

**The relationship between temperament, character and executive  
functioning**

**by**

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## ABSTRACT

Despite emergent attempts to connect temperament to a neurobiological etiology there has been little research that focuses on the relationship between temperament and character and neuropsychological test performance. Therefore, the aim of this study is to explore the relationship between temperament, character and performance on neuropsychological tests of executive functioning. Temperament and character dimensions were operationalized according to the Temperament and Character Inventory (TCI), a 240-item measure that is based on the psychobiological theory of personality. Neuropsychological performance was measured on the University of Pennsylvania Computerized Neuropsychological Test Battery (PennCNP), which is a test of executive functioning and abstract reasoning. The PennCNP comprised a test of Motor Praxis (MPRAXIS), the Penn Abstraction, Inhibition and Working Memory Task (AIM), the Letter-N-Back (LNB2), the Penn Conditional Exclusion Task (PCET), the Penn Short Logical Reasoning Task (SPVRT) and the Short Raven's Progressive Matrices (SRAVEN). The sample comprised 422 first year psychology students at a residential university in South Africa. The results from this explorative study showed a moderate relationship between temperament, character and executive functioning. The temperament dimensions Novelty Seeking and Reward Dependence were positively related to AIM-NM, AIM and SPVRT, and inversely related to MPRAXIS. These results validate the importance of research that investigates the relationship between temperament and character dimensions and neuropsychological performance.

## KEY TERMS

Character; Cloninger; executive functioning; neuropsychology; neurobiology; neuropsychological performance; personality; psychobiological theory; temperament; Temperament and Character Interest Inventory.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 OVERVIEW

Curiosity about the constructs of temperament and personality dates as far back as 350 BC and to this day still continues into the 21<sup>st</sup> century. Consequently there are numerous theories that have evolved over the years; theories that have progressed from identifying the “types” of personality to now trying to understand the neurobiology of human personality (Cloninger, 2000). To date there is substantial evidence indicating a neurobiological underpinning of personality (Cloninger, 2000; Cloninger, Svrakic & Przybeck, 2006; De Pascalis, 1993; Henderson & Wachs, 2007; O’Gorman et al., 2006; Rothbart, 1989; Svrakic et al., 2002; Williams, Suchy & Rau, 2009; Whittle, Allen, Lubman & Yücel, 2006). One such theory that takes into account the neurobiological substrates of neurobiology on personality is Cloninger’s psychobiological theory of personality, which conceptualizes personality as an interaction between temperament and character (Cloninger, 2000; Goncalves & Cloninger, 2010). According to this model the seven dimensions of personality include Harm Avoidance (HA), Novelty Seeking (NS), Reward Dependence (RD) Perseverance (P), Self-Directedness (SD), Self-Transcendence and Cooperativeness (C) (Cloninger, 2000). Temperament dimensions have been linked to different brain regions and neurotransmitters (Carver & Miller, 2006; Cloninger, 2000; Gardini, Cloninger & Venneri, 2009; O’Gorman et al., 2006; Svrakic et al., 2002; Whittle et al., 2006).

Cloninger’s psychobiological theory of personality fashions a link between temperament and neurobiology, which in turn creates opportunity for further research on the association between temperament dimensions and their neurobiological substrates. Research in the fields of personality and neuropsychology often use the same concepts and terms to describe personality profiles and executive functioning strategies. Researchers also found that the brain areas connected to executive functioning are similar to the brain areas linked to certain personality dimensions (Bergvall, Nilsson & Hansen, 2003; Cheung, Mitsis & Halperin, 2004; Cloninger,

2000; Hooper, Luciana, Wahlstrom, Conklin & Yarger, 2008; Whitney, Jameson & Hinson, 2004). Furthermore, individual differences in executive functioning are manifested in characteristic ways of thinking and behaving. Thus, researchers espouse a theoretical association between executive functioning and individual differences in temperament and personality (Williams et al., 2009).

## **1.2 RESEARCH QUESTION**

This research study will explore the association between temperament and character dimensions, on the one hand, and computerized neuropsychological test performance, on the other hand. The primary research question guiding the proposed research study is: Is temperament and character, as defined within the psychobiological framework, associated with neuropsychological tests of executive functioning?

## **1.3 RESEARCH PROBLEM**

Numerous definitions of personality currently co-exist, however for the purpose of this investigation personality will be operationalized according to Cloninger and his psychobiological theory of personality. Thus, personality will refer to the dynamic organization of the innate psychobiological systems, which regulate adaptation to a changing environment (Cloninger, 1998). More importantly, according to Cloninger, personality consists of both temperament and character traits. Despite numerous studies that have connected temperament to a neurobiological etiology, there has been little research that focuses on the relationship between temperament and character and executive functioning. A study by Cassimjee and Murphy (2010), explored the relationship between temperament and character dimensions, and computerized neuropsychological test performance in a non-clinical sample. A significant relationship between neuropsychological performance and temperament and character dimensions was found.

### **1.3.1 Research Instruments Employed in the Study**

This study forms part of a larger research project funded by the National Research Foundation (NRF) and the University of Pretoria Research and Development Fund and uses data that was collected over a two-year period. The instruments employed in the study are the Temperament and Character Inventory (TCI) and the Executive Function and Abstract Reasoning test battery from the University of Pennsylvania Computerized Neuropsychological Test Battery (PennCNP). The neuropsychological tests are as follows: MPRAXIS general sensory-motor test, the Penn Abstraction, Inhibition and Working Memory Task (AIM); The Letter-N-Back (LNB2), the Penn Conditional Exclusion Task (PCET); the Penn Short Logical Reasoning Test (SPVRT) and Short Raven's Progressive Matrices (SRAVEN).

### **1.4 JUSTIFICATION OF RESEARCH**

In South Africa, there is little neuropsychological research and even less with cognitively intact individuals (non-clinical sample). To my knowledge, there have been no studies in South Africa that have employed computer based neuropsychological tests on a large non-clinical sample. The motivation for linking personality and cognition stems from: 1) literature which often links similar concepts to describe both temperament profiles and executive functioning strategies (Bergvall et al., 2003; Cheung et al., 2004; Hooper et al., 2008; Whitney et al., 2004) and 2) psychobiological theory of personality as measured by the TCI.

### **1.5 AIM OF RESEARCH**

The aim of this study is to investigate the relationship between temperament, character and performance on neuropsychological measures of executive functioning in a non-clinical sample.

## 1.6 OBJECTIVES OF RESEARCH

- To determine if temperament and character are significantly associated with specific executive functioning tasks.
- To determine whether temperament or character contributes to performance score variance.

## 1.7 OUTLINE OF CHAPTERS

**Chapter two** provides an overview of the literature pertaining to the research study. It covers temperament and character according to Cloninger's psychobiological model, executive functioning and how the two can be studied together.

**Chapter three** outlines the research process, which includes the sampling and instruments used; and the research design and process.

**Chapter four** presents the results of the research, which comprises the statistical analyses employed as well as the relationships between the variables.

**Chapter five** is the concluding chapter of this study, which discusses the findings in which the theory, results and the literature are integrated and then concluded. Lastly, future recommendations are suggested.

## 1.8 CONCLUSION

There is a scarcity of research that focuses on the relationship between temperament and character and neuropsychological test performance. Furthermore, in South Africa there is very little neuropsychological research, specifically concerning a non-clinical sample. This is an explorative study that endeavors to explore the relationship between temperament and character and neuropsychological performance. Personality is conceptualized according to Cloninger's Psychobiological model, which breaks down personality into

temperament dimensions and character dimensions. This study will contribute to neuropsychological research based on the premise that temperament dimensions and executive functioning share common neurotransmitter and neurological systems. Furthermore, it will supplement the existing literature that often associates similar concepts to describe both temperament dimensions and executive functioning strategies.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 OVERVIEW

This chapter provides a summary of previous investigations into personality and how it can be associated to executive functioning. It will first look at different theories and theorists of personality before it focuses on Cloninger's psychobiological model of personality, which is the theory guiding this research project. This research endeavors to explore the relationship between temperament, character and performance on neuropsychological measures of executive functioning.

From person to person, personality varies greatly; no one individual is the same. Throughout history, researchers have tried to quantify personality (Cloninger, 1994) and today as a result numerous theories and definitions of personality currently co-exist. For the purpose of this investigation personality will be operationalized according to Cloninger and his psychobiological theory of personality. Thus, personality will refer to the dynamic organization of the innate psychobiological systems, which regulate adaptation to a changing environment (Cloninger, 1998).

Intricately related to personality is temperament and character; two major distinguishable domains of personality (Cloninger, 1994). According to Cloninger's psychobiological model of personality, personality consists of both temperament and character (Cloninger & Svrakic, 1997), each of which consists of multiple components that are "causally independent but functionally interactive" (Cloninger, 1994, p.267). Cloninger defines temperament as the disparities between individuals in their automatic responses to emotional stimuli, which involve procedural memory (Cloninger & Svrakic, 1997). Procedural memory involves differences in habits and skills. Character on the other hand, is defined as the disparities between individuals in their voluntary goals and values, which involves propositional memory. Propositional memory involves differences in goals and values (Cloninger, Przybeck, Svrakic & Wetzel, 1994). Thus, temperament refers to the way we are born, whereas

character refers to the way we make ourselves intentionally (Cloninger & Svrakic, 1997).

