticism, Extraversion, Openness, Personality Inventory-Revised
O	Openness to experience
PFC	Prefrontal cortex
pSTS	Posterior superior temporal sulcus
SAS	Supervisory sensory activating system
SD	Standard deviation

SES	Socioeconomic status
WM	Working memory

## **The influence of stable and fluctuating individual differences on executive functioning**

Executive functions (EFs) are neurological constructs and higher order cognitive processes that allow individuals to engage in goal-directed behaviours (Suchy, 2009). Although EF has been well-researched, it is important to note that the contribution of other processes also influences these goal-directed behaviours that humans engage in on a daily basis. Although it is accepted that these groups of cognitive processes are largely heritable (Friedman et al., 2008), environmental markers, such as an individual's attachment or feelings of loneliness, can affect a variety of behaviours throughout life (Cacioppo & Hawkley, 2009; Hazan & Shaver, 1987). EF are heritable; however, certain EFs may be affected by an individual's personality and environment (i.e., attachment and loneliness). That is, with changing environments it may be reasonable to suggest that an individual's cognitive responses may be altered in both the short and long-term. These changes in EF may in turn affect individual propensity for chronic loneliness. To date, researchers have not evaluated two competing models: (1) Chronic loneliness predicts lower EF scores (Diamond, 2013); and, (2) Lower EF predicts higher levels of chronic loneliness (DiTommaso, Fizell, & Robinson, 2015).

### **1.1 Executive Functioning**

EFs are often classified under the umbrella of executive control and share variance with other cognitive processes (Miyake & Friedman, 2012). Most people engage in goal- and future-oriented behaviours on a daily basis, although, EFs require considerable cognitive effort and typically remain dormant until required (e.g., a difficult or stressful situation may stop an otherwise automatic response and require an EF

process; Suchy, 2009). EF engagement involves the formation and maintenance of mental set shifting that allows for effective reasoning, goal generation, behavioural inhibition, and planning. EFs are situation specific and an individual may engage in different behaviours at home versus at work, as goals may be different in each environment (Suchy, 2009). Furthermore, flexible thinking involves the ability to alter previous plans and goals in response to changes in the environment (Gazzaley & D'Esposito, 2007) and is crucial for EF. For example, an individual playing a game of chess is able adapt their strategy in response to the other player's moves. Some researchers contend that the capacity to engage in EF provides an evolutionary advantage that allows many organisms to engage in more than just innate reflexes and over-learned responses (De Luca & Leventer, 2008). For example, Suchy (2009) argued that the fact that a moth's natural magnetism to bright lights continues in spite of the fact that the moth has likely burnt its wings on bright lights before is evidence that the moth is relying on innate reflexes rather than EF processes.

In comparison with other species, it is generally accepted that humans engage in the most complex EF processes (Stout, 2010). Unlike many other species, humans are able to consider numerous options in a given situation and rely on previously acquired knowledge to find the optimal solution to a problem (Gazzaley & D'Esposito, 2007; Stout, 2010; Suchy, 2009). In humans, problem solving for goal attainment involves primary EFs, including working memory (WM) , set-shifting, inhibition, planning, task-monitoring, organization of materials, initiation, attentional control, and emotional control (Suchy, 2009). Although some researchers have offered a dichotomy of EF processes (i.e., metacognitive and emotional EFs) concentrated in the prefrontal cortex

(PFC), it is generally accepted that the term executive functioning encompasses many processes operating in a vast neural network (Ardila, 2008).

Metacognitive EFs are higher-level top down processes that require attention and concentration. These EFs are used when attentional control, understanding of information, planning, problem solving, and working memory are necessary (e.g., an individual playing a game of cards needs to understand the game and gradually their opponent's strategy in order to win; Diamond, 2013). Emotional or behavioural EFs involve balancing emotions and cognition, allowing an individual to satisfy personal urges while also following socially acceptable strategies. As previously mentioned, these processes allow individuals to engage closely with their environments, and some researchers have suggested that without EFs human behaviour would be solely reflexive (De Luca & Leventer, 2008). The close interaction with the environment is naturally a subjective experience and, therefore, EFs can vary on both an individual and situational basis. Not surprisingly, in some situations, the best and most *logical* solution to a problem may not always match an individual's desires (e.g., a dinner guest saying the meal was disgusting, while not intending to offend the host; Bechara, Damasio, & Damasio, 2000)). These inconsistencies suggest that psychosocial factors (i.e., personality, attachment, loneliness) may influence and affect certain EF processes.

**1.1.1 Working Memory.** Schmeichel, Volokhov, and Demaree (2008) defined working memory capacity as “the ability to sustain goal-relevant information processing in the presence of alternative goals or other distractions” (p. 1527). An individual with a good working memory is able to store and extract information relevant to their goals from their memories, despite the numerous distractions present in daily life (e.g., a child

remembering to call their mother when they arrive at a friend's house). In particular, this type of memory is transitory, generating schemas immediately after an experience or shortly after it is retrieved from long-term memory (Curtis & D'Esposito, 2003).

Working memory is a vital EF process that works to both store and manipulate the information an individual encounters daily, and it is therefore essential to cognitive regulation processes (Burgess, 1997).

Similar to other EFs, working memory processes have been linked to activation in the dorsolateral prefrontal cortex (DLPFC). Using an animal model, Funahashi, Bruce, and Goldman-Rakic (1993) conducted experimental DLPFC lesions in monkeys and reported that damage in the principal sulcus can cause delay-dependent impairments. Further, there appeared to be significant loss of "trace" memory as delay times increased. More recent studies using functional magnetic resonance imaging (fMRI) and delayed recognition tasks on humans suggest that the DLPFC was activated during the transition and recollection of task relevant information (Curtis & D'Esposito, 2003). Further research has suggested that the DLPFC does not store memories; rather it monitors incoming information free of distraction, so that this information can later be stored in other areas of the brain (Sakai, Rowe, & Passingham, 2002). These findings have suggested that the DLPFC's role in working memory could influence an individual's external behaviours through the moderation of one's internal representations.

Schemas are an individual's representation of a plan or expectation based on past experiences in similar situations; these are essentially a by-product of working memory (DiMaggio, 1997). The connection between schemas and working memory capacity can be explained by Norman and Shallice's (1986) model of attentional control, one of the

first models linking these processes to EF (Baddeley, 2003). The first aspect of the model relies primarily on habit patterns (i.e., schemas). The second aspect of the model relies on the supervisory sensory activating system (SAS), which interferes with a schema if it is not adequate for the task at hand (Norman & Shallice, 1986). Baddeley (2003) used the example of intending to drive to the store on a weekend but instead ending up on the road to work (i.e., the primary travel route during the weekdays). There is evidence to suggest that this type of lapse in the working memory system also may affect the way individuals act in social situations, resulting in more difficulty hiding emotions even when told to do so (e.g., being disrespectful in a criminal court proceeding; Schmeichel et al., 2008). Problems such as these could indicate poor inhibition and cognitive flexibility, and from the perspective of unified EF (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), a corresponding drop in working memory. Specifically, these individuals may lack the ability to construct socially relevant schemas and may have trouble reacting relative to social norms. This lack of cognitive and outward emotional control could be related to other social factors such as attachment, discussed later.

**1.1.2 Inhibition.** Inhibition refers to the ability to monitor one's thoughts and actions relative to the situation at hand (Suchy, 2009). Inhibition often involves stopping certain behaviours and thoughts deemed inappropriate in a particular setting. Therefore, individuals with low levels of inhibition find it difficult to control ascendant responses (i.e., not filtering responses / saying the first thing that comes to mind; Miyake et al., 2000) and, by definition, low levels of inhibition involve higher levels of impulsivity. As such, trait impulsiveness involves a strong inclination to act upon desires and urges relative to the environment, without thinking about the consequences (Spinella, 2004).

Correlational research has suggested that trait impulsiveness is moderately and negatively correlated with measures of inhibition specific to impulse control, response organization and action (Pietrzak, Sprague, & Snyder, 2008).

Additional research on the unity and diversity of EFs has suggested that inhibition alone appears to correlate almost perfectly with common EF factors (i.e., measurements of an individual's overall levels of EF; Friedman et al., 2008, Friedman, Miyake, Robinson, & Hewitt 2011). Inhibition is necessary for all EF tasks because these processes must be active when individuals try to maintain or achieve a goal (Munakata et al., 2011).

**1.1.3 Set-Shifting.** Set-Shifting (also called cognitive flexibility; Diamond, 2013) is the cognitive process employed when an individual shifts their mental set, thus adapting to a change in the environment (Miyake et al., 2000). People who score higher on set shifting tasks are described as having high levels of cognitive flexibility and those with poor set shifting skills may be described as having cognitive inflexibility or rigidity (Stemme, Deco, & Busch, 2007). Because reacting appropriately to a changing situation requires an individual to assess the situation at hand and draw from previous experiences, set-shifting also may be associated with working memory and inhibition. Anderson (2002) suggested that impairment in this EF domain can be noted when an individual continues to make the same mistake repeatedly. For example, in everyday real-world situations this may occur when a child continuously breaks the same rule or when an individual does something over and over again expecting a different result.

**1.1.4 Planning.** Finally, planning involves the ability to internalize concepts (i.e., working memory) and build strategies in advance to approach tasks in an appropriate

(i.e., inhibition) and well-organized manner, which allows individuals to create and accomplish target goals (Anderson, 2002). Planning typically begins to develop when children are approximately preschool age, when, for instance, although their other EFs are not fully developed, children begin to understand that if they are going outside and want to avoid the cold temperatures they will need to put on their coat. Similar to inhibition, poor planning also has been associated with higher levels of trait impulsiveness (Pietrzak et al., 2008).

**1.1.5 EF Assessment.** Although EF processes are unified in many ways, it is still important to note that these complex processes can be defined individually in a variety of ways. The processes often associated with EF include self-regulation, planning, expectations, cognitive flexibility, attentional control, application of feedback, and selection of goals (Anderson, 2002). Therefore, it is not surprising that EFs contribute to a myriad of both behavioural and emotional responses. Consequently, researchers have developed various measurements for assessing EF.

Historically, EF deficits were considered directly related to damage in the PFC; therefore, many clinical measurements of EF were designed to assess the presence of PFC damage (Shallice, 1988). These early beginnings may have led to some confusion surrounding the operationalization of EF. That is, using certain tasks to measure certain EFs could actually include a cluster of components representing both executive and non-executive functions (Rabbitt, 1997; Bryan & Luszcz, 2000). This is called the *impurity* problem of EF measurement. An example of non-executive components (e.g., reading, colour perception etc.) emerging in an EF task is demonstrated through colour-naming in the Stroop task (Miyake & Friedman, 2012). Issues such as this illustrate a need to

control for the measurement of EF when conducting research. Currently, performance-based EF measures involve examiner-administered, standardized procedures assessing EF via accuracy or response time in tasks.

Contrary to performance-based measurements, some researchers assess EF by using self or other rating measures, in which a respondent indicates their perception of their own or another's behaviour related to EF (Toplak, West, & Stanovich, 2013). Scales rating EF were developed to provide researchers with an indicator of EF in everyday situations (i.e., how individuals normally engage in EF outside the laboratory; Roth, Isquith, & Gioia, 2005). Furthermore, partially due to different administration environments, it has been suggested that rating scales and performance measures may actually be assessing different aspects of EF.

In a recent meta-analysis, Toplak et al. (2013) reported relatively weak correlations between self-rating scales and performance-based EF tasks; only 24% of 286 applicable correlations were statistically significant and the median correlation between the measures was  $r = .19$ . For example, self-reported set-shifting cannot be predicted by examining performance on a task designed to measure the ability to change response patterns (i.e., the Wisconsin Card Sorting Task; Grant & Berg, 1948). In performance-based tests, a researcher or practitioner provides all information necessary for task completion and, therefore, test-takers are not required to use their EFs to create a plan or discover how to complete the task at hand (Salthouse & Ferrer-Caja, 2003).

Methodologically speaking, it makes sense to use both performance and rating measures when assessing EF. The inclusion of both measurements allows researchers to gain knowledge on real-life goal setting (self-report ratings) and levels of cognitive processing

(laboratory examinations). For that reason, the present study applied both methods of EF measurement. Analyses were conducted using both self-report and behavioural measures of EF.

## **1.2 Dispositional Factors: The Influence of Personality**

The aim of the current study was to increase understanding of the link between EF and other individual differences. Thus, it is important to consider that individual behaviours, thoughts, and feelings are often influenced by somewhat heritable personality traits (Jang, Livesley, & Vernon, 1996). The dimensional theory of personality is currently the most widespread theory explaining these individual differences (Digman, 1990; Norman, 1963) and is commonly referred to as the Five Factor Model (FFM; Costa & McCrae, 1985; 1992). The FFM consists of five basic personality factors: Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. Briefly described, Neuroticism is defined by increased levels of psychological distress and other unpleasant feelings and emotions. Extraversion is described by higher levels of friendliness, activity, and the experience of more positive emotions. Openness to Experience is often characterized by an intellectual curiosity, flexibility in thoughts and behaviours, and a readiness to adjust in different situations. Agreeableness is related to feelings of sympathy, cooperation, and trustworthiness; lower scores on this factor indicate feelings of distrust and pessimism. Finally, Conscientiousness is associated with an increased propensity for both organization and diligence (Costa & McCrae, 1985; 1992).

These factors or traits are considered to represent wholly unique aspects of personality that have been identified across different cultures (McCrae & Terracciano,

2005), are similarly described across languages (Goldberg, 1990), and appear to be a part of an individual's biology (Jang, McCrae, Angleitner, Reimann & Livesley, 1998).

According to Costa and McCrae (1992), the FFM also is based on a tiered system with each factor containing six facets representing specific aspects of the overall domain.

These facets can be measured using psychometrically valid questionnaires (i.e.,

Neuroticism, Extraversion, Openness, Personality Inventory-Revised; Costa & McCrae,

1992). The secondary facets may vary in individuals with similar scores on the FFM

(Matthews, Deary, & Whiteman, 2003; McCrae & John, 1992). For instance, two

individuals scoring high on factor Neuroticism may vary on what makes them neurotic,

which can be determined by examining individual facet scores (Neuroticism facets:

Anxiety, Angry Hostility, Depression, Self-Consciousness, Impulsiveness, Vulnerability;

Costa & McCrae, 1992). Researchers using the NEO-PI-R can focus on the broad factor

scores or the more detailed facet scores. The NEO-PI-R is used extensively in personality

research and is the most validated measure of the FFM (Fazeli, 2012). FFM scores can

be used to garner a greater understanding of both sample populations and individuals.

Results with the FFM have provided a rich picture of the relationship between

personality and other individual difference variables. For example, twin studies have

suggested that relatively large amounts of variance in an individual's personality can be

accounted for by genetic effects over and above environmental influences. Jang and

colleagues (1996) found that the genetic aspect of personality traits in both monozygotic

and dizygotic twins accounted for between 41%, (Agreeableness) and 53%

(Extraversion) of the variance in all of the five traits. These researchers also examined

these traits at the facet level; for example, the Straightforwardness facet of Agreeableness

accounted for 47% of the variance in the genetic environmental model. Neuroticism showed 41% heritability; the highest amount of variance was found in facets of Vulnerability and Self-Consciousness, with 44 and 38% respectively. The remaining variability was unaccounted for and could be due to environmental factors or interactions between a combination of environmental and genetic factors.

The heritability of personality is important but despite the aforementioned research it is interesting to consider that some of these traits may only develop and thrive in certain environments. Both and Best (2015) suggested that an individual's overall levels of life satisfaction may be predicted by higher scores on both Conscientiousness and Extraversion, and lower levels of Neuroticism. Further, Both and Best reported that life satisfaction was associated with lower levels of loneliness and increased attachment security suggesting that these traits and life satisfaction may be linked to situational variables. Despite the influence of factors such as EF and personality, it is important to consider how environmental differences (i.e., attachment and loneliness) affect overall EF.

## **1.2 Attachment: A Stable Environmental Factor**

Attachment theory suggests that the caring bonds that humans form with certain individuals (i.e., caregivers, partners, close friends) inform a variety of an individual's behaviours throughout their lifetime (Bretherton & Munholland, 1999; Hazan & Shaver, 1987). These bonds are formed with attachment figures (i.e., those one turns to in times of distress), and are characterized by different patterns of behaviour (Bowlby, 1969). Bowlby suggested that attachment begins at birth and, through one's experiences with their caregivers, develops throughout infancy. The attachment patterns formed during

infancy appear to be constructed based on the quality of exchanges with caregivers, particularly in stressful or threatening situations (Ainsworth, Blehar, Water, & Wall, 1978). Research suggests that when caregivers are readily available in stressful situations, the infant should form a secure attachment. On the contrary, when caregivers are not available or only sometimes available during a stressful episode, the infant is more likely to develop an insecure attachment that is characterized by avoidance and/or anxiety (Sroufe & Waters, 1977).

These attachments appear to remain fairly consistent during a person's lifetime (Bretherton & Munholland, 1999; Hazan & Shaver, 1987), persistently influencing behaviours and attitudes in social situations (Bowlby, 1969; Brennan, Clark, & Shaver, 1998; Hazen & Shaver, 1987). Hazan and Shaver (1987) postulated that the attachment patterns formed in infancy last throughout life; thus the attachment an individual later develops with romantic partners derives from attachments formed in infancy. In adulthood, one may look to their significant other (attachment figure) in stressful situations for support in recovering emotional security or they may turn away from their significant other to avoid emotional proximity (Collins & Feeny, 2010; Simpson & Rholes, 1994).

**1.3.1 Models of Attachment.** Although attachment was traditionally measured by classifying individuals into four distinct categories (secure, anxious-ambivalent, fearful-avoidant, and avoidant; Hazan & Shaver, 1987), more recently attachment has been measured on a continuum assessing individual levels of anxiety and avoidance (Rutter, 1995). These changes were driven by research suggesting that the categorical model of attachment may inhibit the researcher's ability to explore individual differences. The

current dimensional model avoids this problem by placing individuals on a continuum. Equally, it allows researchers to categorize individuals based on where they fall in the anxiety-avoidance dimension and allows them to note specific differences in either insecure or secure individuals (Rutter, 1995).

These dimensions of attachment are easily explained by categorizing individuals who fall along avoidant and anxious continuums. Anxiously attached individuals have consistently unavailable attachment figures and are more likely to have a fear of abandonment and high levels of worry. These individuals often require a large amount of support from their attachment figures in order to maintain comfort with the status of the relationship. Contrary to this, individuals scoring higher on attachment avoidance struggle to trust their partners and, as a result, persistently try to maintain emotional distance and independence (i.e., avoidant attachment). Higher scores on both the anxiety and avoidance dimensions (i.e., fearful-avoidant) indicate that the individual may be hesitant to enter into a relationship and maintain distance (i.e., avoidance) in order to evade rejection. Secure individuals score low on both anxiety and avoidance and tend to be comfortable with intimacy, exhibiting mainly pro-social behaviours (i.e., helping or sharing) throughout attachment relationships (Bartholomew & Horowitz, 1991; Mikulincer & Shaver, 2005).

#### **1.4 Additive Effects of Loneliness: A Fluctuating Environmental Factor**

From an evolutionary perspective, humans have always had a strong emotional need to belong, largely because group inclusion offers individuals access to additional resources (e.g., food, shelter, protection; Hawkey & Cacioppo, 2010). Larger group inclusion is correlated with less individual risk, as social groups offer individuals

protection from other social groups. Diminished social threat, in turn, is advantageous for sleep quality, mortality, and enhanced physical and psychological functioning.

Loneliness can be defined by the feelings of distress that occur when individual social needs are not being met by the quantity, or more importantly, the quality of social relationships (Hawkley et al., 2008; Perlman & Peplau, 1982; Wheeler, Reis, & Nezlek, 1983). Loneliness is the emotional reaction that occurs due to group or peer exclusion. Deprivation of close social ties can result in the expression of many emotions and affect an individual's overall well-being through complex feelings of sadness, shame, depression, and frustration (Cacioppo & Hawkley, 2009). Loneliness is a common phenomenon experienced at some point by up to 80% of individuals under the age of 18 years and 40% of adults over 65 years. Research suggests that loneliness appears to decrease during middle adulthood but increases again in an individual's later years (i.e., >70 years; Berguno, Leroux, McAinsh, Skaikh, 2004; Pinqart & Sorensen, 2001; Weeks, 1994). It is important to note that loneliness is a subjective experience, and although, externally, an individual may appear quite popular, internally they may feel they lack a real connection to those surrounding them. Conversely, some people are capable of living highly satisfactory lives in solitude, without experiencing feelings of loneliness (Pinqart & Sorensen, 2001).