Temperament and character according to Cloninger are distinguishable on the understanding that they involve different major brain systems for procedural versus propositional memory and learning. Procedural memory and learning involves percept-based habits and skills, whereas propositional memory and learning involves concepts about one's self in relation to one's experience (Cloninger et al., 1994). According to his psychobiological model (Cloninger, 1994) temperament can be operationalized in terms of "associative habit learning that is perceptually based and well developed at an early age" (p.267). Whereas character can be operationalized in terms of "abstract symbolic processes...such as self-directed behavior, empathic social cooperation, and creative symbolic invention" (p.266-267).

Researchers throughout history have attempted to connect temperament to a neurological etiology (Rothbart, Ahadi & Evans, 2000). Today there is a growing body of such research (Cloninger, Svrakic & Przybeck, 2006; De Pascalis, 1993; Henderson & Wachs, 2007; O'Gorman et al., 2006; Rothbart, 1989; Svrakic et al., 2002; Whittle, Allen, Lubman & Yücel, 2005). Associations have been found between temperament dimensions and particular brain regions (Cloninger, 2000; Gardini, Cloninger & Venneri, 2009; O'Gorman et al., 2006; Whittle et al., 2006) as well as temperament dimensions and neurotransmitters (Carver & Miller, 2006; Cloninger, 2000; Svrakic et al., 2002).

There are numerous theories of personality that connect personality and neurobiology (Cloninger, 1987; Cloninger et al., 1993; Eysenck, 1967; Ha, Kim, Abbey & Kim, 2007; Rothbart et al., 2000; Whittle et al., 2006; Mardaga & Hansenne, 2007; Zuckerman, 1991). In the following section a brief overview of key theorists' models whose theories are relevant to this study will be provided. Thereafter, Cloninger's psychobiological model of personality will be discussed in more detail as it provides the theoretical framework of this study.

## 2.2 THEORIES OF PERSONALITY

The concept of temperament can be traced back to nearly 2, 000 years ago when it originally referred to a balanced combination of bodily humours (Whittle et al., 2006). The theory of humours was developed and expanded by Hippocrates, and later validated by Galen who extended the theory to temperament. Illness during Hippocrates-Galen time was believed to be caused by humours in the body. The presupposition in Greek medicine was that the food ingested and digested in the body was converted into blood, bones and muscle and that the humours formed from the parts of food that could not be digested by the body. Consequently, an excess or deficiency in the humours was understood to cause illness (Stelmack & Stalikas, 1991).

According to this theory there are four humours, otherwise known as bodily fluids: phlegm, black bile, yellow bile and blood (Stelmack & Stalikas, 1991) and each humour in turn is linked to a temperament. The choleric individual (predominantly yellow bile) was said to be irritable and quick to anger; the melancholic individual (predominantly black bile) was said to be sad and anxious; the sanguine individual (predominantly blood) was said to be positive and outgoing and lastly, the phlegmatic individual (predominant phlegm) was said to be slow rising in emotion and action (Rothbart et al., 2000). However, as medical science progressed, Galen's humoral theory regressed as the temperament observations were seen as fragmentary and limited. Numerous former personality theories, including and proceeding Galen's theory, failed to distinguish between distinct facets of personality as they did not take into account the underlying biological and psychological contributors. However, many prior personality theories, such as Galen's humoral theory have served as a platform for the more recent and more advanced theories of personality (Cloninger, Svrakic & Przybeck, 1993; Cloninger et al., 1994). One such theorist who endeavored to develop a personality theory that would replace Galen's theory and once again change the course of personality research was Eysenck, who will be discussed in the next section.

### 2.2.1 Psychobiological Theories of Personality

The expanding development of personality theories started to be challenged by theorists who recognized an absence of the influence that biology has on personality. They were concerned that the selection of traits in a language (lexical approach) may not reflect the behavioral importance of the trait or their biological significance (Ostendorf & Angleitner, 1994; Zuckerman, 1992). In recent years, psychobiologists have been researching the link between temperament dimensions and biology. They have fashioned the link by pinpointing neural systems that may underlie differences in temperament dimensions (Rothbart et al., 2000). Personality theorists that incorporate underlying biological and psychological contributors have developed what is called psychobiological models of personality. Underpinning all the psychobiological theories of personality is the concurrence that the basic personality dimensions are heritable, can be identified in nonhuman species, associated to neurobiological indicators and are moderately stable over time (Gardini et al., 2009; Ostendorf & Angleitner, 1994). Furthermore, these dimensions are not equally exclusive but rather genetically independent and can occur in different combinations (Cloninger et al., 1994).

There are several personality models that seek to describe the relationship between biology, genetics, and personality (Ha et al., 2007). Theorists that have investigated the biological underpinnings of personality include Zuckerman, Eysenck and Gray whose theories will be discussed briefly as they share theoretical links and are related to the theoretical framework governing this study: Cloninger's psychobiological theory of personality, which will then be covered in more detail in the proceeding section. First however, clarity on the constructs of temperament and personality will be made as each of these theorists views them differently.

The distinction between the constructs of personality and temperament is not clear-cut, as there has been disagreement about the relationship between the two and an ongoing debate remains (Whittle et al., 2006). There are researchers who would argue that personality and temperament are the same construct, others that would argue that they are distinctly two different constructs, others that argue that

temperament is the precursor for the adult personality and others that would argue that temperament is a distinct component of personality (Henderson & Wachs, 2007; Rothbart et al., 2000; Strelau, 1987; Whittle et al., 2006; Zuckerman, 1992; Zuckerman, Kuhlman, Joireman, Teta & Kraft, 1993).

### **2.2.1.1 Zuckerman's Alternative Five Factor Model**

Zuckerman, for one, contended that the distinction between temperament and personality in terms of context is neither clear nor significant and that the elementary traits or dimensions given to describe personality/temperament needs to go beyond describing ones vernacular to the behavioral importance of that trait. Furthermore, he argues that the elementary traits of personality/temperament need to be at least moderately heritable and can be associated to some specific biological mechanism or have a biological basis. Zuckerman's psychobiological theory of personality follows a hierarchical structure, top-to-bottom: (1) traits, which are associated to (2) social behavior, which are associated to (3) conditioning or observational learning, which are associated to (4) physiology, then (5) biochemistry, then (6) neurology and lastly (7) genetics. Each level is a distinct component which needs to be studied on its own, however for an inclusive understanding of any level one cannot ignore the next level down which forms its foundation (Zuckerman, 1992; Zuckerman et al., 1993).

With this theoretical backdrop, Zuckerman proposed an Alternative Five - alternative to the Big Five: *Extraversion, Openness to Experience, Agreeableness* and *Conscientiousness* - whereby his five factors are grounded by theory and have some evidence of a biological basis. Zuckerman's Alternative Five model is: Sociability, Neuroticism-Anxiety, Impulsive-Unsocialized Sensation Seeking, Aggressive Sensation Seeking and Activity. Supposedly these factors measure the constructs of biologically orientated temperament theories (Ostendorf & Angleitner, 1994).

### ***2.2.1.2 Eysenck's Introversion-Extroversion and Cortical Arousability***

Eysenck's point of departure in the personality-temperament construct debate is that temperament is a component of personality, whereby personality is the result of an interaction between social experiences and temperament (Kemp & Center, 2003; Whittle et al., 2006). Eysenck proposed a three-factor model of personality: extraversion (E), neuroticism (N) and psychoticism (P). Eysenck claimed that other factors found in the Big Five or the Alternative Five, for example Agreeableness, Aggression, Activity and Sensation Seeking, are either combinations of his E, N, and P or components of them (Zuckerman et al., 1993).

Eysenck was one of the innovators in finding the relationship between temperament and biology; more specifically individual differences in cortical arousability (Whittle et al., 2006). His research focused on the relationship between introversion-extroversion and cortical arousability (Mardaga & Hansenne, 2007). Eysenck proposed that introverts had weaker inhibitory processes, which lead to a higher tonic cortical arousal level. Whereas extroverts have stronger corticoreticular inhibitory processes and therefore have lower tonic cortical arousal levels (Rothbart, 1989). According to this theory, arousal levels are associated with a pleasant or unpleasant experience, such that extraverts that are in a low stimulus environment may engage in behaviors that increase their arousal level until it is at a pleasant level. Likewise, introverts that are in a high stimulus environment may engage in calming behaviors to lower their arousal (Hagemann, Hewig, Walter, Schankin, Danner & Naumann, 2009). Thus, according to Eysenck's theory of personality, individual differences in cerebral arousal lead to personality variance (Robinson, 2001).

### ***2.2.1.3 Gray's Reinforcement Sensitivity Theory***

When it comes to the constructs of personality and temperament, Gray uses the words interchangeably; they are one and the same construct (Strelau, 1987). Gray disagreed with a few aspects of Eysenck's three-factor model and proceeded to revise it. Gray proposed that anxiety (behavioral inhibition) and impulsivity

(behavioral activation) are the elementary dimensions of personality (Rothbart, 1989). To develop his theory Gray used data which implicated different brain systems involved in emotions, learning, memory and motor behavior. He wanted to show how differences in personality are due to individual differences in three brain systems, namely the Behavioral Inhibition System (BIS), the Behavioral Activation System (BAS) and the Fight-Flight-Freezing System (FFFS). Thus individual differences in personality are caused by individual differences in the relative activity within each brain system as well as in the interaction between the three brain systems (Mardaga & Hansenne, 2007; Whittle et al., 2006).