Current models of loneliness are multidimensional and can differ on a time perspective, leading to the differentiation between transient (or state) and chronic loneliness (Baumeister, DeWall, Ciarocco, & Twenge, 2005). Transient loneliness is a fairly normal experience and is defined by random and brief periods of loneliness. These periods are typically short-lived and over the course of one's life, long-term relationships

with others are formed and maintained (Asher & Paquette, 2003). Conversely, chronic loneliness is a discontent with social relationships that lasts for longer than two years, and can be extremely detrimental to physical and mental well-being (Asher & Paquette, 2003; Hawkley & Cacioppo, 2010). Heinrich and Gullone (2006) suggested that chronically lonely individuals perceived themselves as less socially capable than their transiently lonely counterparts and reported significantly lower self-esteem and higher negative emotionality. Physical implications of chronic loneliness include depression, anxiety, substance use, disrupted sleep, and increased risk for cardiac conditions, to name a few (Hawkley & Cacioppo, 2010). Evidently, higher and more severe levels of loneliness have an effect on daily functioning, suggesting that feelings of loneliness affect the way that some individuals unconsciously engage in cognitive processes.

DiTommaso and Spinner (1993; 1997) developed a tripartite model of loneliness focusing on an individual's levels of family, social, and romantic loneliness. Although these types of loneliness are related, each contributes differently to overall levels of loneliness. For example, social and romantic loneliness differ in that an individual who is romantically involved may still feel the need to increase their social interactions outside of the relationship. The tripartite model of loneliness offers a broad understanding of different loneliness experiences throughout the lifespan. As individuals age, the majority of adults experience a decline in the size of their social networks (Lang, Staudinger, & Carstensen, 1998), resulting in less emotional support during stressful situations and, ultimately, less social contact with others. Although social isolation is often linked to loneliness, it is important to note that one does not have to be socially isolated in order to

feel lonely; an individual can be surrounded by others and not feel as though their social needs are being appropriately met (Victor & Yang, 2012).

Typically, the general public has associated higher rates of loneliness with old age; however, the loneliness age gap may be narrowing as technology continues to advance. Presently, people of all ages spend time together absorbed in their mobile devices, game consoles, or televisions, sometimes without really interacting. Studies have indicated that increased Internet use is positively correlated with higher levels of loneliness (Kubey, Lavin, & Barrows, 2001; Morahan-Martin & Schumacher, 2003; Peper & Harvey, 2018), and, because technology is often aimed at younger generations, it may be beneficial to study levels of loneliness in young adults. Young adults raised after 2010 have grown up in an age of ever-changing and highly influential technology. Breakthrough technologies are utilized by the general public at a faster rate than ever before. Personal computers and handheld devices are key examples of this phenomenon, and both have marked the advent of a new means of interpersonal communication (e.g., instant messaging, texts; Anderson, 2002; Flood, McPhee, Buhay, & Best, 2017).

### **1.5 Potential Dispositional and Situational Links to Executive Functioning (EF)**

Due to a combination of genetic and environmental factors, individuals are unique. One of the oldest questions underlying many psychological theories centres on the nature versus nurture debate. Dispositional attribution refers to internal traits that reside within an individual being ascribed to their behaviour, whereas situational attribution stems from an individual's environment or current location (Reeder, Vonk, Ronk, Ham, & Lawrence, 2004). Today, it is generally accepted that both situational and dispositional factors contribute to behaviour. For a broader understanding of an

individual, it is therefore beneficial to examine both stable (i.e., personality and attachment) and situational (i.e., chronic and transient loneliness) factors when studying individual differences in EF. As such, the current study seeks to elucidate the relations between dispositional, relatively stable situational experiences, and an individual's EF.

**1.5.1 Executive Functioning and Personality.** Presently, little research on the associations between individual personality traits and EFs exists. Research using the Stroop task (Stroop, 1935) has indicated that EFs involve a genetic mechanism indirectly affecting the multifaceted behaviours that characterize one's phenotype (i.e., personality; Canli, 2008). That is, throughout the life span, interactions between personality and EFs relative to the environment may be the cause of associations between dispositional traits and cognitive functioning. Interestingly, a recent literature review suggested that levels of stress and resilience are associated with interactions between personality and EF (Williams, Suchy, & Rau, 2009). It was proposed that different levels of situational stress exposure and reactions as well as overall recovery (resilience) were related to both an individual's EF processes and personality. These results would be expected given that infant temperament (marked by motor, emotional, and attentional reactivity) changes as interactions with the environment occur (Rothbart, 2007). Moving forward, assessing the temperament aspect of personality appears to be essential to understanding the relationship between EF and personality. The Five Factor Model (FFM) is a well-established measure of personality (McCrae & Costa, 1987) that includes multiple facets that tap into underlying positive (e.g., Extraversion) and negative (e.g., Neuroticism) dimensions of personality that develop from infant temperament (Evans & Rothbart, 2007; Rothbart, 2007).

In an overview of research on EF, Williams and colleagues (2009) suggested that, in the future, researchers should use the FFM, and proposed that differences in EF may be expressed through the personality traits that make an individual more or less susceptible to stress. Focusing primarily on stress, Williams et al. provided a theoretical framework outlining the individual differences underlying behavioural and psychophysiological mechanisms and their potential relationships with both poor mental and physical consequences. Their model suggests that personality paired with childhood environmental factors (e.g., neglect, stressors, familial income) can influence stress regulation and EF performance. Namely, there appears to be a reciprocal relationship between EF and the stress response. That is, as environmental stressors increase, adverse stress responses also increase and contribute to decrements in EF. For example, individuals with lower levels of EF appear to be at risk to experience higher levels of stress and to demonstrate a more physiological response to stress, such as a lack of sleep, which in turn impairs levels of EF (Williams et al., 2009). Furthermore, Williams and Thayer (2009) discussed a potential link between personality and behaviours that are related to physical health, such as binge-eating and substance abuse. Given these links, it follows that higher EF (specifically goal setting) would predict an increased ability to alter these maladaptive behaviours. In support of this theory researchers have demonstrated that higher levels of EF can lead to greater success in dieting and maintenance of weight loss (Hall, Fong, Epp, & Elias, 2008). Employing this model could aid in the explanation of the role of FFM traits (e.g., Conscientiousness) in EF mediation of behavioural intention and goal-oriented performance (Williams & Thayer, 2009).

The FFM has been associated with aspects of EF and, although research is limited, all five personality factors and their facets have been linked to EF. Gray's (1970) Behavioural Activation System (BAS) is often associated with Extraversion. This system becomes aroused when stimuli that may be related to a reward are present and, during this time, an individual will engage in behaviours associated with increased sociability. Furthermore, it has been suggested that a higher BAS may be related to better performance on working memory tasks (Gray et al., 2005). Lieberman & Rosenthal (2001) included conditions in which participants had high cognitive loads and found that extroverts performed significantly better on working memory tasks than did introverts. The function of working memory is to update schemas in order to better align with goals (Suchy, 2009) and, because extroverts thrive when involved in social interactions (McCrae & Costa, 2003), they may require a higher functioning working memory to keep up with their changing schemas. That is, perhaps the increased ability to quickly gather and build on previous information during social situations provides extroverts with a sense of comfort and ease in social situations.

Although the other FFM traits lack supporting literature specific to EF, some connections can be drawn. The Agreeableness factor has been associated with inhibition; research with young children has suggested that lower levels of agreeableness predict lower levels of inhibition in EF measurement (Kochanska, Aksan, Penney, & Doobay, 2007). These findings with young children could be explained by the child's expectation of reward in the experiment (i.e., candy). The candy presented to the children as their reward after completion may have potentially skewed their impulsivity ratings and the children may have viewed a speedy completion as a faster means for reward. Equally,

higher levels of Neuroticism have been associated with poorer performance on both inhibition and selection tasks of EF (Luu, Collins, & Tucker, 2000). Openness has been associated with cognitive flexibility (DeYoung, Peterson, & Higgins 2005; Murdock, Oddi, & Bridgett, 2013), which is unsurprising as, by definition, being open reflects a certain degree of flexibility. Finally, Conscientiousness appears outwardly reflective of many EF processes (i.e., organization, inhibition, impulse/control, self-discipline; Murdock et al., 2013), and, given these links, it is surprising that there has been little research supporting any associations between EF and Conscientiousness. Buchanan (2016) put forward results suggesting a significant positive relationship between individuals who self-reported poorer EF and scored lower on levels of Conscientiousness, although additional research is required.

**1.5.2 FFM Facets.** There also is evidence supporting facet level analyses of the FFM and EF associations. Williams, Suchy, and Kraybill (2010) assessed EF using the Delis Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) and personality in 58 healthy aging adults and found facet level relations that indicated that global composite EF scores were negatively associated with the Angry-Hostility and Anxiety-Depression facets of Neuroticism. This implies that these individuals may lack control over their environments, which could be related to the development of certain EF processes (i.e., cognitive flexibility) that involve blocking out extraneous stimuli (Craik & Bialystok, 2006). The same study also found a positive relationship between EF and the Trust, Altruism, Compliance, and Tender-mindedness facets of Agreeableness. Craik and Bialystok (2006) suggested that higher Agreeableness scores may be a protective factor. That is, being agreeable increases the likelihood that an individual would have

solid social support systems and may not be involved in situations that cause them to engage in *disinhibited* conflict-inducing behaviours. In other words, low Agreeableness may be predictive of less inhibitory behaviours simply because these individuals lack the cognitive capacity and social networks to have other responses (Williams et al., 2010). Although there were no significant associations between EF and factor Extraversion or Conscientiousness, there were positive associations with the Warmth, and the Competence facets of Extraversion and Conscientiousness respectively. A potential reason for the lack of a relationship between Extraversion and EF could be that the decline in Extraversion often associated with aging causes a restricted range of scores (Williams et al., 2010). A wider understanding of personality and its relationship to EF is needed.

### **1.6 Attachment & Executive Functioning**

The PFC continues to develop post-birth and, during childhood, growth is characterized by an increase in white matter volume, dendrites, neuronal and synaptic networks, all essential to cognitive processes (Tsujimoto, 2008). Some researchers believe that because EFs are largely focused in the emerging PFC, EFs (though partially genetic) may be influenced by this ongoing development and specific interactions with the child's environment (Diamond, Barnett, Thomas, & Munro 2007). Although it is difficult to simulate a natural environment when measuring EFs, some researchers have begun measuring attachment security as a potential predictor of EF performance. The formation of attachment patterns overlaps with the development of internal working models (IWMs) or mental working models.

IWMs affect the way that individuals view themselves and others throughout the life span. Given that one may incorporate a mirror representation of their attachment figure in their own self-image, secure attachment and positive self-image have been associated (i.e., the traits of attachment figures become a part of an individual's self-image). IWMs allow individuals to function in relation to others and themselves (Bowlby, 1969, 1982; Mikulincer & Shaver, 2007). Working memory and cognitive flexibility develop early and are among the first EFs that emerge in early childhood (Crain & Bialystok, 2006). As children develop cognitive flexibility, they gradually become more independent in their thinking. The age at which cognitive flexibility fully develops is dependent upon the amount of environmental stimuli in an individual's daily life. Environments that foster increased socialization (i.e., family and peer interaction) are associated with the development of set-shifting skills that develop earlier and are superior. Individuals with more impoverished environments (i.e., increased television, video games) may have lower set-shifting abilities that develop later (Iguchi, Hoshi, Tanosaki, Taira, & Hashimoto, 2005; Sarter, Gehring, & Kozak, 2006). There may be an interaction between the development of IWMs, working memory, and cognitive flexibility, as these EF processes appear to be integral to the formation of IWMs.

Bernier, Carlson, Deschênes, and Matte-Gagné (2012) investigated the possible links between the quality of the early caregiving environment and child EF. Sixty-two families were assessed on five occasions in areas of both maternal and paternal interactive behaviour and attachment (1-2 years old). Child EF (working memory and cognitive flexibility) was later measured between 2 and 3 years. Interestingly, correlational results suggested that total scores of parental behaviour and child

attachment were positively and significantly related to the child's performance on EF tasks. Beyond all other social predictors of child EF measured in this study (i.e., child verbal ability and prior EF, family socioeconomic status (SES), and parenting behavior), attachment security was associated with higher overall EF performance in children older than three years. All predictors of performance on working memory and cognitive flexibility measures were statistically significant. However, it is important to note that a child's caregiver attachment was more predictive of EF performance than their verbal ability or SES.

Although researchers have examined the impact of low SES and parenting behaviours on children's levels of cognitive functioning, to date, little research has considered attachment (Bibok, Carpendale, & Müller, 2009; Hughes & Ensor, 2009), with the exception of Bernier and colleagues (2012). For example, Bibok and colleagues (2009) found an association between higher levels of EF in children and better quality parenting (in lieu of attachment) in children of 3 years. Taken together, the ability of attachment to predict child EF over and above other social factors should provide researchers with some insight when predicting environmental factors of EF. Although tolerance and correlations between predictor variables were not reported by Bernier and colleagues (2012), it would have been interesting to see how much variance parent-child relationship/interaction variables took away from attachment, as these were entered into the researcher's model first. Nonetheless, it is likely that attachment plays a role in EF development, and therefore may be influencing EF throughout the lifespan.

## 1.7 Loneliness and Executive Functioning

To date, there has been little research on EF and feelings of loneliness; however, some of the same brain areas implicated in loneliness have been associated with EF processes. Individuals reporting higher levels of loneliness appear to have less gray matter volume in the left posterior superior temporal sulcus (pSTS), an area that appears active during situations where participants are inferring the emotions and social cues of others (Kanai, 2012). Although it is important to note that the pSTS has been implicated in the processes of many different social and cognitive functions, transient loneliness has been associated with activation in this area (Kanai et al., 2012). pSTS volume also has been linked to observations of stimuli in social environments suggesting that lonelier individuals may not have the capacity to properly utilize basic skills associated with social situations, particularly gaze direction and biological motion (Grossman, Battelli, & Pascual-Leone, 2005; Kanai et al., 2012). This supports Gardner, Pickett, and Brewer (2000) who suggested that lonely individuals although aware of social cues and loneliness itself seemingly lack the ability to engage in prosocial behaviours. Further, DiTommaso et al. (2015) proposed a model by which cognitions, emotional responses, and behaviours interact to predict transient and chronic loneliness.

Taken together, these findings reinforce Baumeister and Leary's (1995) theory postulating that the fundamental need for belongingness could drive cognitive responses. That is, in evolutionary terms, belongingness (as with hunger) is considered a basic need. A hungry individual engages in cognitive processes that direct their attention towards food cues previously acquired by their working memory. Likewise, a lonely individual

may direct their attention toward social cues learned from previous experience. Additionally, Gardner and colleagues' (2000) findings point to deficits in certain EF processes (i.e., inhibition, set-shifting, and planning) that may be due to a lapse in working memory. This theory could be supported by research suggesting that although EFs represent a diverse set of cognitive processes, they work together (Miyake & Friedman, 2012). Under this premise it may be that deficits in one EF may influence or cause deficits in others (i.e., if an individual does not have the ability to build a schema, they may not understand which behaviours are appropriate for a given relationship and, thus, appear uninhibited).

Furthermore, brain-imaging studies on individuals with abnormal DLPFCs have suggested that perhaps due to their inability to appropriately set-shift these individuals may be less alert than others to their surroundings (Kanai & Rees, 2011). As previously mentioned, this could be related to a lack of social enrichment throughout childhood (Bernier et al., 2012). Additionally, recent neuroimaging research by Kong et al., (2015), demonstrated that higher levels of loneliness were associated with a larger volume of gray matter in the left DLPFC, an area of the brain often associated with EF processes (Suchy, 2009). Additional research focused on this brain area suggested that individuals with DLPFC damage appear to lack the motivation to do things for themselves and/or for others (Rankin, 2007). In sum, these findings could explain the appearance of asocial behaviours in individuals with high levels of loneliness; perhaps once these people feel they are chronically alone the desire to try and feel a sense of belonging fades *or* they simply lack the ability to approach social situations with ease because of a possible deficit in EF. In addition, loneliness has been associated with both self-regulation (the

ability to regulate thoughts and actions) and poor working memory. Through a series of questionnaires and analysis of grey matter in participant DLPFCs, Kong and colleagues (2015) suggested that a poor working memory capacity may lead to both poor self-regulation and emotional regulation (increased occurrence of negative mood).

Furthermore, it has been suggested that if an individual has less control over emotional responses and cannot regulate experience feedback, there may be a greater chance of loneliness (Schmeichel & Demarree, 2010). Through studying activations in the DLPFC, researchers have started to understand how individuals interact in their social environments through EF, specifically when handling complex social situations and understanding the behaviours of others.

### **1.8 Purpose of the Current Study**

Attachment develops in the context of the environment and relationships, and research has examined the influence of home environments and parental relationships on EF during childhood. Research with elementary school children suggested that, in first grade, performance on attention and memory tasks was related to quality of home environments (National Institute of Child Health and Human Development, 2005). In addition, better parenting may be linked to higher levels of EF performance in children, specifically in areas of attention switching (Bibok et al., 2009). Taken together, these studies indicate that the effects of child-caregiver relationships and specific attachment patterns could be vital to processes beyond social development. Furthermore, it is the constructive outcomes and features of a secure attachment bond that help to foster a safe environment from which children can engage in self-regulated thoughts and thus effective EF strategies (Kochanska & Aksan, 1995; Lewis & Carpendale, 2009).

Stressful situations activate IWMs and attachment patterns (Bowlby, 1969), and similarly complex situations also activate EF (Suchy, 2009). Given the activation of both attachment and EF in stressful situations, researchers should consider that attachment could be predictive of EF (Bernier et al., 2012). There are a variety of explanations for potential variation in child-caregiver attachment security and how these bonds may predict both environmental effects and the progressive development of EF throughout childhood and in turn adulthood. Thus, in spite of the fact that attachment may play an important role in the development of EF processes, researchers have not explored the relation between adult attachment and EF. Although attachment patterns remain fairly stable over time it is important to explore the relationship between EF and attachment activations in adults (DiTommaso et al., 2015).

To a certain extent, EF and personality are not acquired through an individual's environment (Rothbart, 2007; Suchy, 2009); however, research has suggested that attachment and loneliness may be linked to personal circumstances (i.e., cultural values, SES; Empson, 2004). Individuals with high levels of loneliness or insecure attachment bonds may be at a greater risk for EF impairment. Similarly, researchers have suggested that individuals with certain temperaments or personalities may better adapt to harsher situations (Sroufe, Cooper, & DeHart, 1996). Finding the link between situational factors, personality, and EF could provide insight into human behaviour and elucidate specific factors that influence executive functioning in different environments and situations.

Although research has examined the associations between EF and personality, attachment, and loneliness, the direction of these associations is unclear. One purpose of

this research was to examine two competing models. In one model, personality, attachment, and loneliness are used to predict EF. In an extensive review by Diamond (2013), the effects of psychosocial variables (i.e., stress, sadness, loneliness) are outlined. The negative effects of these variables are evident at the physiological (i.e., prefrontal cortex changes) and behavioural levels (i.e., lower EF). Diamond goes on to argue that children and adults alike will have higher EF if they belong to a supportive community that takes their emotional, social, and physical needs into account. In the second model, personality, attachment, and EF are predictors of transient loneliness which, in turn, predicts chronic loneliness (DiTommaso et al., 2015). In this model, individuals with lower EF (i.e., inhibition) may respond inappropriately in social situations increasing the likelihood of peer rejection, which in turn could lead to transient and later chronic loneliness.

In this research I examined two competing questions: 1. Do psychosocial factors (e.g., loneliness) predict our EFs as suggested by Diamond (2013)?; or, 2. Is it more likely that an individual will become chronically lonely because lower executive functioning does not allow them to interact appropriately within the social world (DiTommaso et al., 2015)? Both models were tested after statistically controlling for personality and attachment variables. These individual difference variables are important to consider given that they are both relatively stable factors throughout an individual's life. Based on previous research findings, several replication hypotheses were developed (see Table 1). These hypotheses served to validate the experimental procedure and confirm previous published results. The unique hypotheses (see Tables 2 and 3) have not

been previously tested. These hypotheses were analysed using correlational (see Table 2) and hierarchical multiple regression (see Table 3) analyses.

### 1.8.1 Specific Hypotheses

**Table 1**

*Replication Hypotheses*

Hypotheses	Core Concepts
Higher levels of avoidant or anxious attachment were expected to be associated with higher scores on the Neuroticism factor and facets.	Insecure attachment and personality factor Neuroticism
Higher levels of avoidant or anxious attachment were expected to be associated with higher levels of chronic loneliness.	Insecure attachment and chronic loneliness
Higher levels of overall loneliness were expected to be associated with higher scores on the Neuroticism factor and facets, and lower scores on the Openness, Agreeableness, and Extraversion factors and facets.	Loneliness and personality factors (Neuroticism, Openness, Agreeableness, and Extraversion)
Higher levels of Openness to experience were expected to be associated with better performance on set-shifting tasks, and a higher EF composite score.	Personality factor (Openness), EF performance (set-shifting) and composite EF
Higher levels of Agreeableness were expected to be associated with better performance on inhibition and set-shifting tasks, and a higher EF composite score.	Personality factor (Agreeableness), EF performance (set-shifting and inhibition), and composite EF

*Note.* Hypotheses assessed using Pearson correlations

**Table 2***Unique Hypotheses*

Hypotheses	Core Concepts
Higher levels of secure attachment were expected to be associated with better performance on EF measures of inhibition, set-shifting, working memory, and planning.	Secure attachment and EF performance measures.
Higher levels of chronic loneliness were expected to be associated with poorer performance on EF measures of inhibition, set-shifting, working memory, and planning.	Loneliness and EF performance measures.
Higher levels of Conscientiousness were expected to be associated with better performance on EF measures of inhibition, set-shifting, working memory, and planning.	Personality factor (Conscientiousness) and EF performance measures.
Higher levels of Extraversion were expected to be associated with better performance on working memory tasks, and a higher EF composite score.	Personality factor (Extraversion), EF performance measure (working memory), and EF composite score.
Higher levels of Neuroticism were expected to be associated with poorer performance on EF measures of inhibition, set-shifting, working memory, and planning, and a lower EF composite score.	Personality factor (Neuroticism), EF performance measure (working memory), and EF composite score.

*Note.* Hypotheses assessed using Pearson correlations

**Table 3***Regression Hypotheses to test competing models of EF and loneliness*

Hypotheses	Blocking
It was expected that levels of loneliness would predict performance on EF performance measures over and above personality and attachment.	Demographics Personality, Attachment Loneliness
It was expected that levels of loneliness would predict performance on EF self-report measures over and above personality and attachment.	Demographics Personality, Attachment Loneliness
It was expected that lower levels of EF performance, and transient loneliness would predict chronic loneliness over and above personality and attachment.	Demographics Personality, Attachment EF Transient Loneliness
It was expected that lower levels of EF self-report, and transient loneliness would predict chronic loneliness over and above personality and attachment.	Demographics Personality, Attachment EF Transient Loneliness

*Note.* Hypotheses assessed using hierarchical multiple regression analyses.

## 2.0 Methods

### 2.1 Participants

Both males and females were recruited via posters located on the Psychology Department Research Board, in-class announcements, and postings on social media platforms (e.g., Facebook). At the time of administration, all participants enrolled at the University of the New Brunswick (UNB), Saint John were offered two bonus marks toward their Introduction to Psychology course grade. Participants who were not enrolled at the University of New Brunswick were offered 20 dollars as compensation for their time.

A total of 82 participants completed both performance-based measures (i.e., D-KEFS) and the questionnaire package. The sample was composed of 51 females (62.2%,  $M_{\text{age}} = 32.21$ ) and 31 males (37.8%,  $M_{\text{age}} = 29.38$ ). The average age of participants was 31.15 years ranging from 18 to 64 ( $SD=12.27$ ) and a *t-test* indicated no statistically significant differences in the age of male and female participants. Further, age was normally distributed, with 75% of participants who were 36 years of age or younger and 20% with ages ranging from 42 to 64 years. The majority of participants (82.9%) were residents of New Brunswick, followed by those from other areas of Canada (9.8%), and only 7.3% of participants indicated that they were from another country. Approximately 65.9% of participants indicated that they were involved in a romantic relationship at the time of study administration, with 63% of those relationships being >6 months.

Participants also were asked if they had a current mental or physical illness diagnosis; 53.7% did not report any diagnoses, 17.1% reported physical ailments (e.g., previous concussions, chronic migraines, etc.), and 26.9% of participants reported some kind of psychological diagnosis (e.g., anxiety, depression, attention deficit disorder, etc.).

Furthermore, 63.4% of participants reported that they were not on any medications at the time of the study, 20.7% indicated they were on medication for physical ailments, and 15.9% reported the use of a psycho-pharmaceutical.

## 2.2 Materials

**2.2.1 Demographics Questionnaire.** Participants completed a demographics questionnaire including questions regarding their age, gender, program of study (if applicable), estimated daily technology use, length of current or previous relationship, relationship status, living arrangements, and international or domestic status (see Appendix A).

**2.2.2 The Experiences in Close Relationships Inventory.** The Experiences in Close Relationships Inventory (ECR-I; Brennan et al., 1998) is a 36-item measure designed to evaluate adult attachment. Participants indicated how much they agree or disagree with items on a Likert scale (1- *disagree strongly*, 4- *neutral*, and 7- *agree strongly*). The ECR-I consists of two 18-item subscales assessing avoidance and anxiety, respectively. The ECR-I has evidence for both convergent and divergent validity. The UCLA Loneliness Scale has been positively correlated with both the Avoidance and Anxiety subscales of the ECR-I ( $r = .34$  and  $.53$ , respectively). Additionally, the ECR subscales of both Avoidance and Anxiety have been negatively correlated with the Social Provisions Scale (SPS), a measure of perceived social support. ( $r = -.45$  and  $-.43$ , respectively; Fairchild & Finney, 2006). The ECR has demonstrated high internal reliability in a number of studies, with Cronbach's alphas for an American sample of .92 for the anxiety subscale and .94 for the avoidance subscale (Gillath et al., 2005; see Appendix B). Similar results have been found in international samples, with a recent

Spanish sample reporting Cronbach's alphas of .87 for avoidance, and .85 for anxiety, indicating that cross-culturally the scale has demonstrated internal consistency (Alonso-Arbiol, Balluerka, & Shaver, 2007). In the current study, Cronbach's alphas of .86 were calculated for anxiety and .94 for avoidance.

**2.2.3 Behaviour Rating Inventory of Executive Function- Adult.** (BRIEF-A; Roth, et al., 2005). The BRIEF-A is a 75-item self-report measure used to assess levels of an adult's executive functioning via questions about performance on daily tasks (reading level required for this is Grade four). The BRIEF-A is designed to be a cost-effective manner to assess an individual's EF over the past 6 months. Nine clinical scales are measured on a 9-point Likert scale (*Never, Sometimes, Often*); scales include Inhibit, Shift, Planning, Self-monitor, Organization of Materials, Task Monitor, Working Memory, Initiate, and Emotional Control. For the present study, the following subscales were used: Working Memory (8 items, e.g., I forget what I am doing during the middle of things); Shift (6 items, e.g., I have trouble changing from one activity to another); Inhibit (8 items, e.g., I have problems waiting my turn); and Planning (10 items, e.g., I get overwhelmed by large tasks). The BRIEF-A also consists of two indices: the Behavioural Regulation Index (BRI) and the Metacognition Index (MCI). Finally, there is an overall score, the Global Executive Composite (GEC). All clinical subscales show sufficient internal consistency reliability ( $\alpha = .73$  to  $.90$ ) and exceptional internal consistency reliability for both the indices and global score ( $\alpha = .93$  to  $.96$ ; Roth, et al., 2005). In the current study Cronbach's alphas were within the acceptable range of reliability: GEC ( $\alpha = .77$ ), MCI ( $\alpha = .86$ ), and BRI ( $\alpha = .77$ ; see Appendix C).

#### **2.2.4 The Social and Emotional Loneliness Scale for Adults. (SELSA-S;**

DiTommaso, Brannen, & Best, 2004) The SELSA-S is a 15-item questionnaire measuring an individual's levels of loneliness in social, familial, and romantic relationships. Items are rated on a 7- point Likert scale (1-*strong disagree*, 7-*strongly agree*). Each subscale assesses a different social domain of the participant's life. The familial loneliness scale focuses on family relationships (e.g., in the past year I felt alone with my family). The social loneliness scale assesses an individual's peer relationships (e.g., in the last year I felt a part of a group of friends). Finally, the romantic subscale measures the participant's levels of romantic loneliness (e.g., in the last year I wished I had a more satisfying romantic relationship). Cronbach alphas range from  $\alpha=.87$  to  $\alpha=.90$  for all three SELSA-S subscales (i.e., family, social, romantic) indicating high internal reliability. Two versions of the SELSA-S were included in the questionnaire package; one measuring transient (i.e.  $\geq 2$  weeks) and one measuring chronic (i.e.,  $\geq 2$  years) loneliness (see Appendix D). Cronbach alphas in the present study for transient loneliness were: .87 (Romantic), .84 (Family), and .85 (Social); similar results were found for chronic loneliness: .83 (Romantic), .88 (Family), and .86 (Social).

#### **2.2.5 Neuroticism Extraversion Openness Personality Inventory Revised.**

(NEO-PI-R; Costa & McCrae, 1992). The NEO-PR-I is a 240-item questionnaire that measures five personality factors (i.e., Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness). Each factor consists of 6 additional traits called facets. The NEO-PR-I items are measured on a 5-point Likert scale (1-*strongly agree*, 3-*neutral*, 5-*strongly disagree*). The 5 factors demonstrate good internal consistency as Cronbach alphas range from  $\alpha=.86$  to  $\alpha=.96$ , and facet level score alphas

range from  $\alpha=.56$  to  $\alpha=.81$ . The NEO-PI-R also has demonstrated good validity (Costa & McCrae, 1992). McCrae and Costa (1992) correlated self- and peer-reports of personality factor and facets and reported positive partial correlations among scores; 77% of these were statistically significant. The same study yielded similar but higher correlations for self and spousal report data, indicating good discriminant validity. In a meta-analysis examining the reliability generalization of the NEO-PI-R, the NEO-PI, and the NEO-FFI, Caruso (2000) determined that the NEO-PI-R maintained the highest overall reliability across 47 samples. Reliability means ranged from .91 for Neuroticism to .84, for Agreeableness. Cross-culturally, the NEO-PI-R appears to demonstrate good reliability; using a Korean sample, Piedmont & Chae, (1997) found that all domain scores yielded reliable alphas ranging from .92 (Neuroticism) to .80 (Agreeableness). (In the current study, the NEO-PI-R scale had adequate reliability: .86 (Neuroticism); .75 (Extraversion); .71 (Openness); .76 (Agreeableness); and .86 (Conscientiousness; see Appendix F).

#### **2.2.6 Delis-Kaplan Executive Function System.** (D-KEF-S; Delis et al., 2001).

The D-KEFS consists of a battery of nine standardized tests measuring specific executive functions. The performance-based tests in the D-KEFS battery are administered either in combination with other D-KEFS tests or independently. These nine tasks include the Verbal Fluency Test, the Tower test, the Color-Word Inference Test, the Trail-Making Test, the Design Fluency Test, the Sorting Test, the Word Context Test, the Proverb Test, and the Twenty Questions Test. Correlations between the D-KEFS test scores are in the low positive range, indicating that the tests are uniquely measuring particular EFs (Delis et al., 2001). The D-KEFS is administered such that participants feel they are playing a

game, which means no positive or negative feedback is presented and some researchers have suggested that this method could reduce the number of participants who feel discouraged throughout the task (Homack, Lee, & Riccio, 2005). The D-KEFS tests are able to compare multiple tasks across conditions allowing researchers to observe the many aspects of each executive function (Homack et al., 2005). This study required the use of three D-KEFS tests: 1) the Color-Word Inference Test, 2) the Trail-Making Test, and 3) the Tower Test.

**2.2.6.1 The D-KEFS Color-Word Interference Test.** The D-KEFS Color Word Interference test is a measure of inhibition that is reminiscent of the Stroop task (Stroop, 1935). The test consists of two baseline conditions, word reading and colour naming, then two higher-level conditions of inhibition and inhibition switching. The primary outcome variable is dependent on the participant's completion time of the test. Delis and colleagues (2001) assessed reliability for this measure conducting Spearman-Brown split-half reliability and demonstrated good internal consistency for all age groups (0.62-0.86). All four test conditions and time completions demonstrated moderate intercorrelations ( $r = .41$  to  $.63$ ) for all ages, demonstrating internal validity. Similarly, all ages demonstrated moderate to high correlations for test-retest reliability ( $r = .49$  to  $.90$ ; Delis et al., 2001).

**2.2.6.2 The D-KEFS Trail-Making Test.** Principally a measure of set-shifting, the D-KEFS Trail-Making Test is a performance-based task consisting of 5 conditions. Baseline measurements are assessed in conditions 1, 2, 3, and 5; and condition 4 allows for the measurement of higher order cognition. Condition 1 is a visual scanning task and is followed by conditions 2 and 3, a letter and a number sequencing task. The scores on

these sequencing tasks are combined to calculate a baseline measurement. The fourth condition consists of a number-letter switching task and is the main measurement of EF in this test. Finally, the fifth condition assesses a participant's motor speed and is another baseline measure. The outcome of the test was assessed via a participant's completion time, although the calculation of error scores on these tasks also is considered. Using Spearman-Brown split-half reliability Delis and colleagues (2001) found good internal consistency as suggested by both moderate and high internal consistency coefficients ranging from .57 to .81. The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993) is another EF test that measures inhibition and set-shifting; a preliminary study comparing the D-KEFS Trail-Making test and this test demonstrated that the amount of errors made in the Shifting and Inhibition condition of the D-KEFS was positively correlated with the WCST, at  $r = .44$ .

**2.2.6.3 The D-KEFS Tower Test.** The D-KEFS Tower Test measures an individual's spatial planning ability and inhibition of response. Nine items make up the D-KEFS Tower Test, which requires participants to first establish and then uphold a series of rules. Outcome measures for this task include initiation of set, completion, overall accuracy, time to complete the task, and error scores calculated by total amount of rule violations. Larochette, Benn, & Harrison (2009) reported statistically significant positive correlations between the D-KEFS Tower Test and the similar Tower of London (Shallice, 1982), total move, initiation, and correct scores ( $r = .47$  to  $.58$ ). Further, participant scores on the Tower Test and the Tower of London Test are similar. Correlations for test-retest stability ranging from 9 to 74 days between test administrations were within the moderate range for all age groups ( $r = 0.44$ ; Delis et al.,

2001). Tests for internal consistency were adequate for all age groups, all were .60 or greater, except it should be noted that lower values were found for ages 8 (.56), 13 (.55), 14 (.43), and 50-59 (.56) (Delis et al., 2001). Internal consistency values within the proposed sample of university age students should therefore not be an issue.

Intercorrelations between test scores indicate scale validity (Delis et al., 2001).

### **2.3 Procedure**

University participants recruited from undergraduate psychology courses (42.7% of participants) at the University of New Brunswick, Saint John campus, through Sona Systems (an online research sign-up tool), were prompted to sign up for a two-hour time period offered during a variety of times on Monday through Friday. Participants recruited via social media platforms (57.3% of participants) contacted the principal investigator by email to schedule a meeting time. The principal investigator arranged to meet participants in a private and quiet research office space, in order to ensure anonymity and concentration. Upon meeting, the principal investigator explained the purpose of the study and what tasks would be performed. After a verbal description, participants were presented with an informed consent form and advised that they were free to leave the study at any time without penalty. After signing the consent form, participants completed either the performance-based measures or self-report measures. To avoid order effects, the presentation of the tasks (self-report vs. performance), questionnaires (with the exception of the demographics questionnaire (which was always presented first), and performance-based tasks were randomized.

All participants completed questionnaire packets that included: a Demographics Questionnaire, the ECR-I (Brennan et al., 1998), the BRIEF-A (Roth, et al., 2005), the

SELSA-S (DiTommaso, et al., 2004), the UCLA Loneliness Scale: Version 3 (Russell, 1996), and finally the NEO-PI-R (Costa & McCrae, 1992). Participants completed these questionnaires in the private research office reserved for this study. The performance-based measures were administered independently in the same office by the principal investigator using the D-KEFS examiners manual (Delis et al., 2001). After the administration of all measures was complete the participant was given a debriefing form explaining the purpose of the study and contact information for university counselling services and a member of the Research Ethics Board who was not associated with the study.

**2.3.1 The D-KEFS Color-Word Interference Test.** There are four timed conditions in the Color-Word Interference test; before each condition participants complete an untimed practice test. In the initial phase, or condition one, the participant was asked to name and classify groups of colours. Condition two required the participant to read colour-words (e.g., green, blue, yellow) printed in neutral black ink. The interference phase or condition three required the participant to name the colour that a colour-word is written in and not the colour-word itself. Condition four was similar to condition three, except that when the participant comes across a word in a box they are required to read the colour-word written instead of naming the colour the word is written in.

In the current study, all participants completed the Color-Word Interference Test; however, in some situations such as participant distress it was not possible or advisable to continue to the timed conditions as per the D-KEFS examiners manual. Timed conditions were not administered if the participant made four errors without correcting in the

practice rounds for conditions 1 and 2. Likewise four uncorrected errors in the practice round for condition three resulted in no timed test and the elimination of condition four. Conditions one and two would end if the task was not completed in 90 seconds and three and four would be discontinued after 180 seconds. Scores for the Color-Word Interference Test are calculated by number of seconds taken to complete each task, and number of participant-made corrections and uncorrected errors.

**2.3.2 The D-KEFS Trail-Making Test.** This test consists of five conditions all consisting of an untimed practice test before the timed task. In condition one, participants were asked to write a dash over a specific number as fast as they could. Condition two required participants to connect encircled numbers in ascending order. Condition three in the same way required the participant to connect letters alphabetically. The fourth condition consists of quickly connecting letters and then numbers in ascending order (i.e., A to 1, 1 to B, B to 2, 2 to C, etc.). Finally, in condition five participants were asked to trace a dotted line as quickly as they could. The timed tasks in this test were not administered to participants who made four or more errors in practice tasks. Condition four ended after 240 seconds and all other conditions lasted 150 seconds, if not already complete.

**2.3.3 The D-KEFS Tower Test.** The D-KEFS Tower Test consists of nine trials or items. In each trial, participants were asked to recreate a tower shown to them by the examiner via the transportation of different sized rings across three pegs. In order to recreate the tower successfully the participant was required to follow two rules 1) a larger ring cannot be put on top of a smaller ring and 2) only one ring can be moved at a time. Before showing the participant the picture of the tower they were to recreate, the

examiner placed the rings on the pegs in their starting positions. After all rings were appropriately placed the examiner showed the participant the tower they needed to recreate. In the first two trials the examiner demonstrated the correct one-move solution to the participant if they were not successful; if they were successful the examiner let them know. Throughout each trial the examiner recorded the time it took the participant to make the first move, their total number of moves, rule violations, total time for completion (all timing done in seconds), and successful completion of the task. If the participant failed the task successively 3 times the examiner discontinued the task altogether. Similarly, trials 1 through 3 were discontinued after 30 seconds, trial 4 after 60 seconds, trials 5 through 6 after 120 seconds, trial 7 after 180 seconds, and lastly trials 8 and 9 after 240 seconds.

### **3.0 Results**

#### **3.1 Data Conditioning**

In order to ensure model assumptions were met, data were conditioned and thoroughly screened. First, a frequency analysis was run on all raw data variables to determine accuracy of input. All out of range values were identified by participant number and corrected to match the response entered on the questionnaire package. Univariate outliers were identified using standardized scores and pairwise plots to address assumptions of non-linearity and heteroscedasticity. Skewedness, kurtosis, and probability plots were examined to detect non-normal variables, followed by identifying multivariate outliers. Finally, all variables were assessed for multicollinearity and singularity.

**3.1.2 Consideration of missing data.** Typically, it would be necessary to check the dataset for randomness of missing data; however, frequency analyses indicated that

individual variables were all missing fewer than 2% of data. Furthermore, if a participant completed 80% of individual scale items, total scale and subscale scores were calculated using the mean of the scale items. Because this sample had very few missing data points, all 82 participants yielded total scores for all scales and subscales; that is, no participants were removed from the dataset due to missing data considerations.

**3.1.3 Consideration of univariate outliers and normality.** Univariate outliers were considered by checking all variables for skewedness and kurtosis. Although numerous outliers were identified using the cut off z score as suggested by Tabachnick and Fidell (2013; i.e., z-scores  $>3.29$  or  $<-3.29$ ), with the exception of some D-KEFS percentile rank scores, all univariate outliers appeared continuous in their respective distributions. Despite large coefficients of variation for these percentile rank scores, scores were not adjusted, in order to maintain an accurate reading of where the participant fell among larger samples. For the aforementioned reasons, there were no score adjustments made, as there were no “true” outliers.

Standardized z-scores greater than  $\pm 3.29$  of skewedness or kurtosis are suggestive of abnormality (Tabachnick & Fidell, 2013). Skewedness and kurtosis were assessed using the above z-score criteria and then after consideration of input errors, skewedness and kurtosis were reassessed and normality was assumed for all variables.

**3.1.4 Consideration of multivariate outliers.** A multivariate outlier is a score or participant that deviates away from normal scores on more than one variable, or more precisely away from the multivariate mean. Multivariate outliers were assessed using Mahalanobis (Mahal’s) distance, which was calculated by regressing variables (both criterion and predictors) on identification number. The first Mahal’s regression yielded

statistical significance, and one participant was removed. Subsequently, another Mahal's regression was re-run and did not reveal any other outliers.

The first and only deleted participant was then added back into the sample to perform a stepwise regression to identify the variables that may be contributing to this participant's deviation from the rest of the sample. This was done by creating a dummy variable in which all participants except the multivariate outlier were given the same score. All variables are subsequently regressed on the dummy variable using a stepwise regression; this allows certain predictors to emerge as the largest contributors of the participant's deviation from the rest of the sample. Altogether, the stepwise procedure produced 3 significant models. Results from model 1 indicated that this individual's score on the D-KEFS Trail-Making Test Condition 4 (i.e., set-shifting score) was the most significant predictor of deviation from the sample ( $F(1, 81) = 30.31, p < .0001$ )  $R^2 = .27$ . Additionally, 38% of the variability was demonstrated in model 3, when the D-KEFS set-shifting score was entered first, followed by chronic family loneliness and transient family loneliness ( $F(3, 78) = 15.84, p < .0001$ )  $R^2 = .38$ . At the univariate level, this individual was not an outlier on either chronic or transient family loneliness; however, his or her D-KEFS set-shifting score was the lowest recorded and was an outlier. Although this score previously appeared to be continuous within the distribution, the decision was made to change this individual's score to one less than the next lowest score. Changing the score preserves a certain level of variability between scores on the D-KEFS Trail-Making test. After this score was changed the scores for this variable were normally distributed and this individual remained in the present sample.