Gray's BAS and BIS is theoretically related to Cloninger's psychobiological model of personality, which will be discussed and referred back to in the sections to follow (Mardaga & Hansenne, 2007). According to Gray's theory, the BAS is involved in approaching behaviors, whereby behavior is activated by conditioned or unconditioned signals of reward or relief from punishment. This would elicit impulsivity, typically a positive affect. BAS is linked to the medial forebrain bundle and lateral hypothalamus and affects the neurotransmitters dopamine and norepinephrine (Rothbart et al., 2000).

The BIS brings about inhibition of continuing behavior, and is activated when two or more goals are simultaneously presented and are incompatible. This would elicit an anxiety response, typically a negative affect (Mardaga & Hansenne, 2007). On a neural level, Gray explains that the ascending reticular activating system reacts to signals of punishment or absence of reward by activating the medial septal area, which then activates the hippocampus which then inhibits the reticular activating system resulting in the inhibition of continuing behavior (Henderson & Wachs, 2007). Gray found that the reticular activating system, orbital frontal cortex, medial septal area, hippocampus and other inter-related neural structures underlie BIS reactions. The septohippocampal system, which includes the noradrenergic pathway linking the locus coeruleus and the serotonergic pathway linking the raphe nuclei underlie BIS. The prefrontal cortex has also been linked to BIS reactions (Henderson & Wachs, 2007; Rothbart et al., 2000).

### **2.2.2 Comparison of the Psychobiological Theories of Personality**

Personality schemes of Cloninger (1987), Eysenck (1967) and Zuckerman (1991) are all based on psychobiological models of personality. Cloninger and Zuckerman both focus on monoamine neurotransmitter systems as the foundation for primary personality traits; however they vary on the relationships between specific monoamines and personality traits. Furthermore, all three theorists created questionnaires to assess what they regard as the primary dimensions of personality (Zuckerman & Cloninger, 1996). Cloninger's and Gray's theories are similar in that Cloninger's NS and HA dimensions refer to BAS and BIS respectively, in their theoretical foundation. Moreover, the neurobiological bases of NS and HA mirror BAS and BIS respectively (Mardaga & Hansenne, 2007). Eysenck's extraversion links to Gray's BAS and Cloninger's NS and Eysenck's neuroticism (N) links to Gray's BIS and Cloninger's HA. Cloninger however was the first to research personality in terms of the interaction between temperament and character (Cloninger, 1994). Cloninger (2000) argues that both temperament and character are distinct components of personality. This will be the theory guiding the research project.

### **2.3 CLONINGER'S PSYCHOBIOLOGICAL MODEL OF PERSONALITY**

Cloninger wanted to develop a general model of personality which could be applied to normal personality as well as abnormal personality (Cloninger et al., 1994). Cloninger defines personality as the "dynamic organization within an individual of the psychobiological systems that modulate adaptation to a changing environment" (Cloninger & Svrakic, 1997, p. 121). The psychobiological systems involved are the systems that control cognition, emotion and mood, impulse control and social relations (Cloninger & Svrakic, 1997). Cloninger based his model of personality on longitudinal studies of development, the genetic and psychometric studies of the structure of personality in humans, as well as neurobiological research of humans and other animals, phylogenetic analysis, and neuroanatomical studies of behavioral conditioning. Cloninger's model of personality has been comprehensively researched

in clinical, neurobiological and genetic studies (Cloninger, 2000; Gillespie, Cloninger, Heath & Martin, 2003).

Cloninger initially developed a neurobiologically based operant learning model, similar to Gray's BIS and BAS, which was based on the assumption that the temperament systems in the brain are functionally structured as independently differing systems, for the activation, maintenance, and inhibition of behavior in reaction to specific classes of stimuli. Behavioral activation concerns the activation of behavior in reaction to novelty and signal of reward or relief from punishment, which he called Novelty Seeking (similar to Gray's BAS). Conversely, behavioral inhibition concerns the inhibition of behavior in reaction to signals of punishment or non-reward, which he called Harm Avoidance (similar to Gray's BIS). Moreover behavior that was previously rewarded and maintained afterwards without further reinforcement he called Reward Dependence. Thus three quantitative dimensions of temperament emerged and formed Cloninger's tridimensional model of personality (Cloninger et al., 1994; Madaga & Hansenne, 2007).

Cloninger developed a psychometric scale known as the Temperament Personality Questionnaire (TPQ), a self-report questionnaire, to test the above putative dimensions and determine if it could be a reliable and stable model of personality. Factor analytic studies established that Cloninger's three dimensions of personality were virtually uncorrelated with each other and had a high internal consistency, except that of Persistence (Cloninger et al., 1994; Gillespie et al., 2003). Persistence had originally been the second subdimension of Reward Dependence; however it seemed to be an independent fourth dimension. Cloninger revised his model and included Persistence as a fourth dimension and thus a four factor model of temperament resulted. There is however an ongoing debate as to whether Persistence is a reliable dimension of temperament or not (Gillespie et al., 2003). Regardless, Cloninger's four temperament dimensions were designed to evaluate individual difference in associative conditioning. Interestingly, Cloninger's four factor model can be seen as a modern interpretation of the ancient four temperaments of bodily humours discussed previously: Melancholic (Harm Avoidance), choleric

(Novelty Seeking), sanguine (Reward Dependence, and phlegmatic (Persistence) (Cloninger et al., 1994).

Cloninger's four temperament dimensions were proposed to provide a differential diagnosis within personality disorder populations and it seemed to offer a good description of traditional subtypes of personality disorder. However, the temperament profiles could not discriminate whether an individual had specific personality disorders; i.e. they were not diagnosis specific. Cloninger attributed this limitation to the differences in these dimension measures not being able to discriminate clinical from non-clinical populations. Furthermore, from studies that compared the TPQ to other personality tests, other facets of personality which were not accounted for in the temperament dimensions were found to be lacking (Gillespie et al., 2003). Thus Cloninger's model was revised to include the character components of personality: Self-Directed behavior, Cooperativeness and Self-Transcendence. These were designed to evaluate individual differences in conceptual learning. Thus the TPQ became known as the Temperament and Character Inventory (TCI), a 240-item measure that is based on his psychobiological theory of personality (Cloninger et al., 1994). Cloninger now had a seven-factor model for both normal and abnormal personality. The TCI has been shown to have cross-cultural validity and has been used in numerous research studies with many reproducible results concerning genetics, neurobiology, brain imaging, learning, psychopharmacology, and clinical psychopathology (Goncalves & Cloninger, 2010).

Regarding the differentiation (if any) between the constructs of personality and temperament, Cloninger views temperament as a distinct component of personality (Gillespie et al., 2003). In his psychobiological model he conceptualizes personality as an interaction between temperament and character whereby each interacts with the other in producing behavior (Adan, Serra-Grabulosa, Caci & Natale, 2009). The distinction Cloninger makes between temperament and character has become a trademark of his model (Cloninger, 1998). Cloninger's model incorporates the biological underpinnings of temperament with the socio-cultural aspects of character (Adan et al., 2009). The dimensions of temperament and character will now be discussed.

### **2.3.1 Temperament**

According to Cloninger's psychobiological model, temperament is the components of personality that are heritable, fully evident in infancy, and stable throughout life. The dimensions of temperament control automatic emotional reactions and are often referred to as the 'emotional core' of personality (Cloninger & Svrakic, 1997; Svrakic et al., 2002) and are thought to reflect individual differences in procedural learning of habits and skills. Therefore, temperament can be defined as the "automatic associative responses to emotional stimuli that determine habits and moods" (Cloninger & Svrakic, 1997, p. 266). Differences in temperament are moderately heritable, stable from childhood through adulthood and structurally reliable within diverse cultural and ethnic groups (Cloninger, 1994). Moreover, temperament is generally believed to involve neurochemical systems (Prosnick, Evans & Farris, 2003). The key brain system believed to underlie temperament is the limbic system and the striatum (Cloninger & Svrakic, 1997; Gardini et al., 2009).

#### ***2.3.1.1 Cloninger's Dimensions of Temperament***

The four temperament dimensions are "genetically independent dimensions that occur in all factorial combinations, rather than mutually exclusive categories" (Cloninger et al., 1994, p.16) and can generally be defined as follows: HA (behavioral inhibition dimension) entails a heritable bias in the inhibition of behavior in reaction to stimuli of punishment. It is reflected as pessimistic worry in anticipation of problems, fear of uncertainty, shyness with strangers and a proneness to fatigue (Cloninger et al., 1993). Individuals who are high on the HA dimension are described as "...cautious, careful, fearful, tense, apprehensive, nervous, timid, doubtful, discouraged, insecure, passive, negativistic, or pessimistic". On the contrary individuals who are low on the HA dimension are described as "...carefree, relaxed, daring, courageous, composed and optimistic" (Cloninger et al., 1994, p.20)

NS (behavioral activation) entails a heritable bias in the activation of behavior in response to novel stimuli. It is reflected as exploratory activity in reaction to novelty, impulsiveness, excessiveness in approach to stimuli of reward, and active avoidance

of frustration (Cloninger et al., 1993). Individuals high on the NS dimension are said to be "...quick-tempered, excitable, exploratory, curious, enthusiastic, exuberant, easily bored, impulsive, and disorderly". On the contrary individuals low on the NS dimension are described to be "...slow tempered, indifferent, uninquiring, unenthusiastic, stoical, reflective, frugal, reserved, tolerant of monotony, systematic, and orderly" (Cloninger et al., 1994, p.22).