**3.1.5 Heteroscedasticity and Non-linearity.** Pairwise and residual plots of non-categorical variables were examined to check for linearity and heteroscedasticity. These analyses were run before and after the previous steps to ensure that sufficient changes were made to the dataset. The assumption of linearity was met for all criterion and predictor variables both before and after conditioning. All probability plots were constructed with 95% confidence intervals to assess this assumption.

**3.1.6 Power.** In order to determine the number of participants required while maintaining a power of .80 or greater, power analyses were conducted before data collection using G Power. The number of predictors entered into G Power was 9, and the degrees of freedom numerator was 3, as we anticipated 4 possible outcome variables. Therefore, it was estimated that 80 participants (rounded from 78) were required for these analyses. These parameters allowed for an alpha of .05 and a medium effect size of .15. After data collection and conditioning, power was calculated again. No participants were deleted from this sample, yielding a final sample size of 82. Using 82 as the sample size, G Power calculated a power level of 0.82; this is a fairly high level of power, allowing for a moderate effect size of .25. Given the large number of analyses conducted, it was decided to set alpha levels at .01; results significant at the .05 level are included in the results for information purposes only.

### **3.2 Replication Hypotheses**

The first replication hypothesis postulated that higher levels of avoidant and anxious attachment would be associated with higher scores on the Neuroticism factor and facets. This hypothesis was partially confirmed: higher levels of attachment anxiety were positively and significantly correlated to higher levels of Neuroticism ( $r = .57, p < .01$ ) and

all Neuroticism facets (Anxiety:  $r = .48, p < .01$ ; Anger-Hostility  $r = .39, p < .01$ ; Depression,  $r = .55, p < .01$ ; Self-Consciousness,  $r = .41, p < .01$ ; Impulsivity,  $r = .23, p < .01$ ; Vulnerability,  $r = .55, p < .01$ ). Conversely, there were no statistically significant associations found between attachment avoidance and Neuroticism or its facets.

Hypothesis 2 predicted that higher levels of avoidant or anxious attachment would be associated with higher levels of chronic loneliness. Pearson correlations were conducted using attachment and both transient and chronic loneliness. Interestingly, transient loneliness and anxious attachment style were significantly and positively correlated (Social,  $r = .38, p < .01$ ; Romantic,  $r = .36, p < .01$ ; Family,  $r = .35, p < .01$ ). Further, there were statistically significant associations between anxious attachment and chronic loneliness (Social,  $r = .39, p < .01$ ; Romantic,  $r = .34, p < .01$ ). Attachment avoidance was not related to chronic or transient loneliness at  $p < .01$ .

Furthermore, the relationship between both transient and chronic loneliness and personality was assessed. It was hypothesized that higher levels of overall loneliness would be positively associated with higher levels of factor Neuroticism and each of the Neuroticism facets. Further, it was expected that higher levels of loneliness would be associated with lower scores on the Openness to experience, Agreeableness, and Extraversion factors and facets. There were statistically significant associations between all these personality factors and loneliness scores, confirming the majority of the previously reported relationships (see Table 4). Results for Openness to Experience were unexpected, as the factor score was not associated with loneliness but the Ideas facet of this scale was significantly positively associated with chronic romantic loneliness (Pearson's  $r(82) = .29, p < .01$ ).

**Table 4**

*Pearson correlations: Associations between loneliness and scores on Neuroticism Openness, Agreeableness, and Extraversion factors and facets.*

	Transient Loneliness			Chronic Loneliness		
	Romantic	Family	Social	Romantic	Family	Social
Neuroticism	.26*	<b>.46**</b>	<b>.49**</b>	.13	<b>.29**</b>	<b>.45**</b>
N1	.15	.27*	<b>.41**</b>	.07	.21	<b>.39**</b>
N2	.11	<b>.34**</b>	<b>.30**</b>	.09	<b>.31**</b>	<b>.38**</b>
N3	<b>.32**</b>	<b>.52**</b>	<b>.52**</b>	.22*	<b>.33**</b>	<b>.43**</b>
N4	.21	<b>.32**</b>	<b>.37**</b>	.13	.12	.22*
N5	.20	<b>.30**</b>	.19	.05	.10	.19
N6	.21	<b>.40**</b>	<b>.45**</b>	.05	.24*	<b>.44**</b>
Extraversion	-.16	-.25*	<b>-.45**</b>	-.10	-.10	<b>-.35**</b>
E1	-.12	-.25*	<b>-.44**</b>	-.10	-.15	<b>-.36**</b>
E2	-.16	-.23*	<b>-.36**</b>	-.14	-.14	-.24*
E5	-.15	-.09	-.28*	-.06	.06	-.18
E6	-.19	<b>-.38**</b>	<b>-.47**</b>	-.07	-.13	<b>-.38**</b>
Openness	.12	-.09	-.09	.16	.04	-.06
O5	.22*	-.16	.00	<b>.29**</b>	.02	-.02
O6	.08	-.16	-.23*	.07	-.09	-.25*
Agreeableness	-.07	-.23*	<b>-.29**</b>	-.12	-.23*	-.25*
A1	-.05	<b>-.35**</b>	<b>-.45**</b>	-.06	<b>-.30**</b>	<b>-.45**</b>
A4	-.07	-.24*	-.16	-.08	<b>-.31**</b>	-.17
A6	.07	-.21	-.27*	.03	-.19	-.18

*Note.* Only facets related to loneliness are noted under whole personality factors. N1=Anxiety; N2=Hostility; N3=Depression; N4=Self-consciousness; N5=Impulsiveness; N6=Vulnerability; E1=Warmth; E2=Gregariousness; E5=Excitement-seeking; E6=Positive Emotions; O5=Ideas; O6=Values; A1=Trust; A4=Straightforwardness; A6=Tender-mindedness.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is  $p=.01$ .

Finally, two replication hypotheses focused on the relation between personality and executive function. It was predicted that higher scores on the Openness to experience factor and its facets would be associated with better performance on EF tasks as measured by the D-KEFS Trail-making Test (Condition Four: Scaled Score) and a higher BRIEF-A global composite score. Pearson's correlations were not statistically significant, indicating no association between these variables. Nonetheless, because set-shifting was a primary variable of interest, correlational analyses between Openness to Experience and the BRIEF-A Set-Shifting subscale were examined. There were statistically significant negative correlations at the factor level ( $r = -.31, p < .01$ ) and at the facet level (Actions,  $r = -.41, p < .01$ ; Values,  $r = -.39, p < .01$ ), demonstrating a relation between better self-reported set-shifting ability and higher overall Openness scores and facets (i.e., Actions and Values).

The final replication hypothesis considered the relation between Agreeableness, performance-based set-shifting, inhibition, and self-reported composite EF scores. Similar to findings reported for hypothesis 4, there were no statistically significant relations between performance-based tests measuring specifically set-shifting (Trail-making Test: Condition Four: Scaled Score) and inhibition (Color-Word Interference Test: Condition Three: Scaled Score) and Agreeableness factors and facets. As predicted, Agreeableness and self-reported BRIEF-A global composite scores were significantly associated. The relation between specific subscales (i.e., Set-shifting and Inhibition) and Agreeableness factors and facets yielded statistically significant correlations, indicating a

possible association between inhibition and set-shifting and certain aspects of Agreeableness (see Table 5)

**Table 5**

*Pearson correlations: Associations between Agreeableness, inhibition and set-shifting tasks, and self-report EF.*

	BRIEF-A Global Composite EF	BRIEF-A Inhibition	BRIEF-A Set-shifting	D-KEFS Tower Test Total Score
Factor: Agreeableness	<b>-.36**</b>	<b>-.31**</b>	<b>-.33**</b>	.18
A1: Trust	<b>-.36**</b>	-.21	<b>-.44**</b>	.30
A2: Compliance	<b>-.27*</b>	<b>-.30**</b>	-.13	.24*
A3: Altruism	<b>-.28**</b>	-.26*	-.26*	.06
A4: Straightforwardness	<b>-.39**</b>	<b>-.42**</b>	<b>-.35**</b>	.26*
A5: Modesty	.11	.08	.10	.05
A6: Tender-mindedness	-.28*	-.19	-.25*	-.04

*Note.* Lower BRIEF-A scores indicate higher levels of self-reported executive function. The D-KEFS Tower Test Total Score is a score associated with inhibition, planning, and working memory.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

### 3.3 Unique Hypotheses

A series of Pearson correlations were conducted to evaluate 5 unique hypotheses stimulated by previous research findings (see Table 2). As previously mentioned, considering the number of analyses conducted, alpha levels were set at .01; however, results significant at .05 are noted in the Tables. The first hypothesis stated that higher levels of secure attachment would be related to better performance on EF measures of inhibition, set-shifting, working memory, and planning. Similar to results demonstrated above with the replication hypotheses, performance-based EF measures were not related to levels of attachment. Regardless, these correlations were tested using self-report EF scores from the BRIEF-A. Secure attachment is indicated by low scores on both anxious and avoidant attachment. Lower attachment anxiety was associated with better set-shifting and lower attachment avoidance is associated with better EF planning. Higher self-report working memory was related to low avoidance, indicating that this EF may be more strongly associated with secure attachment. There was no significant relation between inhibition and attachment in this sample (see Table 6).

**Table 6**

*Pearson correlations: Associations between attachment and self-report EF measures of set-shifting, working memory, and planning.*

	BRIEF-A Set- shifting	BRIEF-A Working Memory	BRIEF-A Planning
Anxiety	<b>.49**</b>	.26*	.12
Avoidance	.00	<b>.29**</b>	<b>.29**</b>

*Note.* Lower BRIEF-A scores indicate higher levels of self-reported executive function.

;**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

Hypothesis two explored the relation between chronic loneliness and EF. It was hypothesized that higher levels of chronic loneliness would be related to poorer performance on EF measures of inhibition, set-shifting, working memory, and planning. Higher levels of chronic social loneliness were related to lower self-report set-shifting scores (see Table 7). Chronic romantic and family loneliness were not related to scores on EF performance-based or self-report measures, nor were any associations between chronic loneliness, planning, or working memory indicated.

**Table 7**

*Pearson correlations: Associations between chronic loneliness, self-report EF set-shifting, and inhibition, and performance-based inhibition.*

	D-KEFS Color- Word Interference Test <sup>1</sup>	BRIEF-A Set- Shifting	BRIEF-A Inhibition
Chronic Romantic Loneliness	-.12	.00	.11
Chronic Family Loneliness	-.22*	.20	.22*
Chronic Social Loneliness	-.19	<b>.42**</b>	.04

*Note.* <sup>1</sup>Condition 3: Completion Time (Scaled)-measures inhibition.

Lower BRIEF-A scores indicate higher levels of self-reported executive function.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

The relationship between EF and FFM personality traits was examined using Pearson correlations. It was hypothesized that higher levels of factor and facet Conscientiousness would be associated with better performance on EF measures of inhibition, set-shifting, working memory, and planning. This hypothesis was supported and BRIEF-A subscales of inhibition, set-shifting, working memory, and planning were all negatively and significantly correlated to Conscientiousness and the majority of its facets (see Table 8).

**Table 8**

*Pearson correlations: Associations between Conscientiousness and EF measures of inhibition, set-shifting, working memory, and planning.*

	D-KEFS Trail-Making Test <sup>1</sup>	BRIEF-A Set-shifting <sup>2</sup>	BRIEF-A Inhibition <sup>2</sup>	BRIEF-A Working Memory <sup>2</sup>	BRIEF-A Planning <sup>2</sup>	MCI	BRI
Factor:	-.14	<b>-.34**</b>	<b>-.56**</b>	<b>-.55**</b>	<b>-.67**</b>	<b>-.74**</b>	<b>-.58**</b>
Conscientiousness							
C1: Competence	-.15	<b>-.50**</b>	<b>-.41**</b>	<b>-.45**</b>	<b>-.53**</b>		
C2: Order	.03	-.01	<b>-.31**</b>	<b>-.29**</b>	<b>-.49**</b>		
C3: Dutifulness	-.14	-.23*	<b>-.51**</b>	<b>-.37**</b>	<b>-.42**</b>		
C4: Achievement-striving	-.13	-.22	<b>-.27*</b>	<b>-.41**</b>	<b>-.53**</b>		
C5: Self-discipline	-.27*	<b>-.40**</b>	<b>-.49**</b>	<b>-.66**</b>	<b>-.64**</b>		
C6: Deliberation	-.05	-.27*	<b>-.63**</b>	<b>-.39**</b>	<b>-.52**</b>		

Note. <sup>1</sup>Condition 4 (Scaled)-measures set-shifting.

<sup>2</sup> Lower BRIEF-A scores indicate higher levels of self-reported executive function.

\*\*p<.01

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

Extraversion was also hypothesized to be associated with EF, with higher levels of Extraversion hypothesized to be related to better performance on working memory tasks and higher EF composite scores. There were no statistically significant associations between working memory (both performance-based and self-report scores) and Extraversion.

Lastly, it was hypothesized that higher levels of Neuroticism would be associated with poorer performance on EF measures of inhibition, set-shifting, working memory, planning, and overall EF scores. Once more, a relation between personality and performance-based EF measures was not observed. Despite these results, a relationship between Neuroticism and self-reported EF scores was evident (see Table 9). All BRIEF-A subscales measured were positively and significantly related to Neuroticism and its facets. Indeed, the only Neuroticism variables that were not related to Inhibition were the Anxiety and Self-consciousness facets.

**Table 9**

*Pearson correlations: Associations between Neuroticism, EF measures of inhibition, set-shifting, working memory, planning, and EF composite score.*

	BRIEF-A WM	BRIEF-A Plan <sup>1</sup>	BRIEF-A Set-shifting <sup>1</sup>	BRIEF-A Inhibit <sup>1</sup>	BRIEF-A GEC <sup>1</sup> EF	MCI	BRI
Factor:	<b>.49**</b>	<b>.49**</b>	<b>.70**</b>	<b>.41**</b>	<b>.65**</b>	<b>.45**</b>	<b>.75**</b>
Neuroticism							
N1: Anxiety	.25*	.24*	<b>.58**</b>	.05	<b>.30**</b>		
N2: Hostility	<b>.31**</b>	<b>.29**</b>	<b>.55**</b>	<b>.35**</b>	<b>.50**</b>		
N3: Depression	<b>.42**</b>	<b>.47**</b>	<b>.55**</b>	<b>.45**</b>	<b>.58**</b>		
N4: Self-consciousness	<b>.31**</b>	<b>.33**</b>	<b>.42**</b>	.16	<b>.36**</b>		
N5:							
	<b>.48**</b>	<b>.39**</b>	<b>.36**</b>	<b>.55**</b>	<b>.60**</b>		
Impulsiveness							
N6:	<b>.51**</b>	<b>.58**</b>	<b>.74**</b>	<b>.34**</b>	<b>.69**</b>		
Vulnerability							

*Note.* <sup>1</sup>Lower BRIEF-A scores indicate higher levels of self-reported executive function.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

### 3.4 Competing Models

In total, 10 hierarchical multiple regression analyses were performed to test the two competing models of EF and loneliness. For all regression analyses, the alpha was set at .01, to avoid Type I error, although results significant at the .05 level are included. The model predicting self-reported EF performance (see Diamond, 2013) indicated that psychosocial variables (i.e., loneliness) would have a greater effect on EF processes than somewhat heritable traits (i.e., personality). In the first set of regression analyses, EF performance-based total (i.e., primary measurement scores) scores on the Tower Test (Total score; assessing inhibition, working memory, and planning), the Color-Word Interference Test (Condition 3: Completion Time; assessing inhibition and set-shifting), and the Trail-Making Test (Condition 4: Completion Time; assessing set-shifting) were entered as the criterion variables. In all cases, age and gender were entered into Block 1, followed by relatively stable psychological variables (i.e., personality and attachment) in Block 2, and chronic social, family, and romantic loneliness in Block 3. These regression models were not statistically significant, indicating that neither dispositional nor situational psychological variables affected scores on performance-based EF tests (see Appendices G, H, & I for regression tables).

In the second set of analyses, a regression predicting self-reported BRIEF-A scores was conducted. The overall model accounted for 75.1 % of the variance in overall EF self-report scores ( $F(12, 69) = 17.32, p < .0001$ ). Personality and attachment anxiety were the only statistically significant predictors. As is shown in Table 10, better self-reported EF was associated with higher Conscientiousness and Agreeableness, lower Neuroticism and lower attachment anxiety.

**Table 10***Hierarchical Multiple Regression predicting BRIEF-A total scores.*

BRIEF-A: Global Executive Composite <sup>1</sup>				
	<i>R</i>	<i>B</i>	<i>t</i>	<i>p</i>
<b>STEP 1</b>				<b>R<sup>2</sup>=.03</b>
Age	-.11	-.12.	-1.12	.26
Gender	-.14	-.16	-1.41	.16
<b>STEP 2</b>				<b>ΔR<sup>2</sup>=.72</b>
Openness	-.09	.05	.75	.46
Conscientiousness	-.74**	-.61	-9.17	.0001
Extraversion	-.22	.00	.57	.95
Agreeableness	-.36**	-.16	-2.31	.02
Neuroticism	.65**	.28	2.86	.005
Avoidance	.17	.09	1.52	.13
Anxiety	.39**	.13	1.73	.08
<b>STEP 3</b>				<b>ΔR<sup>2</sup>=.00</b>
Chronic Family Loneliness	.18	-.33	-.46	.65
Chronic Social Loneliness	.24*	-.03	-.46	.64
Chronic Romantic Loneliness	.11	.00	.11	.91

*Note.*<sup>1</sup> Lower BRIEF-A scores indicate higher levels of self-reported executive function.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

The second model as proposed by DiTommaso and colleagues (2015), suggested that EF may be predictive of transient loneliness, which, in turn, could predict chronic loneliness. Six hierarchical multiple regressions ( $\alpha = .01$ ) were conducted to predict the three facets of chronic loneliness (family, social, and romantic). In each regression, age and gender were entered in Block 1, followed by personality and attachment in Block 2, EF performance-based measures (i.e., Tower Test, Color-Word Interference Test, and Trail-Making Test) in Block 3, and transient loneliness on the last step (see Table 11). In addition, following the same step process, three additional regressions were conducted with total self-report EF scores entered on the third step (see Table 12). All of these regression models were statistically significant; however, in all cases, the only significant predictor of chronic loneliness was transient loneliness.

**Table 11**

*Regression predicting Chronic Loneliness scores using D-KEFS primary measurement scores from the Tower Test, Color-Word Interference Test, and the Trail-Making Test.*

	Chronic Family Loneliness		Chronic Social Loneliness		Chronic Romantic Loneliness	
	$\beta$	$t(p)$	$\beta$	$t(p)$	$B$	$t(p)$
<i>STEP 1</i>		$R^2=.01$		$R^2=.01$		$R^2=.01$
Age	-11.	-.97 (.33)	-.03	-.25(.79)	-.11	-.96 (.33)
Gender	-.05	-.42 (.67)	.01	.13(.89)	.06	.53 (.59)
<i>STEP 2</i>		$\Delta R^2=.11$		$\Delta R^2=.31$		$\Delta R^2=.16$
Openness	.08	.69 (.49)	.08	.77 (.44)	.19	1.67 (.09)
Conscientiousness	-.02	-.20 (.84)	.07	.68 (.49)	-.01	-.10 (.92)
Extraversion	-.02	-.15 (.87)	-.21	-1.84 (.07)	-.14	-1.08 (.28)
Agreeableness	-.11	-.85 (.39)	-.05	-.41 (.69)	-.02	-.13 (.89)
Neuroticism	.19	1.07 (.28)	.35	2.17 (.03)	-.09	.57 (.57)
Avoidance	.13	1.12 (.27)	.008	.08 (.93)	.15	1.36 (.18)
Anxiety	.06	.45 (.65)	.21	1.70 (.09)	.35	2.60 (.01)
<i>STEP 3</i>		$\Delta R^2=.06$		$\Delta R^2=.03$		$\Delta R^2=.01$
CWIT Condition 3 <sup>1</sup>	-.12	-.91 (.37)	-.13	-1.14 (.26)	-.14	-1.07 (.29)
TMT Condition 4 <sup>2</sup>	-.19	-1.44(.15)	.16	1.31(.19)	.07	.57(.57)
Tower Test Total <sup>3</sup>	.04	.34(.74)	-.12	-1.08(.28)	.05	.40(.69)
<i>STEP 4</i>		$\Delta R^2=.26$		$\Delta R^2=.28$		$\Delta R^2=.38$
Transient Family Loneliness	.62	5.68(.0001)				
Transient Social Loneliness			.69	7.02(.0001)		
Transient Romantic Loneliness					.72	8.00(.0001)

*Note.* Color-Word Interference Test – Condition 3: Completion Time Scaled<sup>1</sup>; Trail-Making Test- Condition 4: Completion Time Scaled<sup>2</sup>; Tower Test – Total Achievement Score Scaled<sup>3</sup>.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

**Table 12**

*Hierarchical Multiple Regression predicting Chronic Loneliness scores using BRIEF-A total scores.*

	Chronic Family Loneliness			Chronic Social Loneliness			Chronic Romantic Loneliness		
	<i>r</i>	<i>B</i>	<i>t</i> ( <i>p</i> )	<i>r</i>	$\beta$	<i>t</i> ( <i>p</i> )	<i>r</i>	$\beta$	<i>t</i> ( <i>p</i> )
<i>STEP 1</i>			R <sup>2</sup> =.01			R <sup>2</sup> =.01			R <sup>2</sup> =.01
Age	.10	-.11	-.97(.33)	-.31	-.03	-.25(.79)	.11	-.10	-.96(.33)
Gender	-.03	-.05	-.42(.67)	.02	.01	.13(.89)	.07	.06	.53 (.59)
<i>STEP 2</i>			$\Delta$ R <sup>2</sup> =.11			$\Delta$ R <sup>2</sup> =.31			$\Delta$ R <sup>2</sup> =.16
O <sup>1</sup>	.04	.08	.69(.49)	-.06	.08	.77(.44)	.16	.19	1.67 (.09)
C <sup>2</sup>	-.11	-.02	-.20(.84)	-.10	.07	.68(.49)	.00	-.01	-.10 (.92)
E <sup>3</sup>	-.10	-.02	-.15(.87)	-.35**	-.21	-1.84(.07)	-.10	-.14	-1.08(.28)
A <sup>4</sup>	-.23*	-.11	-.85(.39)	-.25*	-.05	-.41(.69)	-.12	-.02	-.13(.89)
N <sup>5</sup>	.29**	.19	1.07(.28)	.45**	.35	2.17(.03)	.13	-.09	.57 (.57)
Avoidance	.17	.13	1.12(.27)	.09	.00	.08(.93)	.17	.15	1.36 (.18)
Anxiety	.22*	.06	.45(.65)	.39**	.21	1.70(.09)	.34**	.35	2.60(.01)
<i>STEP 3</i>			$\Delta$ R <sup>2</sup> =.00			$\Delta$ R <sup>2</sup> =.00			$\Delta$ R <sup>2</sup> =.00
GEC <sup>6</sup>	.18	-.16	-.75(.46)	.24*	-.15	-.75(.46)	.11	-.00	-.006 (.99)
<i>STEP 4</i>			$\Delta$ R <sup>2</sup> =.25			$\Delta$ R <sup>2</sup> =.30			$\Delta$ R <sup>2</sup> =.38
TL-Fam <sup>7</sup>	.58**	.60	5.29(.00)	.53**			.19		
TL-Soc <sup>8</sup>	.32**			.77**	.70	7.48(.00)	.21		
TL-Rom <sup>9</sup>	.08			.31**			.73**	.70	7.81(.00)

Note. Openness to experience<sup>1</sup>, Conscientiousness<sup>2</sup>, Extraversion<sup>3</sup>, Agreeableness<sup>4</sup>, Neuroticism<sup>5</sup>, Global Executive Composite score from the BRIEF-A<sup>6</sup>, Transient Family Loneliness<sup>7</sup>, Transient Social Loneliness<sup>8</sup>, and Transient Romantic Loneliness<sup>9</sup>.

\*\**p*<.01

\**p*<.05 is included for information purposes only, the alpha level in the current study is *p*=.01.

### 3.5 Supplementary Analyses

Contrary to hypotheses, the regressions conducted to test the two competing models (Diamond, 2013; DiTommaso et al., 2015) suggest that there is no relation between chronic loneliness and EF. Overall, it appears that the best predictor of chronic loneliness is transient loneliness. In spite of this, correlational analyses indicated an association between loneliness and self-report EF (see Table 13) warranting further exploration. To further explore possible relations between the variables, total scores for SELSA-S transient loneliness (SELSA-T), SELSA-S chronic loneliness (SELSA-C), and a total Loneliness Burden (SELSA-LB) score were calculated<sup>1</sup>. Total Loneliness Burden was calculated by summing the six original SELSA-S subscale scores and this variable encompasses all social realms associated with levels of chronic and transient loneliness. The Cronbach's alpha levels were all high (i.e., SELSA-T,  $\alpha = .87$ ; SELSA-C,  $\alpha = .86$ ; SELSA-LB,  $\alpha = .93$ ), indicating that the three scales were reliable measures of loneliness

Exploratory Pearson  $r$  correlations were conducted to examine the association between these new loneliness scores and facets of the BRIEF-A. There were statistically significant positive correlations between SELSA-T and EF self-report subscales (with the exceptions of Inhibition, Working Memory, and Organization of Materials). The relation between chronic loneliness and EF was less consistent; however, SELSA-LB scores were consistently associated with BRIEF-A subscale scores (see Table 13). Because SELSA-LB scores were able to account for both types of loneliness, the competing models were

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<sup>1</sup> This decision was made in consultation with the creator of the scale (Personal Communication, DiTommaso, 2018).

retested using LB scores, therefore eliminating transient loneliness as a predictor of chronic loneliness.

**Table 13**

*Pearson r correlations between total SELSA-S transient, chronic, and loneliness burden scores and BRIEF-A EF scales.*

	SELSA-T	SELSA-C	SELSA-LB
<b>BRIEF-A Scales</b>			
Inhibition	.25*	.18	.23*
Set-Shifting	<b>.30**</b>	.26*	<b>.30**</b>
Emotional Control	<b>.43**</b>	.28*	<b>.39**</b>
Self-Monitoring	<b>.38**</b>	.26*	<b>.35**</b>
Initiation	<b>.47**</b>	.27*	<b>.41**</b>
Working Memory	.26*	.20	.25*
Planning	<b>.28**</b>	.10	.21
Task-Monitoring	<b>.31**</b>	.10	.23*
Organization <sup>1</sup>	.07	-.07	.00
BRI <sup>2</sup>	<b>.44**</b>	<b>.31**</b>	<b>.40**</b>
MCI <sup>3</sup>	<b>.33**</b>	.14	<b>.26**</b>
Global Composite	<b>.42**</b>	.24*	<b>.36**</b>

*Note.*<sup>1</sup> Organization of Materials; <sup>2</sup> Behavioural Index; <sup>3</sup> Metacognitive Index.

Lower BRIEF-A scores indicate higher levels of self-reported executive function.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

Two hierarchical multiple regression analyses were conducted to further explore the competing models. In the first regression, SELSA-LB was predicted. Age and gender were entered in Block 1, followed by personality and attachment (i.e., to account for relatively stable factors contributing to loneliness in Block 2), and total BRIEF-A EF scores were entered in Block 3. Although the overall model was statistically significant ( $F(10, 71) = 4.83$ ,  $p < .0001$ ) and accounted for 40.5% of the variance in SELSA-LB, attachment anxiety emerged as the sole predictor ( $\beta = .31$ ;  $t(p < .01) = 2.61$ ). The second regression was conducted by entering age and gender in Block 1, followed by personality and attachment in Block 2, and finally LB on the third and final step, to predict total EF scores. Similarly, SELSA-LB did not predict EF over and above stable factors, though the overall model was statistically significant, ( $F(10, 71) = 21.07$ ,  $p < .0001$ ). That is, 74.8% of the variability in EF was predicted by personality: Neuroticism ( $\beta = .27$ ;  $t(p < .01) = 2.79$ ) and Conscientiousness ( $\beta = -.61$ ;  $t(p < .0001) = -9.09$ ).

#### **4.0 Discussion**

The current study sought to test two competing models of EF and loneliness, with the overall goal of determining specific predictors of these psychological variables. In addition, replication hypotheses and unique hypotheses were formed to test the associations between these constructs and other relevant factors. All replication and unique hypotheses were partially confirmed (see Table 14); however, further research should be conducted to explore different components of the competing models. Overall, the findings indicate that there is a relationship between loneliness, EF, personality, and attachment.

## 4.1 Correlational Analyses

**Table 14**

*Replication and Unique Hypotheses confirmations assessed using Pearson r correlations.*

Hypotheses	Association/Result
<b>Replications</b>	
↑ Avoidant or anxious attachment was expected to be associated with ↑ scores on Neuroticism factor and facets.	↑ Anxious attachment = ↑ Neuroticism
↑ Avoidant or anxious attachment was expected to be associated with ↑ chronic loneliness.	↑ Chronic loneliness = ↑ Anxious attachment
↑ Overall loneliness was expected to be associated with ↑ scores on the Neuroticism factor and facets, and ↓ scores on Openness, Agreeableness, and Extraversion factors and facets.	↑ Loneliness = ↑ Factor N, ↓ E, ↓ A, ↓ C
↑ Openness was expected to be associated with ↑ <i>performance</i> on set-shifting tasks, and ↑ EF composite.	↑ O = ↑ <i>self-report</i> set- shifting
↑ Agreeableness was expected to be associated with ↑ <i>performance</i> on inhibition and set-shifting tasks, and ↑ EF composite.	↑ A = ↑ <i>self-report</i> EF scales.
<b>Unique</b>	
↑ Secure attachment was expected to be associated with ↑ <i>performance</i> on EF inhibition, set-shifting, working memory, and planning.	↑ Secure attachment = ↑ <i>self-report</i> Set-shifting, WM, and planning
↑ Chronic loneliness was expected to be associated with ↓ <i>performance</i> on EF inhibition, set-shifting, working memory, and planning.	↑ Chronic social loneliness = ↓ <i>self- report</i> set-shifting
↑ Conscientiousness was expected to be associated with ↑ <i>performance</i> on EF inhibition, set-shifting, working memory, and planning.	↑ Cs = ↑ <i>self-report</i> EF scales.
↑ Extraversion was expected to be associated with ↑ <i>performance</i> on working memory tasks and EF composite.	Not confirmed
↑ Neuroticism was expected to be associated with ↓ <i>performance</i> on EF inhibition, set-shifting, working memory, and planning, and a ↓ EF composite.	↑ N = ↓ <i>self-report</i> EF scales.

## 4.2 Executive Function Measurement

### 4.2.2 Performance-based versus self-report measurements of Executive

**Function.** In the current study, the measurement of EF was conducted in two ways: using performance-based tests (D-KEFS) and self-report questionnaires (BRIEF-A). Previous researchers have reported few statistically significant correlations between BRIEF-A and D-KEFS scores (Nęcka, Lech, Sobczyk, & Śmieha, 2012) and these results were replicated. In the current study, correlations between corresponding EF scales on the D-KEFS and BRIEF-A not statistically significant.

The current results support the idea that the D-KEFS and the BRIEF-A are measuring different concepts or different aspects of EF. The BRIEF-A measures an individual's perception of their EF and the D-KEFS measures reaction time and accuracy in a laboratory setting. It is likely that neither is an accurate reflection of how an individual engages in real-life situations (Salthouse & Ferrer-Caja, 2003). Thus, it is difficult to speculate on the best method of EF assessment; further research is required to assess the difference between an individual's perception of their EF and their actual task performance. It is possible that overall global EF may be best conceptualized as a composite of performance-based and self-report measures. The current results highlight that additional investigations to assess the difference between an individual's perception of their EF and their actual task performance are required.

One of the early and key steps in the research process is the development of operational definitions (i.e., the process of defining how a phenomena is described, observed, and measured in research; Phillips, 1968) to ensure appropriate measurement across studies. In science, different operational definitions can be used to describe a

single process. For example, in this and other studies, EF is often defined in one of two ways: (1) self-report questionnaire responses; and, (2) performance-based measures (i.e., reaction time, accuracy). Although researchers often assume that they are measuring the same construct (EF), the null correlations are problematic and suggest that the tests are tapping into different underlying constructs. The impurity problem of EF measurement provides a partial explanation for the lack of correspondence. The impurity problem focuses on the likelihood that tasks designed to measure EF processes could also measure other cognitive processes (Miyake & Friedman, 2012). Performance-based tests are more likely to be affected by impurity; for example, the Stroop test of inhibition rests on the speed of a response, which is also affected by reading ability (Miyake & Friedman, 2012). Self-report inventories are affected by impurity to a lesser degree and these differences could account for the lack of association between the tests. These results highlight the importance of clearly defining psychological variables and interpreting results with these definitions in mind.

### **4.3 Loneliness Burden**

Individuals who are lonely (transient or chronic unspecified) often report lower perceived levels of social support and higher stress than their non-lonely counterparts (Cacioppo et al., 2000; Crick & Ladd, 1993). Regardless of the expectation that transient loneliness can be differentiated from chronic loneliness, the ability of participants to assess the two types of loneliness in their lives is questionable. For example, if an individual is in a current state of transient loneliness, he or she may be more likely to assume that they always have and will feel lonely. Given that transient loneliness is often situation-specific, it may be difficult for individuals to distinguish between their current

and past feelings of loneliness. When individuals are not lonely they may be able to look back on situations and perhaps parse apart transient loneliness from the more long-lasting, chronic loneliness. It is possible that although chronically lonely individuals recognize that these are separate circumstances, transiently lonely individuals may not distinguish their current loneliness from past loneliness. If this is the case, the SELSA-S scores may actually be more reflective of transient loneliness than chronic loneliness.

As it is generally accepted that loneliness is multidimensional (DiTommaso & Spinner, 1997; Hoza, Bukowski, & Beery, 2000), measurement of either chronic or transient loneliness on the SELSA-S varies on time (i.e., two weeks vs. two years), which may be confounded by memory. Further, measures of loneliness may fail to truly capture the division between transient and chronic loneliness (Heinrich & Gullone, 2006; Marangoni & Ickes, 1989). Thus, it may be beneficial to combine these scores into a single Loneliness Burden scale that includes aspects of both transient and chronic loneliness.

Regression analyses to assess competing models of EF and loneliness were conducted and despite statistically significant correlations (see Table 14), these analyses ultimately suggested a lack of predictability between self-report EF and loneliness (see Table 15). After careful consideration of these results and based on discussions with the creator of the SELSA-S, a total SELSA-S score was created (Loneliness Burden). Chronic and transient loneliness are by definition symbiotic and, therefore, combining them to further examine the relationship loneliness has with EF was justified. Competing models were tested using the new criterion variable. When self-report EF was the criterion variable, the only significant predictors were personality variables. When

loneliness burden was the criterion variable, attachment anxiety emerged as the best predictor, accounting for 40.5% of the variability. In the previous models predicting chronic loneliness, variability contributed by transient loneliness ranged from 25 to 38 percent and was the only contributing predictor to chronic loneliness scores (excluding Neuroticism for chronic social loneliness; see Table 12).

**Table 15***Regression hypotheses: Competing model confirmations.*

Hypotheses	Result
<b>Predicting Chronic Loneliness</b>	
It was expected lower levels of EF performance and transient loneliness would predict chronic loneliness over and above personality and attachment.	Only transient loneliness was a significant predictor
It was expected lower levels of EF self-report and transient loneliness would predict chronic loneliness over and above personality and attachment.	Only transient loneliness was a significant predictor
<b>Predicting Executive Function</b>	
It was expected levels of loneliness would predict performance on EF performance measures over and above personality and attachment.	Not confirmed
It was expected levels of loneliness would predict performance on EF self-report measures over and above personality and attachment.	Not confirmed <sup>1</sup> .

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*Note.* <sup>1</sup>Not confirmed does not mean the Model was not significant.

**4.5 Self-reported EF or self-reported personality?** Costa and McCrae (1985; 1992) defined Conscientiousness as the personality trait composed of organization and diligence. The relationship between Conscientiousness and EF may be one of the most interesting findings in the current study. Murdock and colleagues (2013) proposed that, in theory, Conscientiousness is related to EF processes. The current results demonstrated robust positive associations between self-report EF processes and Conscientiousness and facets (see Table 10), such that higher scores on Conscientiousness were related to higher levels of self-report EF. Similar associations among Conscientiousness and self-report EF were reported Buchanan (2016).

Although Conscientiousness and self-report EF did not emerge as significant predictors of chronic loneliness, it is important to note that there may be issues with multicollinearity when these three variables are entered as predictors. Hair, Black, Babin, and Anderson (2010) defined multicollinearity as the degree of correlation between independent variables (i.e., predictors) and it occurs when variables are too highly correlated (0.8 or higher is typically problematic; Allison, 1999; Cooper & Schindler, 2003). It is interesting to note the similarities between questions posed on the BRIEF-A and the NEO-PI-R. Pearson  $r$  correlations were conducted between all individual questions measuring Neuroticism and Conscientiousness and all BRIEF-A questions (see Table 16). Moderate to strong correlations were found between all BRIEF-A questions and these personality factors.

**Table 16***Correlations between selected NEO-PI-R and BRIEF-A items.*

Conscientiousness and Neuroticism	Self-report EF	<i>r</i>
N1: Anxiety: <i>"I often worry about things that might go wrong"</i>	Set-shifting: <i>"After having a problem I don't get over it easily"</i>	.52**
C1: Competence: <i>"I am efficient and effective at my work"</i>	Inhibition: <i>"I rush through things"</i>	-.48**
N2: Anger-Hostility: <i>"I am known as hot-blooded and quick tempered"</i>	Emotional Control: <i>"I have angry outbursts"</i>	.69**
C2: Order: <i>"I never seem to be able to get organized"</i> <sup>Я</sup>	Task-Monitoring: <i>"People say I am disorganized."</i>	-.61**
N3: Depression: <i>"I am seldom sad or depressed"</i> <sup>Я</sup>	Set-shifting: <i>"My mood changes frequently"</i>	.58**
C3: Dutifulness: <i>"Sometimes I am not as dependable or reliable as I should be"</i> <sup>Я</sup>	Initiate: <i>"I have a short attention span".</i>	-.48**
N4: Self-Consciousness: <i>"I feel I am capable of coping with most of my problems"</i>	Working Memory: <i>"I have trouble remembering things even for a few minutes (such as directions, phone number)"</i>	.46**
C4: Achievement-striving: <i>"I have a clear set of goals and work toward them in an orderly fashion."</i>	Inhibition: <i>"I rush through things."</i>	-.47**
N5: Impulsivity: <i>"I have trouble resisting my cravings"</i>	Emotional Control: <i>"I don't think about consequences before doing something"</i>	.58**
C5: Self-discipline: <i>"I have a lot of self-discipline"</i>	Initiate: <i>"I lie around the house a lot"</i>	-.55**
N6: Vulnerability: <i>"When everything goes wrong, I can still make good decisions"</i> <sup>Я</sup>	Emotional Control: <i>"I have emotional outbursts for little reason"</i>	.66**
C6: Deliberation: <i>"I think things through before coming to a decision"</i>	Emotional Control: <i>"People say that I don't think before acting"</i>	-.61**

Note. <sup>Я</sup> Item is reverse scored. Lower BRIEF-A scores indicate higher levels of self-reported executive function.

\*\*p<.01

Diamond (2013) defined metacognitive EFs as processes activated when attention and concentration are required whereas behavioural EFs involve satisfying urges in accordance with what is deemed socially acceptable (i.e., accomplishing goals without emotional disturbances). The composite MCI score encompasses cognitive abilities involved in the processes of initiation, working memory, planning, task-monitoring, and organization of materials. MCI tasks are mental tasks that involve organizing and evaluating information. On the other hand, the BRI composite involves motor action and consists of inhibition, set-shifting, and self-monitoring. Individuals with high BRI scores are able to initiate, change, and inhibit their actions.

The current results highlight the relation between questions posed on the BRIEF-A and questions measuring Neuroticism and Conscientiousness on the NEO-PI-R. For this reason, correlational analyses were conducted to examine the relation between these personality factors and the two EF indexes (i.e., BRI and MCI) that form the global composite score of EF. An examination of the associations between personality and the BRI and MCI scores indicated that Conscientiousness and Neuroticism reflected opposing aspects of self-report EF. Conscientiousness was strongly associated with MCI scores and Neuroticism was strongly related to BRI (see Tables 8 & 9). Taken together, it appears that the BRIEF-A is really measuring aspects of personality; that is, individuals' differences in personality also may be reflected in how individuals perceive their EFs.

#### **4.6 Future Models for Predicting Loneliness**

**4.6.1 Controlling for Conscientiousness and Neuroticism.** Both correlational and regression analyses indicated that there was little relation between loneliness and EF (performance-based and self-report). Nonetheless, the similarities between the BRIEF-A

composite scores and personality (specifically, Neuroticism and Conscientiousness) prompted further analysis. Partial correlations were conducted to control the effects of personality. When Conscientiousness and Neuroticism were controlled, there were no statistically significant associations between BRIEF-A loneliness scores (see Appendix K). This is contradictory to the original analyses (see Tables 7 & 14). Although these results need to be examined in further detail, it appears that the BRIEF-A is measuring, at least in part, these two personality factors.

It is interesting to note that, even when Conscientiousness and Neuroticism were controlled, transient loneliness was significantly and positively associated with self-report scores on the Initiation ( $p < .01$ ) and Task-Monitoring subscales (for discussion purposes,  $p < .05$ ). Thus, these subscales may be capturing an aspect of self-report EF that is not explained by levels of conscientiousness and neuroticism. These partial correlations demonstrate a relationship between two EFs and loneliness that was not previously hypothesized and warrants further study. Thus, mediation (i.e., a variable that explains a relationship between other variables) or moderation (i.e., a variable that influences the strength of the relationship between other variables; Baron & Kenny, 1986) models are possible and should be explored.