RD (social attachment) entails a heritable bias in the tendency to maintain behavior in reaction to stimuli of social reward. It is reflected as sentimentality, social sensitivity, attachment, and a dependence on others approval (Cloninger et al., 1993). Individuals high on the RD dimension are described to be "...tender-hearted, loving and warm, sensitive, dedicated, dependent, and sociable. In contrast individuals low on the RD dimension are described to be "...practical, tough minded, cold, and socially insensitive..." (Cloninger et al., 1994, p. 23).

P (ambition) entails a heritable bias in maintaining behavior regardless of frustration, fatigue, and reinforcement that only occurs from time to time. It is reflected as industriousness, determination, and perfectionism (Cloninger et al., 1993). Individuals high on the P dimension are said to be "...industrious, hard-working, persistent, and stable despite frustration and fatigue". In contrast individuals low on the P dimension are said to be "...indolent, inactive, unreliable, unstable and erratic..." (Cloninger et al., p. 24).

### ***2.3.1.2 Neuroanatomy of Temperament***

If an association can be found between Cloninger's temperament dimensions and regional brain structures, then it can be proposed that various individual differences in HA, NS, RD and P (in a normal population) reflects various structural differences found in the brain, which manifests itself behaviorally as individual differences in temperament (Gardini et al., 2009). There have been numerous investigations into this link between neuroanatomy and temperament. Due to the advances in neuroimaging techniques, researches have been able to better understand the association between the temperament dimensions and brain structures and in effect

add to the growing body of evidence of neurobiology underlying personality (O’Gorman et al., 2006).

Cloninger (2000) reviewed research between May 1999 and May 2000, which reported on the neurobiology of personality. Studies that focused on brain imaging reported a link between temperament traits and specific differences in regional cerebral blood flow: NS is positively correlated with activity of the paralimbic cortex, predominantly the left anterior cingulate and right insula; HA is negatively correlated with paralimbic regions, for example, the left parahippocampal gyrus and right orbitoinsular junction and various neocortical regions in the frontal, parietal, and temporal cortex; similarly, RD is negatively correlated with different paralimbic regions, for example, the parahippocampal gyri bilaterally, the left insula, anterior cingulate, and different neocortical regions in the frontal and temporal cortex. Cloninger views “the architecture of human personality as an interactive set of partially overlapping dimensions with non-linear relations to one another” (p. 612), which can be related to the fact that brain systems interact with one another and overlap with one another to some extent (Cloninger, 2000).

Whittle et al. (2006) reported evidence of specific areas of the prefrontal cortex, such as the dorsolateral prefrontal, anterior cingulate, and orbitofrontal cortices, and limbic structures such as the amygdala, hippocampus and nucleus accumbens, as the key areas connected with the three primary dimensions of temperament. The three primary dimensions according to Whittle et al. (2006) are Negative Affectivity, Positive Affectivity and Constraint, which reflect Cloninger’s HA, NS and RD respectively. Cloninger et al. (1994) reported a negative correlation between RD with prefrontal activity. More specifically the dorsolateral prefrontal cortex purportedly is involved in working memory and goal directed behavior, whereby it preserves the representation of goals and the resources to attain them. The right dorsolateral prefrontal cortex is the significant region involved in HA, whereas the left dorsolateral prefrontal cortex is the significant region associated with NS behavior. Furthermore, the dorsal anterior cingulate cortex, which is involved in attention, effortful control over behavior, error conflicting checking, reward-based decision making, motivation and the control of motor functions; implicates this brain structure in approach

behavior, NS. Lastly, the medial areas of the orbitofrontal cortex have been implicated in the decoding and monitoring the importance/relevance of reward in terms of reinforcement. The lateral areas of the orbitofrontal cortex have been implicated in monitoring the importance/relevance of punishers, which can cause the inhibition of present behavior. This brain region has therefore been associated to RD (Whittle et al., 2006).

O’Gorman et al. (2006) provide evidence for the hypothesized neuroanatomical basis of personality by using magnetic resonance perfusion imaging technique. Their sample comprised of 30 adults (equal male to female ratio and the average age of participants 28 years of age), with no history of psychiatric and neurological illness (non-clinical sample). Their aim was to pinpoint regions of the brain where the regional perfusion revealed significant correlation with any of Cloninger’s personality dimensions. They found significant connections between temperament dimensions and cerebral perfusion in various cortical and subcortical regions of the brain. The NS dimension was significantly connected with perfusion in the thalamus, cuneus and cerebellum. The HA dimension was significantly connected with perfusion in the cerebellar vermis, cuneus, and medial frontal gyrus. Therefore, confirming that Cloninger’s personality dimensions have a neurobiological basis.

Cohen, Manion & Morrison (2008) researched whether connections in the brain underpin personality. The striatum and the interactions between the striatum and other cortical and subcortical connections were the focus in this study as these areas of anatomy are essential in the functions of cognition, emotions and motor control. A non-clinical sample of 20 young adults completed Cloninger’s personality questionnaire and underwent diffusion-weighted magnetic resonance imaging. The temperament dimensions of NS and RD were the dimensions under investigation. This study revealed that individuals who scored high on the dimension of NS have stronger fiber connections from the hippocampus and amygdale with the ventral and mesial striatum, chiefly in the left hemisphere. Individuals who scored high on the dimension of RD had stronger connections from a network of cortical regions, including medial and lateral orbitofrontal cortices, dorsolateral prefrontal cortex and

supplemental area. In conclusion, this study found that the personality dimensions of NS and RD are unpinned by two different striatum networks.

Gardini et al. (2009), like O’Gorman et al. (2006) used Magnetic Resonance Imaging (MRI) to investigate whether individual differences in HA, NS, RD and P reflect structural differences (in regional grey matter volume) in specific brain areas. Their sample was much larger than the study by O’Gorman et al. (2006), with a sample of 85 individuals (58 males, 27 females). However a history of psychiatric and neurological illness in the sample was not taken into account. They found that HA correlated negatively with grey matter volume in orbito-frontal, occipital and parietal structures. NS correlated positively with grey matter volume in frontal and posterior cingulate regions. RD was negatively correlated with grey matter volume in the caudate nucleus and rectal frontal gyrus. Lastly, P correlated positively with grey matter volume in the precuneus, paracentral lobule and parahippocampal gyrus. Thus, this recent investigation provides support for previous neuroimaging studies and it can be argued that there is a neuroanatomical basis for Cloninger’s temperament traits.

### ***2.3.1.3 Neurotransmitters and Temperament***

Cloninger (1987) proposed that different neurotransmitter systems - dopaminergic, serotonergic and noradrenergic systems - influence the expression of NS, HA and P respectively. Today, research surrounding the notion that specific neurotransmitters are associated with specific temperament dimensions is steadily gaining ground (Carver & Miller, 2006). Various studies to date have reported the association between neurotransmitters and temperament as Cloninger proposed 23 years ago.

Cloninger (2000) confirmed his earlier proposition, utilizing the Tridimensional Personality Questionnaire (TPQ), which as already discussed preceded the development of the TCI. Cloninger reported that HA is associated with serotonergic function and NS is associated with both dopaminergic and noradrenergic processes. Cloninger et al. (2006) reported that HA, NS, RD and P are associated with the underlying serotonergic, dopaminergic, noradrenergic and cholinergic

neurotransmitters systems. More specifically, HA has been associated with gamma amino butyric acid (GABA)-ergic and serotonergic activity, NS with dopaminergic activity and RD with central noradrenergic activity (Svrakic et al., 2002).

In a study by Wickens, Reynolds and Hyland (2003) the neural mechanisms involved in reward-related learning was investigated. Putatively, reward and motor learning go hand-in-hand whereby neural signals related to rewards meet neural tracks concerned with motor performance. The dopamine system has been linked to being a key processor of reward, which is connected to the striatum, which in turn has been identified as being important in the control of motor movement and learning. In this study reward-related learning was connected to dopamine-dependent synaptic flexibility. An aspect of Cloninger's NS dimension is the behavior of looking for reward as well as feeling rewarded by novel experiences. NS has continuously been linked to dopaminergic systems (Cohen et al., 2009; Cloninger 2000; Cloninger et al., 2006; Svrakic et al., 2002).

Carver and Miller (2006) focused specifically on the neurotransmitter serotonin and its function on personality. They reported studies, which utilized the TCI and tests of serotonin receptor sensitivity with non-clinical samples. The aim of these studies was to investigate the relationship between serotonin and personality. These studies yielded a positive association between HA and serotonin levels: High HA was associated to high serotonin receptor sensitivity. However, they warned that researchers should not oversimplify any given neurotransmitter's involvement in the expression of temperament, as it is more likely that the involvement of one neurotransmitter on a specific temperament dimension may be due to levels of another neurotransmitter.

### **2.3.2 Character**

The aspect of character was added to Cloninger's model of personality once it was realized that his temperament profiles were not diagnosis specific for the reason that differences in temperament dimensions do not differentiate between clinical and non-clinical populations. Thus, through cognitive and social development research and

personality theories according to humanistic and transpersonal psychology, three dimensions of character resulted: Self-directedness (SD), Cooperativeness (C) and Self-transcendence (ST) (Gillespie et al., 2003).