**4.6.2.1 Task-Monitoring.** Task-monitoring (commonly referred to as multi-tasking or task-switching; Diamond, 2013) is the performance of simultaneous tasks that each has its own unique stimuli and response associations (i.e., studying while listening to the news; Meyer & Kieras, 1997). Meyer and Kieras postulated that an individual's ability to task-monitor appropriately depends on how information-processing is coordinated across various tasks. Furthermore, it appears that the majority of people are

not good at multitasking. Research has demonstrated that unless an individual is a part of a small group of “supertaskers”, task-switching with a cellphone while driving significantly increases the risk of an accident (Strayer, Drews, & Crouch, 2006; Strayer & Drews, 2007; Strayer; Watson, & Drews, 2011).

Recent studies examining media multitasking have suggested that participants who engage in social media-related activities parallel to actual social interaction (e.g., posting on and checking Instagram during dinner with friends) report lower levels of social success (Xu, Wang, & David, 2016). Peper and Harvey (2018) suggested that digital addiction may be associated with higher levels of loneliness. Furthermore, research has found that higher levels of loneliness and more frequent social media use are predictive of lower levels of life satisfaction (Flood, Best, & DiTommaso, 2018). Although the current literature focuses on different media-related tasks, additional research is required in order to examine the overall relation between loneliness and task-monitoring.

**4.6.2.2 Initiation.** Initiation refers to the *commencement* of responses (Suchy, 2009) and is defined as the length of time it takes an individual to respond to a situation relative to their goal (i.e., the time it takes for an individual to begin a task that has been presented to them). Suchy suggested that initiation is the first step in a goal-oriented response pattern and is the first step necessary for the attainment of a specific goal. Lower scores on initiation tasks have been associated with procrastination (Rabin, Fogel, & Nutter-Upham, 2011). Additionally, individuals with initiation problems typically want to succeed but require additional cues/prompts in order to focus on their goals (Roth et al., 2005). Although there is little research on the possible social associations with

individual differences in initiation, it is possible that transient loneliness may involve difficulties with task initiation. Thus, an individual who is lonely may not be able to focus on a new goal or task, despite the potential benefits of a new distraction. Issues with task-monitoring and initiation during stressful situations may be associated with an individual's coping strategies, and future research should consider coping flexibility in addition to these EFs and loneliness.

**4.6.3 Coping Flexibility?** Coping is the strategy humans employ to regulate negative emotions (Gross & Thompson, 2007). The coping process involves cognitive appraisal, which is defined by an individual's assessment of a stressful event as challenging or threatening (Lazarus & Folkman, 1984). Coping changes as one encounters different stressful events; this change in coping is referred to as coping flexibility (Lazarus, 1999). More specifically, coping flexibility is an individual's ability to employ a different strategy once it becomes apparent that the previous strategy is ineffective (Kato, 2012).

Previous research has suggested that lonely individuals adopt sad and passive strategies in response to their loneliness (e.g., crying, sleeping, overeating, substance use), rather than confronting the issue (Cacioppo et al., 2000; Moore & Schultz, 1983; Rubenstein & Shaver, 1980; Van Buskirk & Duke, 1991). In social environments, these strategies may be reflected in the way that a chronically lonely individual interacts with others. Van Buskirk and Duke (1991) reported positive associations between individuals with higher levels of inflexible coping strategies and loneliness. The same study suggested that individuals who reported lower levels of loneliness recognized these strategies as maladaptive, whereas those who reported higher levels did not, thus

exacerbating their situation. The association between EF task-monitoring and initiation processes and loneliness may be moderated by an individual's coping flexibility. That is, an individual with poor coping flexibility may be less likely to engage in initiation because they feel they lack the capacity to navigate stressful situations. Taken together, future research should consider a model of coping flexibility, loneliness, and EF (with measurement considered).

#### **4.6.4 Performance-based measurement: Initiation and Task-monitoring.**

Because of time constraints, only three D-KEFS tests were administered to measure working memory: planning, inhibition, and set-shifting. Thus, it may be interesting to examine the relation between loneliness and performance-based initiation and task-monitoring. Furthermore, given the relation demonstrated by the partial correlations (see Appendix K), it may also be interesting to examine whether or not these BRIEF-A subscales are capturing a part of EF also captured by the D-KEFS. It should be noted that in the Tower Test, the Mean-First-Move Time captures the average amount of time it takes an individual to begin each task on the test. It is typically used as a measure of planning but may capture an initiation score as well. Correlational analyses were conducted between the Mean-First-Move time, loneliness, and the BRIEF-A Initiation subscale, and there were no significant relations. Nonetheless, as Mean-First-Move time is not a primary measure of initiation, future research using performance-based measures should employ the D-KEFS Design Fluency Test (a measure of both initiation and task-monitoring; Delis et al., 2001) to further explore this relation between EF and transient loneliness.

## **4.7 Strengths and Limitations of the Current Study**

### **4.7.1 Strengths**

**4.7.1.1 Age and Gender.** In spite of the lack of correspondence between the difference EF measures, the present study had many strengths. The sample was demographically diverse, with participants ranging in age from 18 to 64 years. As age is perhaps one of the best markers of individual differences in EF, this diversity is important. Throughout childhood and adolescence the prefrontal cortex is still maturing (Tsujiimoto, 2008) and EF development often parallels the neurophysiological developments in this and other brain areas (Anderson, 2002). Specifically, as the processing abilities of neural areas mature, the principal EFs start to appear (Anderson, 2002). These EFs, in turn, form the basis for the evolution of other more intricate functions that are still intermittently developing until early adulthood (Anderson, Anderson, Jacobs, & Smith, 2010). Later in adulthood, EFs begin to decline at different rates (De Luca & Leventer, 2008). There were no significant differences between age groups in the current study. Nonetheless, mean trends demonstrated a slight decline of global executive composite scores over time, suggesting that this may be a key factor in EF research, and may vary more within a larger sample.

The current study was conducted using both university students and members of the general public. The inclusion of participants from the general public help ensure that the sample is representative of the non-clinical population in New Brunswick. It is often difficult to compare males and females in psychological research because females are more likely to volunteer to participate in research, resulting in a disproportionate number of females in research samples. Further, at UNB Saint John, approximately 70% of

introductory psychology students are female and the trend of increased female participation in past departmental research studies (e.g., Fowler, 2017; Gaudet, 2017) curtails research on gender differences. In the current study, males were more actively recruited, which increased the participation rate of males to 37.8% of the present sample, allowing for a fairly reasonable gender split. Although gender was entered into Block 1 for all competing model regression equations, it did not add significantly to any of the models. Independent sample t-tests comparing mean scores of males and females revealed almost no mean differences on principal study variables. The current research replicates past findings that females reported lower levels of emotional control than males and higher levels of Neuroticism than males (Costa Jr, Terracciano, & McCrae, 2001; Flood, Ciszewski, & Best, 2015).

**4.7.1.2 Relatively representative of New Brunswick's general population.** The present sample was diverse; in 2013-2014, 9.7% of the population in New Brunswick (New Brunswick Department of Health, 2016) reported being diagnosed with a psychological disorder. Given the growing trend of mental health awareness, the Department of Health (2016) estimated that these numbers will steadily increase. In the present study, 26.9% of participants reported a diagnosed mental health issue, which is likely indicative of this growing number of psychological diagnoses in the province. Similarly, the provincial physical disability average (17.2%; Statistics Canada, 2008) is virtually identical to that reported in the current study, as 17.1% of participants reported some kind of physical ailment (including chronic migraines and concussions). The majority of the current participants were either employed or in school implying that serious debilitations are likely minimal, considering provincial statistics are largely

drawn from those seeking social assistance for disability stipends (Premier's Council on the Status of Disabled Persons, 2008).

#### **4.7.2 Limitations**

**4.7.2.1 Small sample size.** Although power analyses were conducted to determine the number of participants necessary to conduct statistical analyses associated with the primary hypotheses of the study, the small sample size is a limitation. Post-hoc power analyses using observed effect sizes and G\*Power Statistical Software (Faul, Erdfelder, Lang, & Buchner, 2007) suggested that analyses were adequately powered for all competing model regressions at 0.86, for observing moderate effects ( $f^2=0.25$ ). Given that the tripartite of loneliness (i.e., social, romantic, and family loneliness scales) requires 3 subscales to be tested separately and the current study used both measures of EF, examining only moderate effects was deemed appropriate as this study contained a large number of predictors. Future research would require larger sample sizes to capture smaller effects. Given the time constraints on the present study this was not possible as each participant was individually tested for a 2-hour time period.

#### **4.7.2.2 Administration of BRIEF-A and D-KEFS for comparison purposes.**

Despite comparisons of both BRIEF-A and D-KEFS noted above (see Appendix J), it is important to note that the entire D-KEFS battery was not used in the current study. The D-KEFS consists of 9 tests of EF performance (Delis et al., 2001), and therefore it is unlikely that the current study was able to capture the true association between these performance-based tests and self-report EF. As noted above, it may be valuable to conduct a study using the entire D-KEFS battery, in order to compare to other self-reported EFs (e.g., task-monitoring and initiation).

## 4.8 Future Directions.

**4.8.1. EF Measurement Explored.** The results of the present study point to some interesting issues with psychological measurement techniques. The BRIEF-A, in particular, may need to be studied in conjunction with the D-KEFS and other performance-based measures. The variance shared with the NEO-PI-R personality variables and the BRIEF-A subscale scores should be examined further. In the past, researchers have highlighted issues with the lack of correlation between performance-based and self-report measures of EF (e.g., Nęcka et al., 2011; Toplak, et al. 2013). The current study expands these findings and suggests that self-report EF may be tapping into certain personality factors (i.e., Neuroticism and Conscientiousness), necessitating future research between self-report EF and the FFM as well as performance-based testing.

The association between personality and self-report EF needs to be parsed apart. If measures like the BRIEF-A are truly measuring aspects of Neuroticism and Conscientiousness, it is important to test other self-report EF questionnaires to see if they can capture something similar to what is being found using performance-based testing. In the future it may be valuable to create a measure of EF that employs both performance-based and self-report techniques, while accounting for personality. Although this method may be time-consuming, if the appropriate measurement and operationalization of EF does not occur, it will be difficult to interpret and draw inferences based on research data.

**4.8.2 Self-Discipline and Set-Shifting.** Finally, there are some results that were statistically significant at the  $p < .05$  level that may be worth exploring in future research. In the current study, there was a negative relation ( $p < .05$ ) level between the Self-discipline facet of Conscientiousness and performance on the D-KEFS Trail-Making

Test, which is a measure of set-shifting. That is, it may be that better performance-based set-shifting is associated with lower levels of Self-discipline. Interestingly, this facet was significantly associated with higher self-reported set-shifting (see Table 8). Although this result may be indicative of a measurement issue, it is also possible that individuals with higher levels of self-discipline are less adaptive to fluid situations. A recent study demonstrated that individuals high on the Self-discipline facet perform better within the realms of “self-made” regularity (Loya, Gopal, Shukla, Jermann, & Tormey, 2015). Specifically, Loya et al.’s results demonstrated that even in independent online courses, individuals high in self-discipline outperformed others because they signed on and completed work at approximately the same time each week. It may be that set-shifting is difficult for these individuals because it presents as a distraction from the task at hand.

**4.8.3. Focus on Aging.** Although the complex interplay between cognitive function and psychosocial factors such as loneliness is important at all life stages, it may become more relevant as individuals age. In the future, it may be beneficial to study a restricted age range of older individuals who are perhaps more likely to be experiencing difficulties in both areas. In the current study, although there was a small (but not statistically significant) decline in EF in the oldest group of participants, there was no association between age and loneliness. These results warrant further examination. These individual differences and situations should be examined given the increasingly aging population and the lack of resources to deal with this demographic group.

Research on elderly individuals has suggested that initiation response time predicts independence in everyday activities (Cahn-Weiner, Boyle, & Malloy, 2002). If initiation processes are related to loneliness as the partial correlations suggest, it is

possible that an individual who is not lonely possesses a protective factor for independence later in life. In addition, Anguera and colleagues (2013) also found that older adults willing to participate in “effortful” video gaming were more likely to have increased task-monitoring scores and greater overall EF than participants who chose not to partake. Thus, engaging in tasks (social activities included) may have positive implications for declines in EF related to aging. It is important to fully explore the associations between these EFs and loneliness as they may be protective in later life.

### **5.0 Implications of the Current Research**

The present results are conducive to the understanding of individual differences in EF and demonstrate the importance of examining psychosocial factors that potentially influence the ability to engage effectively in higher order cognitive functioning. Statistics Canada (2010) estimates that by 2051 approximately 1 in 4 Canadians will be over the age of 65. Given that general cognitive decline generally begins as individuals near the age of 60 (Baltes & Lindenberger, 1997) and 40% of adults over the age of 65 report increased levels of loneliness (Berguno, et al., 2004), understanding the risk factors facing this population is imperative moving forward. Previous research using larger samples indicates that the age-related decline of EF and increased loneliness occur simultaneously (Baltes & Lindenberger, 1997; Berguno, et al., 2004).

Furthermore, research has consistently suggested that there are serious health risks associated with poor EF and increased loneliness. EF and certain personality traits could be indicators of early onset Alzheimer’s disease (Storandt, 2008) and there is some evidence to suggest that increased engagement in EF processes throughout the lifespan may delay the onset of decline (Craik & Bialystok, 2006). Similarly, loneliness has been

associated with cardiac issues, trouble sleeping, and substance abuse (Cacioppo et al., 2002).

If researchers can identify situational variables such as loneliness and encourage individuals to engage in activities that stimulate EF, it may be possible to delay the onset of EF decline through a specified target-training initiative. The specific relations between relatively stable factors (i.e., personality, attachment, EF) and environmental circumstances (i.e., transient and chronic loneliness) were explored in the current study and provided at least a glimpse into the relationship between these variables. Although EF was not predictive of loneliness in the current study, there was a possible relation found between loneliness and two EFs (task-monitoring and initiation) that has not been explored previously.

## 6.0 Conclusion

Loneliness is becoming an increasingly prevalent issue and, almost daily, news outlets around the world are publishing articles warning the public about the risks of a lonely existence (e.g., *Why loneliness can be as unhealthy as smoking 15 cigarettes a day*, (Birak & Cuttler, 2017); *All the lonely people: Epidemic of loneliness is leading to chronic health problems* (O’Callaghan, 2018); *Loneliness can actually hurt your heart. Here’s Why* (Ducharme, 2018). Evidently, the public in Western countries appears to be legitimately worried about the consequences of loneliness. The rate at which the population in Western countries is currently aging also is a prevalent issue (e.g., *Millennials struggling to care for aging baby boomer parents call for better paid leave* [Abrams, 2018]; *Are baby boomers about to crash long-term care?*, [Krantz, 2018]). Clearly, studies such as this one can have strong implications for the future of the baby

boomer generation and beyond. If researchers work to operationalize these factors and measure them appropriately, than perhaps the wave of incoming aging issues (loneliness and EF decline among them) could be attenuated. That is, a more in-depth understanding of the nature of these associations may provide information that researchers can use to target potentially problematic factors before they lead to more serious consequences for individuals and society as a whole.

## 7.0 References

- Abrams, A. (2018, March 23). Millennials struggling to care for aging baby boomer parents call for better paid leave. *TIME*. Retrieved from <http://time.com/5203203/fmla-paid-leave-millennials-caregiving/>.
- Ainsworth, M. D. S. Blehar, M. C., Waters, E., & Wall, S. (1978) *Patterns of attachment: A psychological study of the Strange Situation*. Hillsdale, NJ: Erlbaum.
- Allison, P. D. (1999). *Logistic regression using the SAS system: Theory and application*. Cary, NC: SAS Institute.
- Alonso-Arbiol, I., Balluerka, N., & Shaver, P. R. (2007). A Spanish version of the Experiences in Close Relationships (ECR) adult attachment questionnaire. *Personal Relationships, 14*, 45-63.
- Anderson, R. E. (2002). Youth and information technology. *Changing Adolescent Experience: Societal trends and the transition to adulthood*, 175-207.
- Anderson V., Anderson P. J., Jacobs, R., & Smith, S. M. (2010). Development and assessment of executive function: From preschool to adolescence. In V. Anderson, R. Jacobs, P. J., Anderson. *Executive functions and the frontal lobes. A lifespan perspective*. (pp.123-154) New York, NY: Taylor & Francis Group.
- Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., Kong, E., Larraburo, Y., Rolle, C., Johnston, E.... & Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature, 501*(7465), 97.
- Ardila, A. (2008). On the evolutionary origins of executive functions. *Brain and Cognition, 68*, 92-99.

- Asher, S. R., & Paquette, J. A. (2003). Loneliness and peer relations in childhood. *Current Directions in Psychological Science, 12*, 75-78.
- Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience, 4*, 829-839.
- Baltes, P. B., & Lindenberger, U. (1997). Emergence of a powerful connection between sensory and cognitive functions across the adult life span: A new window to the study of cognitive aging? *Psychology and Aging, 12*, 12-21.
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.
- Bartholomew, K., & Horowitz, L. M. (1991). Attachment styles among young adults: A test of four-category model. *Journal of Personality and Social Psychology, 61*, 226-244.
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*, 497-529.
- Baumeister, R. F., DeWall, C. N., Ciarocco, N. J., & Twenge, J. M. (2005). Social exclusion impairs self-regulation. *Journal of Personality and Social Psychology, 88*, 589-604.
- Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex, 10*, 295-307.

- Berguno, G., Leroux, P., McAinsh, K., & Shaikh, S. (2004). Children's experience of loneliness at school and its relation to bullying and the quality of teacher interventions. *The Qualitative Report, 9*, 483-499.
- Bernier, A., Carlson, S. M., Deschênes, M., & Matte-Gagné, C. (2012). Social factors in the development of early executive functioning: A closer look at the caregiving environment. *Developmental Science, 15*, 12-24.
- Bibok, M. B., Carpendale, J. I., & Müller, U. (2009). Parental scaffolding and the development of executive function. *New Directions for Child and Adolescent Development, 2009*, 17-34.
- Birak, C., & Cuttler, M. (2017, August 16). Why loneliness can be as unhealthy as smoking 15 cigarettes a day. *CBC News*. Retrieved from <http://www.cbc.ca/news/health/loneliness-public-health-psychologist-1.4249637>.
- Both, L. E., & Best L. A. (2015). Coping style as predicted by personality and attachment. Paper presented at *The European Congress for Psychology*. Milan, Italy.
- Bowlby, J. (1969). *Attachment and loss: Vol I. Attachment*. New York, NY: Basic Books.
- Bowlby, J. (1982). *Attachment and loss (Rev. ed., Vol. 1)*. New York, NY: Basic Books.
- Brennan, K. A., Clark, C. L., & Shaver, P. R. (1998) Self-report measure of adult attachment: An integrative overview. In J. A. Simpson & W. S. Rholes (Eds.), *Attachment Theory and Close Relationships*. New York, NY: Guilford Press.
- Bretherton, I., & Munholland, K. (1999). Internal working models in attachment relationships: A constructive revisited. In J. Cassidy & P. Shaver (Eds.),

*Handbook of Attachment: Theory, Research, and Clinical Applications* (pp. 89-111). New York, NY: Guilford Press.

Bryan, J., & Luszcz, M. A. (2000). Measurement of executive function: Considerations for detecting adult age differences. *Journal of Clinical and Experimental Neuropsychology*, 22, 40-55.

Buchanan, T. (2016). Self-report measures of executive function problems correlate with personality, not performance-based executive function measures, in nonclinical samples. *Psychological Assessment* 28, 372-385.

Burgess, P. W. (1997). Theory and methodology in executive function research. In P. Rabbitt (Ed.), *Methodology of frontal and executive function* (pp. 81-116). East Sussex, England: Psychology Press.

Cacioppo, J. T., & Hawley, L. C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Sciences*, 13, 447-454.

Cacioppo, J. T., Ernst, J. M., Burleson, M. H., McClintock, M. K., Malarkey, W. B., Hawley, L. C., ... & Spiegel, D. (2000). Lonely traits and concomitant physiological processes: The MacArthur social neuroscience studies. *International Journal of Psychophysiology*, 35, 143-154.

Cacioppo, J. T., Hawley, L. C., Crawford, L. E., Ernst, J. M., Burleson, M. H., Kowalewski, R. B., ... & Berntson, G. G. (2002). Loneliness and health: Potential mechanisms. *Psychosomatic Medicine*, 64, 407-417.

- Cahn-Weiner, D. A., Boyle, P. A., & Malloy, P. F. (2002). Tests of executive function predict instrumental activities of daily living in community-dwelling older individuals. *Applied Neuropsychology, 9*, 187-191.
- Canli, T. (2008). Toward a “molecular psychology” of personality. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of personality: Theory and research*, (pp. 311-327), New York, NY: Guilford Press.
- Caruso, J. C. (2000). Reliability generalization of the NEO personality scales. *Educational and Psychological Measurement, 60*, 236-254.
- Collins, N. L., & Feeney, B. C. (2010). An attachment theoretical perspective on social support dynamics in couples: Normative processes and individual differences. In K. Sullivan & J. Davila (Eds.), *Support processes in intimate relationships* (pp. 89–120). New York, NY: Oxford University Press.
- Cooper, D. R., & Schindler, P. S. (2003). *Business research methods*, (8<sup>th</sup> ed.). New York, NY: McGraw-Hill/Irwin.
- Costa, P. T., & McCrae, R. R. (1985). The NEO Personality Inventory.
- Costa, P. T., & McCrae, R. R. (1992). NEO PI-R Professional Manual.
- Costa Jr, P. T., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: Robust and surprising findings. *Journal of Personality and Social Psychology, 81*, 322-331.
- Craik, F. I., & Bialystok, E. (2006). Cognition through the lifespan: Mechanisms of change. *Trends in Cognitive Sciences, 10*, 131-138.

- Crick, N. R., & Ladd, G. W. (1993). Children's perceptions of their peer experiences: Attributions, loneliness, social anxiety, and social avoidance. *Developmental Psychology, 29*, 244-254.
- Curtis, C. E., & D'Esposito, M. (2003). Persistent activity in the prefrontal cortex during working memory. *Trends in Cognitive Sciences, 7*, 415-423.
- Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan executive function system (D-KEFS)*. San Antonio, TX: Psychological Corporation.
- De Luca, C. R., & Leventer, R. J. (2008). Developmental trajectories of executive functions across the lifespan. In V. Anderson, R. Jacobs, P. J., Anderson (Ed.) *Executive functions and the frontal lobes. A lifespan perspective* (pp. 23-56). New York NY: Taylor & Francis Group.
- DeYoung, C. G., Peterson, J. B., & Higgins, D. M. (2005). Sources of openness/intellect: Cognitive and neuropsychological correlates of the fifth factor of personality. *Journal of Personality, 73*, 825-858.
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135-168.
- Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*, 1387-1388.
- Digman, J. M. (1990). Personality structure: Emergence of the five-factor model. *Annual Review of Psychology, 41*, 417-440.
- DiMaggio, P. (1997). Culture and cognition. *Annual Review of Sociology, 23*, 263-287.
- DiTommaso, E., & Spinner, B. (1993). The development and initial validation of the Social and Emotional Loneliness Scale for Adults (SELSA). *Personality and Individual Differences, 14*, 127-134.

- DiTommaso, E., & Spinner, B. (1997). Social and emotional loneliness: A re-examination of Weiss' typology of loneliness. *Personality and Individual Differences, 22*, 417-427.
- DiTommaso, E., Brannen, C., & Best, L. A. (2004). Measurement and validity characteristics of the short version of the Social and Emotional Loneliness Scale for Adults. *Educational and Psychological Measurement, 64*, 99-119.
- DiTommaso, E., Fizell, S. R., & Robinson, B. A., (2015). Chronic loneliness within an attachment framework: Processes and interventions. In A. Rokach & A. Sha'ked (Eds.), *Addressing Loneliness: Coping, Prevention, and Clinical Interventions* (pp. 241-255). New York, NY: Routledge.
- Ducharme, J. (2018, March 26). Loneliness can actually hurt your heart. Here's why. *TIME*. Retrieved from <http://time.com/5212558/loneliness-social-isolation-heart-health/>.
- Empson, J. M., (2004). *Atypical Child Development in Context* (pp. 39-72) Gordonsville, VA: Palgrave Macmillian.
- Evans, D. E., & Rothbart, M. K. (2007). Developing a model for adult temperament. *Journal of Research in Personality, 41*, 868-888.
- Fairchild, A. J., & Finney, S. J. (2006). Investigating validity evidence for the experiences in close relationships-revised questionnaire. *Educational and Psychological Measurement, 66*, 116-135.
- Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G\* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191.

- Fazeli, S. H. (2012). The exploring nature of the assessment instrument of five factors of personality traits in the current studies of personality. *Asian Social Science*, 8, 264-275.
- Flood, K. E., Best, L. A., & DiTommaso, E. (March, 2018). Understanding subjective well-being: The impact of loneliness, executive function, and social media use. Poster presentation presented at *Interprofessional Health Research Day*, Saint John Regional Hospital, Saint John, NB.
- Flood, K., Ciszewski, S., & Best, L. (March, 2015). Relationship between disordered eating and executive functioning in a non-clinical sample of males and females. Oral presentation presented at *Interprofessional Health Research Day*, Saint John Regional Hospital, Saint John, NB.
- Flood, K., McPhee, R., Buhay, D., & Best, L. (2017, April). Technology use: The influence of psychological variables. In Pracana, C. & Wang, M. *International Psychological Applications Conference and Trends Proceedings*. Budapest, Hungary: World Institute for Advanced Research and Science. ISBN: 978-989-99864-1-1 © 2017.
- Fowler, S. (2017) *Friendships and Subjective Well-being: The Role of Best Friends, Causal Friends, and Acquaintances*. (Master's thesis). University of New Brunswick, Saint John, NB.
- Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., & Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General*, 137, 201.

- Friedman, N. P., Miyake, A., Robinson, J. L., & Hewitt, J. K. (2011). Developmental trajectories in toddlers' self-restraint predict individual differences in executive functions 14 years later: a behavioral genetic analysis. *Developmental Psychology, 47*, 1410-1430.
- Funahashi, S., Bruce, C. J., & Goldman-Rakic, P. S. (1993). Dorsolateral prefrontal lesions and oculomotor delayed-response performance: Evidence for mnemonic "scotomas". *The Journal of Neuroscience, 13*, 1479-1497.
- Gardner, W. L., Pickett, C. L., & Brewer, M. B. (2000). Social exclusion and selective memory: How the need to belong influences memory for social events. *Personality and Social Psychology Bulletin, 26*, 486-496.
- Gaudet, D. J. (2017) *Detecting Deceit from Idiosyncratic Deception Clues*. (Master's thesis). University of New Brunswick, Saint John, NB.
- Gazzaley A, & D'Esposito, M., (2007). Unifying prefrontal cortex function: Executive control, neural networks, and top-down modulation. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders*. (pp. 187-206) (2<sup>nd</sup> ed.). New York, NY: Guilford Press.
- Gillath, O., Shaver, P. R., Mikulincer, M., Nitzberg, R. E., Erez, A., & Van Ijzendoorn, M. H. (2005). Attachment, caregiving, and volunteering: Placing volunteerism in an attachment-theoretical framework. *Personal Relationships, 12*, 425-446.
- Goldberg, L. R. (1990). An alternative "description of personality": The big-five factor structure. *Journal of Personality and Social Psychology, 59*, 1216-1229.

- Grant, D. A., & Berg, E. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Weigl-type card-sorting problem. *Journal of Experimental Psychology*, *38*, 404-411.
- Gray, J. A. (1970). The psychophysiological basis of introversion extraversion. *Behaviour Research and Therapy*, *8*, 249-266.
- Gray, J. R., Burgess, G. C., Schaefer, A., Yarkoni, T., Larsen, R. J., & Braver, T. S. (2005). Affective personality differences in neural processing efficiency confirmed using fMRI. *Cognitive, Affective, & Behavioral Neuroscience*, *5*, 182-190.
- Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 3-24). New York, NY: Guilford Press.
- Grossman, E. D., Battelli, L., & Pascual-Leone, A. (2005). Repetitive TMS over posterior STS disrupts perception of biological motion. *Vision Research*, *45*, 2847-2853.
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7<sup>th</sup> ed.). Englewood Cliffs, NJ: Prentice Hall.
- Hall, P. A., Fong, G. T., Epp, L. J., & Elias, L. J. (2008). Executive function moderates the intention-behavior link for physical activity and dietary behavior. *Psychology and Health*, *23*, 309-326.
- Hawley, L. C., & Cacioppo, J. T. (2010). Loneliness matters: A theoretical and empirical review of consequences and mechanisms. *Annals of Behavioral Medicine*, *40*, 218-227.

- Hawkey, L. C., Hughes, M. E., Waite, L. J., Masi, C. M., Thisted, R. A., & Cacioppo, J. T. (2008). From social structural factors to perceptions of relationship quality and loneliness: The Chicago health, aging, and social relations study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *63*, 375-384.
- Hazan, C. & Shaver, P. (1987). Romantic love conceptualized as an attachment process. *Journal of Personality and Social Psychology*, *52*, 511-524.
- Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G., & Curtiss, G. (1993). *Wisconsin Card Sorting Test (WCST): Manual: Revised and Expanded*. Psychological Assessment Resources (PAR).
- Heinrich, L. M., & Gullone, E. (2006). The clinical significance of loneliness: A literature review. *Clinical Psychology Review*, *26*, 695-718.
- Homack, S., Lee, D., & Riccio, C. A. (2005). Test review: Delis-Kaplan executive function system. *Journal of Clinical and Experimental Neuropsychology*, *27*, 599-609.
- Hoza, B., Bukowski, W. M., & Beery, S. (2000). Assessing peer network and dyadic loneliness. *Journal of Clinical Child Psychology*, *29*, 119-128.
- Hughes, C. H., & Ensor, R. A. (2009). How do families help or hinder the emergence of early executive function? *New Directions for Child and Adolescent Development*, *2009*, 35-50.
- Iguchi, Y., Hoshi, Y., Tanosaki, M., Taira, M., & Hashimoto, I. (2005). Attention induces reciprocal activity in the human somatosensory cortex enhancing relevant-and suppressing irrelevant inputs from fingers. *Clinical Neurophysiology*, *116*, 1077-1087.

- Jang, K. L., Livesley, W. J., & Vernon, P. A. (1996). The genetic basis of personality at different ages: A cross-sectional twin study. *Personality and Individual Differences, 21*, 299-301.
- Jang, K. L., McCrae, R. R., Angleitner, A., Riemann, R., & Livesley, W. J. (1998). Heritability of facet-level traits in a cross-cultural twin sample: Support for a hierarchical model of personality. *Journal of Personality and Social Psychology, 74*, 1556-1565.
- Kanai, R. (2012). Brain Structure and Individual Differences in Social Behaviors. In *AAAI Spring Symposium: Self-Tracking and Collective Intelligence for Personal Wellness*.
- Kanai, R., & Rees, G. (2011). The structural basis of inter-individual differences in human behaviour and cognition. *Nature Reviews Neuroscience, 12*, 231-242.
- Kanai, R., Bahrami, B., Duchaine, B., Janik, A., Banissy, M. J., & Rees, G. (2012). Brain structure links loneliness to social perception. *Current Biology, 22*, 1975-1979.
- Kato, T. (2012). Development of the Coping Flexibility Scale: Evidence for the coping flexibility hypothesis. *Journal of Counseling Psychology, 59*, 262-273.
- Kochanska, G., & Aksan, N. (1995). Mother-child mutually positive affect, the quality of child compliance to requests and prohibitions, and maternal control as correlates of early internalization. *Child Development, 66*, 236-254.
- Kochanska, G., Aksan, N., Penney, S. J., & Doobay, A. F. (2007). Early positive emotionality as a heterogeneous trait: Implications for children's self-regulation. *Journal of Personality and Social Psychology, 93*, 1054-1066.

- Kong, X., Wei, D., Li, W., Cun, L., Xue, S., Zhang, Q., & Qiu, J. (2015). Neuroticism and extraversion mediate the association between loneliness and the dorsolateral prefrontal cortex. *Experimental Brain Research*, *233*, 157-164.
- Krantz, L. (2018, April 6). Are baby boomers about to crash long-term care? *The Globe and Mail*. Retrieved from <https://www.theglobeandmail.com/life/first-person/article-are-baby-boomers-about-to-crash-long-term-care/>.
- Kubey, R. W., Lavin, M. J., & Barrows, J. R. (2001). Internet use and collegiate academic performance decrements: Early findings. *Journal of Communication*, *51*, 366-382.
- Lang, F. R., Staudinger, U. M., & Carstensen, L. L. (1998). Perspectives on socioemotional selectivity in late life: How personality and social context do (and do not) make a difference. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *53*, 21-30.
- Larochette, A. C., Benn, K., & Harrison, A. G. (2009). Executive functioning: A comparison of the Tower of London DX and the D-KEFS Tower Test. *Applied Neuropsychology*, *16*, 275-280.
- Lazarus, R. (1999). *Stress and emotion: A new synthesis*. New York, NY: Springer.
- Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York, NY: Springer.
- Lewis, C., & Carpendale, J. I. (2009). Introduction: Links between social interaction and executive function. *New Directions for Child and Adolescent Development*, *2009*, 1-15.

- Lieberman, M. D., & Rosenthal, R. (2001). Why introverts can't always tell who likes them: Multitasking and nonverbal decoding. *Journal of Personality and Social Psychology, 80*, 294-310.
- Loya, A., Gopal, A., Shukla, I., Jermann, P., & Tormey, R. (2015). Conscientious behaviour, flexibility and learning in massive open on-line courses. *Procedia-Social and Behavioral Sciences, 191*, 519-525.
- Luu, P., Collins, P., & Tucker, D. M. (2000). Mood, personality, and self-monitoring: Negative affect and emotionality in relation to frontal lobe mechanisms of error monitoring. *Journal of Experimental Psychology: General, 129*, 43-60.
- Marangoni, C., & Ickes W. (1989) Loneliness: A theoretical review with implications for measurement. *Journal of Social and Personal Relationships, 6*, 93-128.
- Matthews, G., Deary, I. J., & Whiteman, M. C. (2003). *Personality traits*. Cambridge, England: Cambridge University Press.
- McCrae, R. R., & Costa, P. T. (1987). Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology, 52*, 81-90.
- McCrae, R. R., & Costa, P. T. (1992). Discriminant validity of NEO-PI-R facet scales. *Educational and Psychological Measurement, 52*, 229-237.
- McCrae, R. R., & Costa, P. T. (2003). *Personality in adulthood: A five-factor theory perspective*. New York, NY: Guilford Press.
- McCrae, R. R., & John, O. P. (1992). An introduction to the five-factor model and its applications. *Journal of Personality, 60*, 175-215.

- McCrae, R. R., & Terracciano, A. (2005). Universal features of personality traits from the observer's perspective: data from 50 cultures. *Journal of Personality and Social Psychology, 88*, 547-561.
- Meyer, D. E., & Kieras, D. E. (1997). A computational theory of executive cognitive processes and multiple-task performance: Part I. Basic mechanisms. *Psychological Review, 104*, 3-65.
- Mikulincer, M., & Shaver, P. R. (2005). Attachment theory and emotions in close relationships: Exploring the attachment-related dynamics of emotional reactions to relational events. *Personal Relationships, 12*, 149-168.
- Mikulincer, M., & Shaver, P. (2007). Attachment-related mental representations of self and others. In M. Mikulincer & P. Shaver (Eds.), *Attachment in Adulthood* (p.149-187). New York, NY: Guilford Press.
- Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21*, 8-14.
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.
- Moore, D., & Schultz, N. R. (1983). Loneliness at adolescence: Correlates, attributions, and coping. *Journal of Youth and Adolescence, 12*, 95-100.
- Morahan-Martin, J., & Schumacher, P. (2003). Loneliness and social uses of the Internet. *Computers in Human Behavior, 19*, 659-671.

- Munakata, Y., Herd, S. A., Chatham, C. H., Depue, B. E., Banich, M. T., & O'Reilly, R. C. (2011). A unified framework for inhibitory control. *Trends in Cognitive Sciences, 15*, 453-459.
- Murdock, K. W., Oddi, K. B., & Bridgett, D. J. (2013). Cognitive correlates of personality. *Journal of Individual Differences, 34*, 97-104.
- National Institute of Health and Human Development (2005). *The NICHD study of early child care and youth development. Findings for children up to age 4 ½ years*. U.S. Department of Health and Human Services, NICHD Early Child Care Research Network.
- Nęcka, E., Lech, B., Sobczyk, N., & Śmieha, M. (2012). How much do we know about our own cognitive control? Self-report and performance measures of executive functions. *European Journal of Psychological Assessment, 28*, 240-247.
- New Brunswick Government. New Brunswick Department of Health (2016) *Profiles on health: Mental health and substance use disorders in New Brunswick*. Fredericton, New Brunswick.
- Norman, W. T. (1963). Toward an adequate taxonomy of personality attributes: Replicated factor structure in peer nomination personality ratings. *The Journal of Abnormal and Social Psychology, 66*, 574-583.
- Norman, D. A., & Shallice, T. (1986). Attention to action. In R. J. Davidson, G. E. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation* (pp. 1-18). Boston, MA: Springer US.
- O'Callaghan, H. (2018, March 16). All the lonely people: Epidemic of loneliness is leading to chronic health problems. *Irish Examiner*. Retrieved from

<https://www.irishexaminer.com/breakingnews/lifestyle/healthandlife/all-the-lonely-people-epidemic-of-loneliness-is-leading-to-chronic-health-problems-832702.html>.

Peper, E., & Harvey, R. (2018). Digital addiction: Increased loneliness, anxiety, and depression. *NeuroRegulation*, 5, 3–8.

Perlman, D., & Peplau, L. A. (1982). Theoretical approaches to loneliness. In L. A. Peplau, & D. Perlman (Eds.) *Loneliness: A Sourcebook of Current Theory, Research and Therapy*, (pp.123-134), New York, NY: John Wiley and Sons

Phillips, D. C. (1968). Operational definitions in Educational Research. *Australian Journal of Education*, 12, 311-323.

Piedmont, R. L., & Chae, J. H. (1997). Cross-cultural generalizability of the five-factor model of personality development and validation of the NEO PI-R for Koreans. *Journal of Cross-Cultural Psychology*, 28, 131-155.

Pietrzak, R. H., Sprague, A., & Snyder, P. J. (2008). Trait impulsiveness and executive function in healthy young adults. *Journal of Research in Personality*, 42, 1347-1351.

Pinquart, M., & Sorensen, S. (2001). Influences on loneliness in older adults: A meta-analysis. *Basic and Applied Social Psychology*, 23(4), 245-266.

Premier's Council on the Status of Disabled Persons (2008). Fredericton, New Brunswick.

Rabbitt, P. (1997). Introduction: Methodologies and models in the study of executive function. In P. Rabbitt (Eds.), *Methodology of Frontal and Executive Function*, (pp. 1-38), Psychology Press.

- Rabin, L. A., Fogel, J., & Nutter-Upham, K. E. (2011). Academic procrastination in college students: The role of self-reported executive function. *Journal of Clinical and Experimental Neuropsychology, 33*, 344-357.
- Rankin, K. (2007). Social cognition in frontal injury. *The Human Frontal Lobes: Functions and Disorders, 2*, 345-360.
- Reeder, G. D., Vonk, R., Ronk, M. J., Ham, J., & Lawrence, M. (2004). Dispositional attribution: Multiple inferences about motive-related traits. *Journal of Personality and Social Psychology, 86*, 530-544.
- Roth, R. M., Isquith, P. K., & Gioia, G. A. (2005). *BRIEF-A: Behavior rating inventory of executive function--adult version: Professional manual*. Lutz, FL: Psychological Assessment Resources.
- Rothbart, M. K. (2007). Temperament, development, and personality. *Current Directions in Psychological Science, 16*, 207-212.
- Rubenstein, C., & Shaver, P. (1980). Loneliness in two northeastern cities. In J. Jarrog, J. R. Audy, & Y. A. Cohen (Eds.), *The anatomy of loneliness*, (pp. 319-337) New York, NY: International Universities Press.
- Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. *Journal of Personality Assessment, 66*, 20-40.
- Rutter, M. (1995). Clinical Implications of attachment concepts: Retrospect and prospect. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 36*, 549-571.
- Sakai, K., Rowe, J. B., & Passingham, R. E. (2002). Active maintenance in prefrontal area 46 creates distractor-resistant memory. *Nature Neuroscience, 5*, 479-484.

- Salthouse, T. A., & Ferrer-Caja, E. (2003). What needs to be explained to account for age-related effects on multiple cognitive variables? *Psychology and Aging, 18*, 91-110.
- Sarter, M., Gehring, W. J., & Kozak, R. (2006). More attention must be paid: The neurobiology of attentional effort. *Brain Research Reviews, 51*, 145-160.
- 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*, 739-744.
- 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*, 1526-1540.
- Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London. Series B. Biological Sciences, 298*, 199-209.
- Shallice, T. (1988). *From neuropsychology to mental structure*. New York, NY: Cambridge University Press.
- Simpson, J. A., & Rholes, W. S. (1994). Stress and secure base relationships in adulthood. In K. Bartholomew & D. Perlman (Eds.), *Attachment processes in adulthood* (pp. 181–204). London, England: Kingsley.
- Spinella, M. (2004). Neurobehavioral correlates of impulsivity: Evidence of prefrontal involvement. *International Journal of Neuroscience, 114*(1), 95-104.
- Sroufe, L. A., & Waters, E. (1977). Attachment as an organizational construct. *Child Development, 48*, 1184–1199.