### ***2.3.2.1 Cloninger's Dimensions of Character***

The three character dimensions can be defined as follows: SD relates to the extent to which an individual is responsible, reliable, resourceful, goal-orientated, and self-confident. According to Cloninger et al. (1994) individuals high on the SD dimension are said to be “mature, strong, self-sufficient, responsible, reliable, goal-orientated, constructive, and well-integrated individuals when they have the opportunity for personal leadership” (p. 24). Individuals low on the SD dimension, on the other hand, are said to be “immature, weak, fragile, blaming, destructive, ineffective, irresponsible, unreliable, and poorly integrated when they are not conforming to the direction of a mature leader” (p. 24).

ST relates to the extent to which individuals consider themselves an important part in the universe. It is reflected in spiritually mature, unpretentious, humble, and fulfilled individuals. Individuals high on the ST dimension are said to be “unpretentious, fulfilled, patient, creative, selfless, and spiritual” (Cloninger et al., 1994, p. 27). On the contrary, individuals who are low on the ST dimension are said to be “proud, impatient, unimaginative, unappreciative of art, self-aware, materialistic, and unfulfilled” (p. 27).

The last character dimension is C, which relates to the extent to which individuals consider themselves an important part in society. It is reflected in socially mature, empathic, agreeable and cooperative individuals. Individuals high on the C dimension are said to be “empathetic, tolerant, compassionate, supportive, fair, and principled individuals” (Cloninger et al., 1994, p.26). Individuals low on the dimension of C, in comparison are said to be “self absorbed, intolerant, critical, unhelpful, revengeful, and opportunistic” (p. 26).

### **2.3.2.2 The Underpinnings of Character**

The three character dimensions of personality - SD, C and ST - are based on social and cognitive development (Bond, 2001) and entail individual differences in self-concepts about goals and values (Cloninger et al., 1994). Self-concepts differ in relation to the extent to which an individual recognizes themselves as (1) an autonomous individual (SD), (2) an important part of humanity (C), and (3) an important part of the universe as a whole (ST) (Cloninger et al., 1993). The character dimensions describe how an individual relates to themselves, other people and other objects (Cloninger & Svrakic, 1997). Depending on the self-concept an individual has, it will modify the meaning of what the individual experiences, thus the individual's emotional reaction will also be altered. As a result, the character dimensions are viewed as having an intellectual viewpoint about self/non-self-boundaries as well as an emotional viewpoint (Cloninger et al., 1994).

Furthermore, the character dimensions involve individual differences in higher cognitive processes (Svrakic et al., 2002) such as self-concepts about goals and values. The goals and values an individual has is an intentional process and are based on insight learning of intuitions and concepts regarding ourselves, other people, and other objects (Cloninger, 2003; Cloninger et al., 1994; Cloninger & Svrakic, 1997). Character is believed to be environmentally influenced, dependent on an individual's experiences, influenced by cultural and social influences and has been associated with different psychotherapeutic approaches (Prosnick et al., 2003). Therefore, character is an acquired aspect of personality and according to Mardaga and Hansenne (2007) character is not related to innate and neurobiological underpinnings. Conflicting to this Cloninger et al. (1994) propose that neuroanatomy does influence character, such that prefrontal activity is predicted to be predominantly essential for SD, the tempo-parietal activity is predicted to be predominantly essential for the C and the unity of activity in homologous sections of the two sides of the brain is predicted to be predominantly essential for the ST.

The character dimensions begin to develop in infancy with infant-caregiver attachment, then in self-object differentiation in toddlers, and continue to develop

and mature throughout life (Cloninger & Svrakic, 1997). Thus, the character dimensions mature in adulthood and ultimately influences personal and social efficiency (Cloninger et al., 1993). Character traits that are poorly developed can be linked to all categorical subtypes of personality disorder and can be utilized to diagnose the presence and the severity of personality disorder. The TCI character scores can be used to indicate the likelihood for the presence or absence of a personality disorder (Svrakic et al., 2002). According to Gutiérrez et al. (2008) the TCI is the only personality inventory that clearly differentiates personality types from abnormal functioning. In their study of personality disorders they found that individuals with a personality disorder scored lower on the SD and C character dimensions. Their study confirms that SD and C are at the core of personality disorders and thus can be used to determine the presence or absence of personality disorders.

### **2.3.3 Summary**

Personality according to Cloninger's psychobiological model can be conceptualized as the different but interrelated and interactive psychobiological systems within an individual that modulate ones adaptation to a changing environment. The psychobiological systems comprise the systems that control cognition, emotion and mood, impulse control and social interactions. Central to Cloninger's model is that personality can be decomposed into two distinct psychobiological dimensions of temperament and character (Cloninger & Svrakic, 1997). Table 1 on the following page summarizes the key differences between temperament and character in their psychobiological processors and how they function.

Table 1

*Differences between Temperament and Character*

Variable	Temperament	Character
Awareness level	Automatic	Intentional
Memory form	Percepts	Concepts
	Procedures	Propositions
Activity type	Habits, Skills	Goals, Values
Learning principle	Associative	Conceptual
	Conditioning	Insight
Key brain system	Limbic System	Temporal Cortex
	Striatum	Hippocampus

*Note.* Adapted from “Integrative Psychobiological Approach to Psychiatric Assessment and Treatment,” by C.R Cloninger and D.M. Svrakic, 1997, *Psychiatry*, 60, p. 122.

## 2.4 EXECUTIVE FUNCTIONING

The term ‘executive functions’ is not foreign in the field of psychology as it has been linked to various psychological disorders: Attention Deficit Hyperactivity Disorder (ADHD) (Sergeant, Geurts & Oosterlaan, 2002), Antisocial Personality Disorder (Morgan & Lilienfield, 2000) and Schizophrenia (Nieuwenstein, Aleman & de Haan, 2001) to name a few. However, there is ongoing uncertainty and confusion about what ‘executive functioning’ actually means or how executive functions should be operationalized (Salthouse, 2005). The term executive functioning “typically” refers to the higher-level cognitive functions implicated in the control and regulation of lower-level cognitive processes and goal-directed, future-orientated behavior (Williams et al., 2009). Higher-level cognitive functions include functions such as inhibition, flexibility of thinking, problem solving, planning, impulse control, concept formation, abstract thinking, and creativity. Lower-level cognitive functions include functions of visual-spatial perception, visual and auditory attention, and short- and/or long term memory (Alvarez & Emory, 2006; Suchy, 2009). Executive functions aid novel problem solving and adjustment of behavior in response to changes in the

environment. It aids in planning and formulating strategies for complex actions, and the ability to inhibit adverse behavior and emotional responses to engage in goal-directed behavior (Williams et al., 2009). Thus, executive functioning is composed of behavioral, affective, motivational and cognitive components (Alvarez & Emory, 2006; Suchy, 2009).

There is also a debate regarding how best to assess executive functioning. Well known and commonly used measures that have been used to assess executive functioning include the Wisconsin Card Sorting Test (WCST), Phonemic Verbal Fluency, Trail Making, Stroop Color Word Interference Test and Digit Symbol (Alvarez & Emory, 2006; Salthouse, 2005). A study by Salthouse (2005) set about to investigate the relationship between cognitive processes and various variables that have been used to show executive functioning. This study found that there was a strong relationship between measures of executive functioning and the cognitive processes of reasoning and perceptual speed abilities. However, in a study by Alvarez and Emory (2006) they used the Wisconsin Card Sorting Test, Phonemic Verbal Fluency and Stroop Color Word Interference Test to authenticate the method of linking executive functioning to frontal lobe lesions. This study did not find a “one-to-one relationship between executive functions and frontal lobe activity” (p.17). They conclude the frontal lobes as well as the regions in the other lobes of the brain are required for effective executive functions.

Historically, executive functions have been linked to the prefrontal cortex of the brain, and continue to be so today. This belief arose from studies that demonstrated that individuals who performed poorly on tests of abstract reasoning and verbal fluency had severe lesions in their frontal lobe. However, such studies have also been found to be inconsistent. This is not to say that executive functions are not linked to the frontal lobe, but rather the frontal lobes may take part in a greater extent than other areas of the brain in functions thought to be “executive” (Alvarez & Emory, 2006; Suchy, 2009).

### **2.4.1 The Components of Executive Functioning and the Prefrontal Cortex**

There are three processes that have emerged as component factors underlying executive functions: (1) inhibition and switching, (2) working memory, and (3) sustained and selective attention (Alvarez & Emory, 2006). These three components of executive functioning have been shown to be clearly distinguishable. Although despite being clearly distinguishable they are not totally independent as they have been shown to share some basic commonalities. Therefore, these three component factors of executive functioning are said to be “separable but moderately correlated constructs” (Miyake, Friedman, Emerson, Witzki & Howerter, 2000, p.87).

The component of inhibition and switching refers to the purposeful and intentional process of suppressing prepotent responses (Miyake et al., 2000). Working memory can be defined as the ability to keep information in mind so that it can easily be accessed (Crone, Wendelken, Donohou, Leijenhorst & Bunge, 2006). Working memory involves monitoring and coding information that is currently coming in for importance and relevance to that moment in time and then correctly revising the information in working memory by replacing old, irrelevant information to that moment in time, with newer and more relevant information. In other words, working memory can be referred to as storage and maintenance of information. Lastly, attention shifting involves shifting to and fro between several tasks, operations or mental sets. This requires the ability to free oneself from irrelevant tasks or mental sets and then take on more relevant or important tasks or mental sets. In other words attention shifting is the ability to carry out new processes despite interference (Miyake et al., 2000).

The above three components of executive functioning are believed to involve three principle frontal-subcortical circuits: (1) the dorsolateral frontal cortex, which projects primarily to the dorsolateral head of the caudate nucleus. This area has been shown to be involved in verbal and design fluency, ability to maintain and shift set, planning, response inhibition, working memory, organizational skills, reasoning, problem-solving, and abstract thinking. (2) The ventromedial circuit, which is involved

in motivation, starts in the anterior cingulate and projects to the nucleus accumbens. Lesions to this area of the brain have been shown to cause apathy, a decline in day to day social interactions, and psychomotor slowing. (3) The orbitofrontal cortex projects to the ventromedial caudate nucleus and is associated to socially appropriate behavior. Individuals who suffer a lesion to this area have been shown to be disinhibited, impulsive, and antisocial (Alvarez & Emory, 2006; Suchy, 2009). Executive functions have also been found to involve the anterior cingulate gyrus, the basal ganglia and diencephalic structures, the cerebellum, deep white matter tracks, and some parts of the parietal lobes (Williams et al., 2009).

### **2.4.2 Cognitive Processes and Executive Functions**

As already mentioned the executive functions are involved in cognitive processes and goal-directed, future-orientated behavior. Executive functions are implicated in the human ability to solve novel problems and the ability to adjust or change one's behavior according to changes in the environment (Williams et al., 2009). The cognitive process in decision-making processes involves both abstract and analogical reasoning (Breuning, 2003).

Tests that measure abstract reasoning are the common tests used to test executive functioning or the functions of the frontal lobe because individuals who have lesions on the frontal lobes perform poorly on these tests (Alvarez & Emory, 2006). The prefrontal cortex has been found to be involved in maintaining information at varying degrees of abstraction. Degrees of abstraction can vary from concrete information (i.e. objects and perceptual features) to abstract rules about relationships between these objects (i.e. whether the objects are the same or different) to very abstract tasks that consist of several abstract rules. Putatively different areas of the prefrontal cortex are involved to differing degrees in supporting information at the varying levels of abstraction. The dorsolateral prefrontal cortex is thought to support abstract dimensional representations, whereas the orbitofrontal prefrontal cortex is thought to support the more concrete information. Furthermore, the rostral prefrontal cortex has been implicated in the highest levels of abstraction, whereas the dorsolateral and ventrolateral prefrontal cortex has been implicated in the more basic

levels of abstraction. Therefore, cognitive control processes have been mapped according to a hierarchical system with regards to the function of the prefrontal cortex; from posterior-to-anterior (Christoff, Keramatian, Gordon, Smith & Mädler, 2009).

Analogic reasoning is one of the most common types of reasoning. It happens when one tries to establish a relationship or similarities between different items, stimuli or events and then applying that relationship to assist in reasoning with other items, stimuli or events. This is an important function as it is required for learning and problem solving, and even human survival. Through neuroimaging, the left prefrontal cortex (specifically the left dorsolateral prefrontal cortex) has been shown to be predominately involved in performing the cognitive process of analogic in the process of analog reasoning (Boroojerdi et al., 2001; Luo et al., 2003). Luo et al. (2003) used functional magnetic resonance imaging to investigate the anatomical substrate underpinning analogical reasoning. Their sample comprised ten university students (five males and five females), aged between 20 and 25. The prefrontal cortex was activated during analogic reasoning, specifically the left inferior prefrontal cortex and the right prefrontal cortex. The left prefrontal region is particularly involved in deductive reasoning.

## **2.5 TEMPERAMENT AND CHARACTER AND EXECUTIVE FUNCTIONING**

There has been a recent interest in the neurocognitive basis/etiology of individual differences (Williams et al., 2009). Individual differences in temperament have been attributed to neurophysiological divergence in brain functioning (Henderson & Wachs, 2007). It has been reported that individuals with executive functioning impairment are significantly impaired in their ability to work, attend school, and function interpersonally (Alvarez & Emory, 2006). According to Bergvall et al. (2003) many executive functions and temperament dimensions involve the prefrontal cortex. The prefrontal cortex and its other associated cortical areas are involved with planning, abstraction, attention and working memory tasks, which can be classified under executive functioning (Cassimjee & Murphy, 2010). Therefore, executive

functioning is vital for everyday human behavior, which is why deficits in executive functions have been pinpointed as a fundamental factor in various mental disorders (Henderson & Wachs, 2007).

The relationship between temperament and character and executive functioning has not been researched enough. It has been hypothesized that both temperament and character dimensions share a common underlying neural base with several executive functioning tasks (Bergvall et al., 2003). However, there is a paucity of studies dealing with this association, particularly in non-clinical samples (Cassimjee & Murphy, 2010).

### **2.5.1 Clinical Studies**

There is a growing widespread belief that there is a significant relationship between temperament and the specific psychopathologies. As already mentioned neurobiological systems are being linked to different temperaments, which in turn are being connected to the same biological underpinnings of numerous psychopathologies (Whittle et al., 2006). Cloninger's psychobiological model and his TCI can assess the presence and severity of personality disorders and is frequently used in clinical studies that research the relationship between personality and various psychopathologies. Putatively individual differences in temperament and character have a significant influence on the risk of various psychopathologies (Cloninger & Svrakic, 1997). A few clinical studies that have found a significant relationship between temperament, character and psychopathologies will be discussed next.

In a study on incarcerated offenders - where cognitive executive dysfunctions and abnormal personalities are prevalent - Bergvall et al. (2003) explored the relationship between personality variance and deficits in cognitive executive functions. Their sample comprised 22 incarcerated offenders who were convicted of committing violent crimes such as murder or rape. The participants were divided into two groups depending on whether they could be diagnosed with a personality disorder or not. Of the 22 participants, ten were diagnosed with a personality disorder according to the

Diagnostic and Statistical Manual of Mental Disorders – IV. The Swedish version of the TCI was the personality assessment utilized, which statistically resembles the American one. The aim of the study was to explore whether there is a relationship between personality deviation and deficits in executive functioning. Their attempt to relate personality and executive functioning stemmed from two observations. Firstly, the same concepts such as ‘impulsivity’ have been used in both executive function tasks and in descriptions of personality. The question is: Does an individual who performs impulsively on a test also have an impulsive personality? Secondly, various executive functions and personality dimensions involve the prefrontal cortex. This comes from numerous research studies (Miller, 2000; Roberts, Robins & Weiskrantz, 1996; Smith & Jonides, 1999) that have linked the prefrontal cortex with working memory, planning, attention, inhibition and set-shifting. They found a significant association between character dimensions and performance on a set-shifting task (executive functioning). This could be explained on the basis that character dimensions on the TCI build on complex cognitive processes including insight learning and reorganization of experience (Bergvall et al., 2003).

Numerous studies have assessed personality in Attention Deficit Hyperactivity Disorder (ADHD) using Cloninger’s model (Anckarsäter et al., 2006; Jacob et al., 2007; Cloninger et al., 1991, Cloninger et al., 1996; Svrakic et al.1993). A study done by Faraone, Kunwar, Adamson and Biederman (2009) investigated the relationship between adult ADHD and personality (utilizing the TCI). They found that individuals with ADHD had significant deviations on all TCI dimensions apart from RD and ST. Low scores on the P dimension is particularly relevant to this study as low P is consistent with the executive functioning deficit seen in a lot of individuals with ADHD. Several neuroimaging studies report that ADHD mainly implicates the prefrontal cortex. Furthermore, it has been documented that individuals with ADHD have a deficit in their working memory (Barkley, 1997). According to Anckarsäter et al. (2006) the existence of a personality disorder can be linked to character immaturity, which can be seen by low scores on Cloninger’s character dimensions of SD and/or C. In their study they found that individuals with ADHD scored high on NS and HA dimensions.

Boeker et al. (2006) in their exploratory study investigated the relationship between neuropsychological functions, numerous dimensions on personality, and the different types of psychopathological symptoms. They found that the character dimensions of ST and SD were significantly associated with working memory tasks in healthy individuals and were significantly associated with executive functioning tasks in schizophrenic individuals. A more recent study on individuals with schizophrenia by Smith, Cloninger, Harms and Csernansky (2008) reported similar findings to Boeker et al. (2006). In this study, neurocognitive deficits and psychopathology were correlated with the TCI. They found that individuals with schizophrenia as well as their siblings scored lower on SD and C dimension and higher on the ST dimension of personality, compared to their non-psychotic siblings, the controls and the siblings of the control group. With the non-psychotic siblings, SD and C were correlated with working memory and crystallized IQ, hence aspects of neurocognition and executive abilities. Hori et al., (2008) studied the personality of individuals with schizophrenia with a non-clinical sample utilizing the TCI. Their clinical sample comprised of 86 chronically diagnosed individuals with schizophrenia and their non-clinical sample comprised 115 individuals. This study found that individual's with schizophrenia compared to controls scored significantly lower on NS, RD, SD and C and higher on HA and ST dimensions. They conclude that personality is an important feature of schizophrenia as it influences social functioning and therefore individuals with schizophrenia can be said to have pervasively changed personalities.

In a study with patients with Parkinson's disease, McNamara, Durso and Harris (2008) theorized that variations in a sense of self and variations in temperament and character are linked to executive cognitive function. Individuals with Parkinson's disease are known to show evidence of dysfunction in the prefrontal cortex. This study set out to test the hypothesis that executive cognitive functioning deficits found in Parkinson's disease patients contribute to the personality changes found in the disease. Individuals with Parkinson's disease scored higher on the HA dimension. Furthermore, the higher the HA score, the lower the verbal fluency performance. The study concludes that the subcomponent HA of personality and the self-related changes found in Parkinson's disease patients are partly due to a memory disorder connected with frontal dysfunction. Taken together these clinical studies indicate that

differences in neuropsychological performance between clinical samples and healthy samples appear to be moderated by temperament and character. Thus, of interest in terms of subclinical signs and putative risk factors are investigations of the relationship between temperament and character in non-clinical samples (Cassimjee & Murphy, 2010).