- Sroufe, L. A., Cooper, R. G. & DeHart, G. B. (1996). A clear and readable introduction to child development which explains the concepts of risk, vulnerability, and protective mechanisms in relation to problems in child development. In G. B. DeHart, L. A. Sroufe & R. G. Cooper (Eds.) *Child Development: Its Nature and Course* (3<sup>rd</sup> ed). New York, NY: McGraw-Hill.
- Statistics Canada, Minister of Industry. (2010). *Population Projections for Canada, Provinces and Territories*. Retrieved from <http://www.statcan.gc.ca/pub/91-520-x/2010001/aftertoc-aprestdm1-eng.htm>
- Stemme, A., Deco, G., & Busch, A. (2007). The neuronal dynamics underlying cognitive flexibility in set shifting tasks. *Journal of Computational Neuroscience*, 23, 313-331.
- Storandt, M. (2008). Cognitive deficits in the early stages of Alzheimer's disease. *Current Directions in Psychological Science*, 17, 198-202.
- Stout, D. (2010). The evolution of cognitive control. *Topics in Cognitive Science*, 2, 614-630.
- Strayer, D. L., & Drews, F. A. (2007). Cell-phone-induced driver distraction. *Current Directions in Psychological Science*, 16, 128-131.
- Strayer, D. L., Drews, F. A., & Crouch, D. J. (2006). A comparison of the cell phone driver and the drunk driver. *Human Factors*, 48(2), 381-391.
- Strayer, D. L., Watson, J. M., & Drews, F. A. (2011). Cognitive distraction while multitasking in the automobile. In B. Ross (Eds.), *Psychology of Learning and Motivation* (pp. 29-58). Burlington, VT: Academic Press.

- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643-662.
- Suchy, Y. (2009). Executive functioning: Overview, assessment, and research issues for non-neuropsychologists. *Annals of Behavioral Medicine*, *37*, 106-116.
- Tabachnick, B. G., & Fidell, L. S. (2013) *Using multivariate statistics* (6<sup>th</sup> ed.). Boston, MA: Pearson Education.
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry*, *54*, 131-143.
- Tsujimoto, S. (2008). The prefrontal cortex: Functional neural development during early childhood. *The Neuroscientist*, *14*, 345-358.
- Van Buskirk, A. M., & Duke, M. P. (1991). The relationship between coping style and loneliness in adolescents: Can “sad passivity” be adaptive? *The Journal of Genetic Psychology*, *152*, 145-157.
- Victor, C. R., & Yang, K. (2012). The prevalence of loneliness among adults: A case study of the United Kingdom. *The Journal of Psychology*, *146*, 85-104.
- Weeks, D. J. (1994). A review of loneliness concepts, with particular reference to old age. *International Journal of Geriatric Psychiatry*, *9*, 345-355.
- Wheeler, L., Reis, H., & Nezlek, J. B. (1983). Loneliness, social interaction, and sex roles. *Journal of Personality and Social Psychology*, *45*, 943-953.
- Williams, P. G., & Thayer, J. F. (2009). Executive functioning and health: Introduction to the special series. *Annals of Behavioral Medicine*, *37*, 101-105.

- Williams, P. G., Suchy, Y., & Rau, H. K. (2009). Individual differences in executive functioning: Implications for stress regulation. *Annals of Behavioral Medicine, 37*, 126-140.
- Williams, P. G., Suchy, Y., & Kraybill, M. L. (2010). Five-factor model personality traits and executive functioning among older adults. *Journal of Research in Personality, 44*, 485-491.
- Xu, S., Wang, Z. J., & David, P. (2016). Media multitasking and well-being of university students. *Computers in Human Behavior, 55*, 242-250.

## Appendix A

**Demographics Questionnaire**

**Please check or fill in the appropriate answer.**

1. How old are you? \_\_\_\_ Years
2. Gender? \_\_\_\_ Male \_\_\_\_ Female \_\_\_\_ Transgender \_\_\_\_ Prefer not to say
3. Year of study \_\_\_\_\_
4. Indicate whether you are an international or domestic student  
\_\_\_\_ International \_\_\_\_ Domestic (New Brunswick) \_\_\_\_ Domestic (Canada)
5. Are you currently in a romantic relationship? \_\_\_\_ Yes \_\_\_\_ No
6. If **yes**, for how long? \_\_\_\_ Years \_\_\_\_ Months (please indicate number)
7. How many hours on average daily do you spend on social media?  
\_\_\_\_ Not at all  
\_\_\_\_ About 1 hour  
\_\_\_\_ About 2 hours  
\_\_\_\_ About 3 hours  
\_\_\_\_ About 4 hours  
\_\_\_\_ More than 4 hours
8. Please indicate which of the following best describes your current living situation  
\_\_\_\_ Living with both parents  
\_\_\_\_ Living with one parent  
\_\_\_\_ Living with roommate(s) off campus  
\_\_\_\_ Residence  
\_\_\_\_ Alone  
\_\_\_\_ Living with spouse/partner  
\_\_\_\_ Other

## Appendix B

## ECRI

The following statements concern how you feel in **close relationships**. We are interested in how you generally experience relationships, not just in what is happening in a current relationship. Respond to each statement by indicating how much you agree or disagree with it (i.e., rate the extent to which each item below describes your feelings in close relationships). Write the number in the space provided, using the following rating scale:

1	2	3	4	5	6	7
<i>Disagree Strongly</i>	.....	.....	<i>Neutral/ Mixed</i>	.....	.....	<i>Agree Strongly</i>

- \_\_\_ 1. I prefer not to show a partner how I feel deep down.
- \_\_\_ 2. I worry about being abandoned.
- \_\_\_ 3. I am very comfortable being close to romantic partners.
- \_\_\_ 4. I worry a lot about my relationships.
- \_\_\_ 5. Just when my partner starts to get close to me I find myself pulling away.
- \_\_\_ 6. I worry that romantic partners won't care about me as much as I care about them.
- \_\_\_ 7. I get uncomfortable when a romantic partner wants to be very close.
- \_\_\_ 8. I worry a fair amount about losing my partner.
- \_\_\_ 9. I don't feel comfortable opening up to romantic partners.
- \_\_\_ 10. I often wish that my partner's feeling for me were as strong as my feelings for him/her.
- \_\_\_ 11. I want to get close to my partner, but I keep pulling back.
- \_\_\_ 12. I often want to merge completely with romantic partners, and this sometimes scares them away.
- \_\_\_ 13. I am nervous when partners get too close to me.
- \_\_\_ 14. I worry about being alone.
- \_\_\_ 15. I feel comfortable sharing my private thoughts and feeling with my partner.
- \_\_\_ 16. My desire to be very close sometimes scares people away.
- \_\_\_ 17. I try to avoid getting too close to my partner.
- \_\_\_ 18. I need a lot of reassurance that I am loved by my partner.
- \_\_\_ 19. I find it relatively easy to get close to my partner.
- \_\_\_ 20. Sometimes I feel that I force my partners to show more feeling, more commitment.
- \_\_\_ 21. I find it difficult to allow myself to depend on romantic partners.
- \_\_\_ 22. I do not often worry about being abandoned.
- \_\_\_ 23. I prefer not to be too close to romantic partners.
- \_\_\_ 24. If I can't get my partner to show interest in me, I get upset or angry.
- \_\_\_ 25. I tell my partner just about everything.
- \_\_\_ 26. I find that my partner(s) don't want to get as close as I would like.
- \_\_\_ 27. I usually discuss my problems and concerns with my partner.
- \_\_\_ 28. When I'm not involved in a relationship, I feel somewhat anxious and insecure.
- \_\_\_ 29. I feel comfortable depending on romantic partners.

- \_\_\_\_\_ 30. I get frustrated when my partner is not around as much as I would like.
- \_\_\_\_\_ 31. I don't mind asking romantic partners for comfort, advice, or help.
- \_\_\_\_\_ 32. I get frustrated if romantic partners are not available when I need them.
- \_\_\_\_\_ 33. It helps to turn to my romantic partner in times of need.
- \_\_\_\_\_ 34. When romantic partners disapprove of me, I feel really bad about myself.
- \_\_\_\_\_ 35. I turn to my partner for many things, including comfort and reassurance.
- \_\_\_\_\_ 36. I resent it when my partner spends time away from me.

Appendix C  
**Behaviour Rating Inventory of Executive Functioning – Adult Form**

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Appendix D  
SELSA-S

**On this page you will find a number of statements that an individual might make about his/her social relationships. Please read these statements carefully and indicate the extent to which you agree or disagree with each one as a statement about you, using the 7-point rating provided to the right of each question.**

**Please take a moment to think about your relationships with your partner, your family and your friends over the *past year*. Please circle the number that best reflects the degree to which each of the following statements describes your thoughts and feelings during the *PAST TWO YEARS*. Please try to respond to each statement.**

*In the past 2 years:*

	Disagree Strongly						Agree Strongly
1. In the past two years I felt alone when I was with my family.	1	2	3	4	5	6	7
2. In the past two years I felt part of a group of friends.	1	2	3	4	5	6	7
3. In the past two years I had a romantic partner with whom I shared my most intimate thoughts and feelings.	1	2	3	4	5	6	7
4. In the past two years there was no one in my family I could depend upon for support and encouragement, but I wish there had been.	1	2	3	4	5	6	7
5. In the past two years my friends understood my motives and reasoning.	1	2	3	4	5	6	7
6. In the past two years I had a romantic or marital partner who gave me the support and encouragement I needed.	1	2	3	4	5	6	7
7. In the past two years I didn't have a friend(s) who shared my views, but I wish I had.	1	2	3	4	5	6	7
8. In the past two years I felt close to my family.	1	2	3	4	5	6	7
9. In the past two years I was able to depend on my friends for help.	1	2	3	4	5	6	7
10. In the past two years I wished I had a more satisfying romantic relationship.	1	2	3	4	5	6	7
11. In the past two years I felt a part of my family.	1	2	3	4	5	6	7

12. In the past two years my family really cared about me.	1	2	3	4	5	6	7
13. In the past two years I didn't have a friend(s) who understood me, but I wish I had.	1	2	3	4	5	6	7
14. In the past two years I had a romantic partner to whose happiness I contributed.	1	2	3	4	5	6	7
15. In the past two years I had an unmet need for a close romantic relationship.	1	2	3	4	5	6	7

### SELSA-S

On this page you will find a number of statements that an individual might make about his/her social relationships. Please read these statements carefully and indicate the extent to which you agree or disagree with each one as a statement about you, using the 7-point rating provided to the right of each question.

Please take a moment to think about your relationships with your partner, your family and your friends over the *past year*. Please circle the number that best reflects the degree to which each of the following statements describes your thoughts and feelings during the PAST TWO WEEKS. Please try to respond to each statement.

*In the past two weeks:*

	Disagree Strongly						Agree Strongly
1. In the past two weeks I felt alone when I was with my family.	1	2	3	4	5	6	7
2. In the past two weeks I felt part of a group of friends.	1	2	3	4	5	6	7
3. In the past two weeks I had a romantic partner with whom I shared my most intimate thoughts and feelings.	1	2	3	4	5	6	7
4. In the past two weeks there was no one in my family I could depend upon for support and encouragement, but I wish there had been.	1	2	3	4	5	6	7
5. In the past two weeks my friends understood my motives and reasoning.	1	2	3	4	5	6	7
6. In the past two weeks I had a romantic or marital partner who gave me the support and encouragement I needed.	1	2	3	4	5	6	7
7. In the past two weeks I didn't have a friend(s) who shared my views, but I wish I had.	1	2	3	4	5	6	7
8. In the past two weeks I felt close to my family.	1	2	3	4	5	6	7
9. In the past two weeks I was able to depend on my friends for help.	1	2	3	4	5	6	7
10. In the past two weeks I wished I had a more satisfying romantic relationship.	1	2	3	4	5	6	7
11. In the past two weeks I felt a part of my family.	1	2	3	4	5	6	7
12. In the past two weeks my family really cared about me.	1	2	3	4	5	6	7

13. In the past two weeks I didn't have a friend(s) who understood me, but I wish I had.	1	2	3	4	5	6	7
14. In the past two weeks I had a romantic partner to whose happiness I contributed.	1	2	3	4	5	6	7
15. In the past two weeks I had an unmet need for a close romantic relationship.	1	2	3	4	5	6	7

Appendix E  
**Neuroticism, Extraversion, Openness, Personality Inventory, Revised.**

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## Appendix G

*Hierarchical Multiple Regression predicting scores on the D-KEFS Color-Word Interference Test.*

Color-Word Interference Test <sup>1</sup>				
	r	B	t	p
<b>STEP 1</b>				<b>R<sup>2</sup> = .00</b>
Age	-.02	-.02	-.24	.808
Gender	-.05	-.06	-.53	.595
<b>STEP 2</b>				<b>ΔR<sup>2</sup> = .05</b>
Openness	.09	.03	.26	.789
Conscientiousness	.04	-.03	-.27	.781
Extraversion	.15	.08	.60	.547
Agreeableness	-.00	-.11	-.83	.407
Neuroticism	-.14	-.18	-.96	.336
Avoidance	.03	.04	.40	.690
Anxiety	-.13	-.09	-.63	.525
<b>STEP 3</b>				<b>ΔR<sup>2</sup> = .04</b>
Chronic Family Loneliness	-.22	-.21	-1.54	.128
Chronic Social Loneliness	-.19	.00	.00	.993
Chronic Romantic Loneliness	-.12	-.08	.66	.506

Note. <sup>1</sup> Condition 3: Completion Time

\*\*\*p<.01

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01

## Appendix H

*Hierarchical Multiple Regression predicting scores on the D-KEFS Trail-Making Test.*

Trail-Making Test <sup>1</sup>				
	R	B	t	p
<b>STEP 1</b>				<b>R<sup>2</sup>=.03</b>
Age	.15	.17	1.53	.129
Gender	.09	.10	.981	.329
<b>STEP 2</b>				<b>ΔR<sup>2</sup>=.09</b>
Openness	-.07	-.01	-.14	.888
Conscientiousness	-.17	-.19	-1.55	.125
Extraversion	-.01	.05	.41	.676
Agreeableness	-.17	-.26	-1.96	.053
Neuroticism	.01	-.06	-.35	.722
Avoidance	.10	.09	.86	.391
Anxiety	-.06	-.04	-.34	.728
<b>STEP 3</b>				<b>ΔR<sup>2</sup>=.09</b>
Chronic Family Loneliness	-.18	-.35	-2.78	.007
Chronic Social Loneliness	.08	.26	1.81	.073
Chronic Romantic Loneliness	.00	.01	.16	.871

Note. <sup>1</sup> Condition 4: Completion Time.

Although chronic family loneliness appears to be adding something, Model 3 overall is not significant, rather  $p=.092$ .

**\*\* $p<.01$**

\* $p<.05$  is included for information purposes only, the alpha level in the current study is  $p=.01$

## Appendix I

*Hierarchical Multiple Regression predicting scores on the D-KEFS Tower Test.*

Tower Test <sup>1</sup>				
	r	$\beta$	t	p
<b>STEP 1</b>				<b>R<sup>2</sup>=.02</b>
Age	.06	.08	.72	.472
Gender	.13	.14	1.24	.216
<b>STEP 2</b>				<b><math>\Delta R^2=.08</math></b>
Openness	-.14	-.12	-.96	.336
Conscientiousness	-.05	.03	.300	.765
Extraversion	-.09	-.09	-.68	.497
Agreeableness	.12	.11	.87	.384
Neuroticism	-.11	-.11	-.64	.520
Avoidance	.20*	-.17	-1.54	.127
Anxiety	-.00	.12	.90	.368
<b>STEP 3</b>				<b><math>\Delta R^2=.02</math></b>
Chronic Family Loneliness	-.09	.04	.356	.723
Chronic Social Loneliness	-.12	-.19	-1.25	.212
Chronic Romantic Loneliness	-.02	-.02	.19	.845

Note.<sup>1</sup> Total Achievement Score

;**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01

## Appendix J

Correlations between D-KEFS performance-based tasks and BRIEF-A subscales.

	D-KEFS: Tower Test	D-KEFS: Color- word Interference Test	D-KEFS: Trail- Making Test
<b>BRIEF-A Scales</b>			
GEC	-.11	-.06	.15
Working Memory	-.16	-.11	.10
Planning	-.14	-.01	.05
Set-shifting	-.12	-.19	-.05
Inhibition	.08	-.08	.08

*Note.* All of these Pearson  $r$  values are not statistically significant.

## Appendix K

*Partial correlations between total loneliness scores and measures of EF when controlling for the effects of Conscientiousness and Neuroticism.*

	SELSA-T	SELSA-C	SELSA-LB
<b>BRIEF-A Scales</b>			
Inhibition	.03	.07	.05
Set-Shifting	-.07	-.00	-.04
Emotional Control	.06	-.01	.02
Self-Monitoring	.20	.16	.20
Initiation	<b>.31**</b>	.14	.25
Working Memory	.00	.05	.03
Planning	.03	-.08	-.02
Task-Monitoring	.22*	.04	.15
Organization <sup>1</sup>	-.00	-.09	-.05
BRI <sup>2</sup>	.09	.07	.09
MCI <sup>3</sup>	.14	.01	.08
Global Composite	.14	.04	.10
<b>D-KEFS Measures</b>			
TMT Condition 4	.16	-.04	.06
CWIT Condition 3	-.03	-.04	-.13
Tower Test Total	-.05	-.05	-.06

*Note.* <sup>1</sup> Organization of Materials; <sup>2</sup> Behavioural Index; <sup>3</sup> Metacognitive Index.

Lower BRIEF-A scores indicate higher levels of self-reported executive function.

This table demonstrates that the previously examined associations between loneliness and are no longer significant when Conscientiousness and Neuroticism are “partialed” out.

D-KEFS measures were included for comparison purposes, however, there were no zero-order correlations between the D-KEFS and loneliness scores.

**\*\*p<.01**

\*p<.05 is included for information purposes only, the alpha level in the current study is p=.01.

## CURRICULUM VITAE

Kathryn Flood

St. Francis Xavier University, Bachelor of Arts, 2012.

University of New Brunswick, Honours Equivalent in Psychology, 2014.

### Publications:

Gaudet, D.J., **Flood**, K.E., & Best, L.A. (2017). Predicting Socio-Political Attitudes: Insights from the 2015 Federal Election in Canada. (C. Pracana & M. Wang, Eds.). In *Psychology Applications & Developments* (Vol 3, pp. 74-84). InScience Press.

Freeze, D., Freeze, T.A., Best, L.A., & **Flood**, K.E. (2017). Using Personality Tests in Research: Are Longer Tests Necessarily Better? (C. Pracana & M. Wang, Eds.). In *Psychology Applications & Developments* (Vol 3, pp. 257-268). InScience Press.

**Flood**, K., McPhee, R., Buhay, D., & Best, L. (2017, April). Technology use: The influence of psychological variables. In Pracana, C. & Wang, M. *International Psychological Applications Conference and Trends Proceedings*. Budapest, Hungary: World Institute for Advanced Research and Science. ISBN: 978-989-99864-1-1 © 2017.

Gaudet, D., **Flood**, K. & Best, L. (2016, April). Personality and political ideology in Canada. In Pracana, C. & Wang, M. *International Psychological Applications Conference and Trends Proceedings*. Lisbon, Portugal. 55- 59. Lisbon, Portugal: World Institute for Advanced Research and Science. ISBN: 978-989-99389-6-0 © 2016

### Conference Presentations:

**Flood**, K.E., Best, L.A., & DiTommaso, E. (March, 2018). Understanding subjective well-being: The impact of loneliness, executive function, and social media use. Poster presentation to be presented at Interprofessional Health Research Day, Saint John Regional Hospital, Saint John, NB.

Proctor, C., Nwaonumah, L., **Flood**, K.E., & Best, L.A. (March, 2018). Impact of Personality, Attachment, and Psychological Flexibility on Thriving. Poster presentation to be presented at Interprofessional Health Research Day, Saint John Regional Hospital, Saint John, NB.

Best, L., Buhay, D., & **Flood**, K. (August, 2017). The Evolution of the University Library and its Services: A Five Year Examination of Student Experiences and Perceptions. Poster presentation presented at IFLA's 83rd World Library and Information Congress (WLIC) in Wroclaw, Poland.

**Flood, K., McPhee, R., Buhay, D., & Best, L.** (May, 2017). Technology use: The influence of psychological variables. Oral presentation presented at International Psychological Applications Conference and Trends, Budapest, Hungary.

Gaudet, D., **Flood, K., & Best, L.** (September, 2016). Personality and political ideology in Canada. Poster presentation presented at University of New Brunswick Research Showcase, Fredericton, N.B.

Gaudet, D., **Flood, K., & Best, L.** (May, 2016). Personality and political ideology in Canada. Oral presentation presented at International Psychological Applications Conference and Trends, Lisbon, Portugal.

**Flood, K. & DiTommaso, E.** (June, 2015). Attachment, relationship quality, and the use of anger tactics in romantic relationships. Oral presentation presented at Canadian Psychological Association National Conference, Ottawa, ON.

**Flood, K., Ciszewski, S., & Best, L.** (March, 2015). Relationship between disordered eating and executive functioning in a non-clinical sample of males and females. Oral presentation presented at Interprofessional Health Research Day, Saint John Regional Hospital, Saint John, NB.