Cassimjee and Murphy (2010) in a pilot study investigated the association between temperament, character dimensions and computerized neuropsychological test performance in a non-clinical sample. They found a significant correlation between HA and reaction time on the Inhibition and Working Memory Task (AIM). RD was significantly correlated with reaction time on the AIM and the response speed on the Penn Short Logical Reasoning Task (SPVRT). Lastly, ST of the character dimensions was significantly associated with performance on the AIM (working and non-working components). Thus, according to this study there is a significant association between temperament and character dimensions and performance on neuropsychological measures of executive functioning. However, due to their limited sample size the generalizability of their study is limited.

## **2.6 CONCLUSION**

The enduring research on personality has advanced into linking personality to a neurobiological etiology. According to Cloninger's psychobiological model of personality, personality consists of both temperament and character or more precisely an interaction between the two. Temperament has been found to be associated with certain brain regions, such that various individual differences in the temperament dimension reflects various structural differences found in the brain, which manifests itself behaviorally as individual differences in temperament. Temperament has also been linked to different neurotransmitter systems. Character on the other hand is believed to be environmentally influenced, dependent on an individual's experiences, influenced by cultural and social influences. Individual differences in temperament have been attributed to neurophysiological differences in brain functioning and it has been hypothesized that both temperament and character dimensions share a common underlying neural base with several executive

functioning tasks. From the literature review it can be extrapolated that most studies on personality and executive function are conducted on clinical cohorts. The purpose of this study is to explore the relationship between temperament, character and performance on neuropsychological measures of executive functioning in a non-clinical sample.

## **CHAPTER 3**

### **RESEARCH METHODOLOGY**

#### **3.1 OVERVIEW**

The purpose of this chapter is to describe the research design of the study. The process of data collection, the measuring instruments that were utilized and their psychometric properties will be discussed in this chapter. The ethical considerations that were undertaken in this research will also be discussed.

The original study comprised data collection over a period of two years. It was funded by the National Research Foundation and the University of Pretoria Research and Development Fund (Grant Number: TTK2006042400049).

#### **3.2 RESEARCH DESIGN**

The research design employed in this study is quantitative. Quantitative research is a form of conclusive research and is based on the research paradigm of positivism and post-positivism (Struwig & Stead, 2007). At the core of positivism is the assumption that there is a true reality, which can be discovered through empirical observations (Cohen et al., 2003). Positivism utilizes deductive reasoning and accurate measurements of data to discover or confirm casual laws, which can then be used to predict, understand and/or explain human behavior. Post-positivism – also known as neo-positivism – believes that reality can only be imperfectly understood and research findings are probable rather than truth (Struwig & Stead, 2007).

For the purpose of this study a non-experimental correlational design was employed. Thus, no variables were manipulated but rather a comparison of scores was used to explore the relationship between temperament, character and executive functioning, making this an explorative study only (Gravetter & Forzano, 2009).

The University of Pennsylvania Computerized Neuropsychological Test Battery was used in the original study (PennCNP). The choice of a computerized battery

facilitated group administration of tests (Gur et al., 2001). Working in collaboration with researchers at the Brain-Behavior Laboratory at the University of Pennsylvania, a web-interface was set up between the South African site and the USA site. The PennCNP comprises four computerized neuropsychological test batteries (Emotions, Memory, Executive Function and Abstract Reasoning and a full battery comprising all the tests from the three batteries). For the purpose of this study, the Executive Function and Abstract Reasoning test battery was utilized for analysis.

### **3.3 THE SAMPLE**

First year psychology students registered for the modules biological and cognitive psychology at a residential University in South Africa were invited to participate in the study. Of the 1124 registered students, 630 agreed to participate. To insure a non-clinical sample, participants who had any history of medical/psychiatric conditions were excluded from the sample. Furthermore, participants with incomplete neuropsychological test and/or TCI data were also excluded. As a result a realized sample of 422 was available for analyses.

### **3.4 DATA COLLECTION**

Ethical clearance for the original study (the grant project No: TTK2006042400049) was obtained from the relevant departmental and faculty committees at the University of Pretoria. Participants provided informed consent and were assured of confidentiality.

Participants were required to choose a scheduled session and were assigned to groups. In total 30 group sessions were scheduled for phase one of the study. Each group comprised a maximum of 25 participants. Pre-administration requirements were implemented and checked by the test administrators. Participants were seated at computer consoles in the Computer-Based Testing Laboratory (CBT) at the university. An introductory session was delivered to the participants informing them of the nature of the testing process, as well as providing information on the nature and complexity of some of the tasks. In addition to three attending researchers, eight

research assistants were trained in the administration of the battery. Each research assistant was responsible for the monitoring of four participants. The research assistants had to electronically submit, upon completion of each task, the test status code (C-complete, I-incomplete) and the number 1 (good data), 2 (questionable data) or 3 (bad data) at the end of the testing session.

### **3.5 MEASURING INSTRUMENTS**

A socio-demographic questionnaire was designed to capture basic data about respondents' gender, age, education of sample, parents' level of education, handedness and past and current medical and psychiatric history. The questionnaire was administered to each participant at the beginning of the battery of tests.

#### **3.5.1 PennCNP**

The PennCNP begins with a general sensory-motor and familiarization trial (MPRAXIS) so as to allow participants to become comfortable with the computer-based testing procedure and demonstrate adeptness at using a computer and mouse. The battery of tests does not commence until the participant has successfully completed the MPRAXIS trial.

#### **3.5.2 Tasks of Executive Function and Abstract Reasoning**

The Executive Functioning and Abstract Reasoning battery consists of six tests (five tests of abstract reasoning and executive functioning and one sensory-motor test), which are as follows: the Penn Abstraction, Inhibition and Working Memory Task (AIM); The Letter-N-Back (LNB2), the Penn Conditional Exclusion Task (PCET); the Penn Short Logical Reasoning Test (SPVRT) and Short Raven's Progressive Matrices (SRAVEN). The tests from the Executive Functioning and Abstract Reasoning Battery are administered in a set order (MPRAXIS, AIM, LNB2, PCET, SPVRT and SRAVEN). Below is a description of each task and the performance indicators selected for statistical analyses.

### **3.5.2.1 Motor Praxis (MPRAXIS)**

The MPRAXIS is a measure of sensory-motor ability. It is also designed to familiarize the participant with the computer mouse, which is used for all of the tasks. During the MPRAXIS trial practice session, the participant needs to move the computer mouse cursor over an ever-shrinking green box and click on it once. The box appears in a different location on the test-screen. If participants cannot complete the MPRAXIS, it is likely they will not be able to complete any other PennCNP task. During the test session, the participant needs to move the computer mouse cursor over an ever-shrinking green box and click on it once, each time it appears on a different location on the test-screen. This is presented 20 times, non-randomized. As soon as the participant clicks on the box it will disappear and reappear at another location on the test-screen in a smaller size. This will continue until all 20 sizes/locations of the green box are presented. The participant must click on the green box within 5 seconds, otherwise the green box will automatically move to the next location on the computer screen. Total correct responses on the test trial and reaction time for correct responses were selected as performance measures.

### **3.5.2.2 Penn Abstraction, Inhibition and Working Memory Task (AIM)**

The AIM assesses abstraction and concept formation with and without working memory. It is divided into two separate question types, which the participant practices before starting the task. During the first question type, the participant sees two pairs of stimuli on the top of the screen (adjusted to the left and to the right) and one single stimulus on the mid-bottom of the screen. The participant's task is to decide with which pair the stimulus on the bottom best belongs. The participant then clicks on the pair that best fits the bottom stimulus. Immediate feedback in the form of the word 'correct' or 'incorrect' is displayed on the screen, without any explanation of the rules. The task moves automatically onto the next question after the feedback is presented. In the second question type, the bottom stimulus flashes for less than a second and then the two pairs of stimuli appear on the top. This type of trial also measures working memory: the participant's ability to keep the bottom stimulus in mind so that a choice of the best fit can be made. As with the first type of question,

the second trial type presents feedback and moves on to the next question. Once the task begins, the participant has 10 seconds to answer each trial. There are 60 questions in total, 30 based on the first trial type and 30 based on the second (working memory) type. The criteria for best fit must take into consideration colour and shape of all stimuli figures. Total number correct and reaction time for correct responses were selected as performance measures.

### **3.5.2.3 Letter-N-Back (LNB2)**

The LNB2 assesses attention and working memory. In this task, participants are asked to pay attention to flashing letters on the computer screen, one at a time, and to press the spacebar according to three different principles or rules: the 0-back, the 1-back and the 2-back. During the 0-back the participant must press the spacebar whenever the letter X appears on the screen. During the 1-back the participant must press the spacebar whenever the letter on the screen is the same as the previous letter (i.e. in the series 'T', 'R', 'R' the participant should press the spacebar on or immediately after the second "R"). During the 2-back, the participant must press the spacebar whenever the letter on the screen is the same as the letter before the previous letter (i.e. in the series 'T', 'G', 'T', the participant should press the spacebar on or immediately after the second 'T'). In all trials, the participant has 2.5 seconds to press the spacebar (each letter flashes for 500 milliseconds and is followed by a blank screen lasting for 2000 milliseconds). The participant practices all three principles and mistakes are allowed during the practice sessions. Once all practice sessions are completed successfully, the task will begin. During the actual test trials, the participant does the 0-back, 1-back and 2-back three times each. No feedback is given in terms of correct or incorrect responses. Total number of true positive responses for each of the trails (0-Back, 1-Back, and 2-Back) and the reaction time for true positive responses on 0-Back, 1-Back and 2-Back trials were selected as performance measures.

#### **3.5.2.4 Penn Conditional Exclusion Task (PCET)**

The PCET is a measure of abstraction in executive function related to the Wisconsin Card Sorting Test (Kurtz, Ragland, Moberg & Gur, 2004; Kurtz, Wexler & Bell, 2004). It is a computerized variant form of the 'Odd Man Out' model where participants must decide which object, out of four objects, does not belong with the other three. There are three principles/criteria for choosing an object, which change as the participant achieves 10 consecutive correct answers for each principle: line thickness, shape and size (respectively). The participant has 48 trials to get 10 consecutive answers correct for each criterion. There is only one principle for any trial, but a response may match more than one principle. The participant is not told what the ruling principle is at any moment of the task and must make a decision by clicking with the mouse on the object that does not belong with the group. It is a forced-choice task (the question will remain on the computer screen until the participant chooses one of the answers). Feedback is given with a correct or incorrect message displayed on the screen with no explanation of the sorting principle rule. Total correct, categories achieved, preservation errors and reaction time for correct responses were selected as performance measures.

#### **3.5.2.5 Short Penn Logical Reasoning Test (SPVRT)**

The SPVRT is a measure of verbal intellectual ability. It is a short version of the Penn Verbal Reasoning Test (Gur et al., 2001; Gur, Gur, Obrist, Skolnick & Reivich, 1987). It is a multiple-choice task in which the participant must answer verbal analogy problems. The SPVRT has a total of eight questions. The participant must click with the computer mouse on one of the four choices that he/she thinks best fits the analogy presented. It is a forced-choice task (the question will remain on the computer screen until the participant chooses one of the four answers). No feedback is given in terms of correct or incorrect responses. Total number correct and reaction time for correct responses were selected as performance measures.

### **3.5.2.6 Short Raven's Progressive Matrices (SRAVEN)**

The SRAVEN is a measure of abstraction and mental flexibility. It is a short version of the University of Pennsylvania's RAVEN, which is a computerized version of the standard paper and pencil task published in 1960 (Raven, 1960; Gur et al., 2001). It is a multiple-choice task in which the participant must conceptualize spatial, design and numerical relations that range in difficulty from very easy to increasingly complex (Gur et al., 2001). During the SRAVEN task, the participant must click with the mouse on the pattern that best fit the visual analogy of non-representational designs displayed on the page. The SRAVEN has a total of 9 questions drawn from the regular RAVEN, which has 60 questions. Of the 9 questions, questions 1 and 2 have six responses to choose from and questions 3-9 have eight responses. It is a forced-choice task (the question will remain on the computer screen until the participant chooses one of the alternatives). No feedback is provided in terms of correct or incorrect responses. The SRAVEN stimuli were created by scanning and digitalizing the original stimuli cards from the paper and pencil RAVEN task (Gur et al., 2001). Total number correct and reaction time for correct responses were selected as performance measures.

### **3.5.2.7 The Temperament and Character Inventory (TCI)**

The Temperament and Character Inventory (TCI) comes from Cloninger's psychobiological model of personality. It is a 238 item forced-choice true/false standardized self-administered questionnaire measuring four independent, largely genetically determined dimensions of temperament, as well as three character dimensions, which are supposed to be predominantly determined by socialization processes during the life-span. Cloninger's unified psychobiological theory of personality states that four predominant genetically determined temperaments and three predominantly developmentally determined character dimensions exist. The temperament dimensions are Novelty Seeking (NS), Harm Avoidance (HA), Reward Dependence (RD), and Persistence (P). The character dimensions are Self-Directedness (SD), Cooperativeness (C), and Self-Transcendence (ST). Internal consistency coefficients range from .70 to .89 for the seven factors in a non-clinical

sample (Cloninger et al., 1994). The TCI has been used before in different groups in South African (du Preez, Cassimjee, Ghazinour, Lauritz & Richter, 2009; Peirson & Heuchert, 2001; Lochner, Simeon, Niehaus & Stein, 2002).

### **3.6 DATA ANALYSIS**

As this study is quantitative in nature, statistical analysis was utilized for interpreting the data. The Department of Statistics at the University of Pretoria (UP) aided in the data analysis of this study.

#### **3.6.1 Descriptive Statistics**

The aim of this study was to investigate the relationship between temperament, character and performance on neuropsychological measures of executive functioning. Descriptive statistics were used for this purpose, to indicate the sample performance on the TCI and executive and abstract reasoning battery. These data sets comprised raw scores on the relevant measuring instruments and no personal identifiers were included in the data files.

#### **3.6.2 Correlational Analysis**

Gay and Airasian (as cited in Johnson, 2001) clarifies that correlational research entails gathering data so that it can be determined whether and to what extent a relationship exists between two or more variables. The purpose of a correlational design is to determine relationships between variables. Thus, for the purpose of this study, a correlational design will be implemented to determine if there is a relationship between temperament, character and executive functioning.

Canonical correlation was developed by Hotelling (1935). It is a multivariate statistical analysis, which allows for the researcher to examine the relationships between sets of multiple dependent and interdependent variables. Canonical correlation can be used to quantify the strength of a relationship between two sets of variables by identifying the best structure of each variable set that maximizes the

relationship between the independent variable set and the dependent variable set (Hair Jr., Anderson, Tatham & Black, 1998).

Hotelling's canonical correlational analysis will be applied to determine significant associations between variables. Multiple regression analysis will be used to connect a dependent variable (the variable observed) to independent variable(s) (variable changed).

There are two important advantages to using canonical correlation analysis: Firstly, it is a multivariate technique which confines the probability of finding a statistically significant result (i.e. finding a relationship) one should not have. This is a common error in statistical analysis when there are too many statistical tests carried out on the same variables in a data set. Canonical correlation analysis limits this probability because it allows for concurrent comparisons among variables in a data set. Another important advantage to using canonical correlation is that it is possibly the most applicable method to use in the field of psychology specifically because most psychology research investigates variables that have several causes and effects. Therefore, canonical correlation analysis minimizes the probability of simplifying or distorting the complexity of human behavior (Sherry & Henson, 2005). As the literature review in chapter 2 revealed, personality is a complex and dynamic construct that involves many psychobiological systems. Thus, canonical correlation analysis is the most appropriate statistical technique for this research project as it not only is capable of analyzing the data but is also theoretically consistent with the purpose of this research project.

### **3.7 ETHICAL CONSIDERATION**

The relevant departmental and faculty committees at the University of Pretoria approved the original study (the grant project No: TTK20060434400049) from which the data is obtained for this project. The data set utilized for this study comprises raw scores on the relevant measuring instruments and no personal identifiers are included in the data files. Permission has been obtained from the primary investigator (supervisor) to study, to analyze and report on the collected data.

### **3.8 CONCLUSION**

This study explored the relationship between temperament, character and executive functioning in a non-clinical sample. The design is non-experimental in nature and utilized quantitative methods in analyzing the data. Canonical correlation, which is a multivariate statistical analysis, was used as it allows for the relationships between sets of multiple dependent and interdependent variables to be analyzed simultaneous. Canonical correlation also quantifies the strength of a relationship between two sets of variables by identifying the best structure of each variable set that maximizes the relationship between the independent variable set and the dependent variable set. The results of the statistical analysis will be discussed in the next chapter.

## CHAPTER 4 RESULTS

### 4.1 OVERVIEW

The results of the study are presented in this chapter. Canonical Correlation Analysis was used to assess the relationship between sets of multiple dependent variables and multiple independent variables (Hair Jr. et al., 1998). The biographical characteristics of the sample will be discussed first. This will be followed by the canonical correlation analyses and interpretation.

### 4.2 SAMPLE DEMOGRAPHICS

First year psychology students registered at a residential University in South Africa were invited to participate in the study. Of the 1, 124 registered students, 630 agreed to partake. After excluding participants with medical and psychiatric history and participants with incomplete neuropsychological test and TCI data, a realized sample of 422 was available for analyses. The demographics of the sample are described below.

#### 4.2.1 Gender

The sample comprised of 356 females (84%) and 66 males (16%).

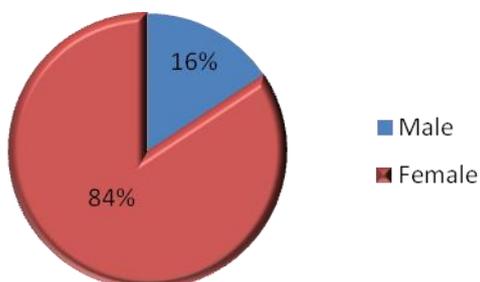


Figure 1. Gender Distribution

#### 4.2.2 Age

The participant's ages ranged between 17 years to 45 years.  $M = 19$  and  $SD = 2.90$ .

#### 4.2.3 Language

The majority of the sample was Afrikaans speaking (49%), followed by English (26%). The rest of the sample comprised other African languages (25%).

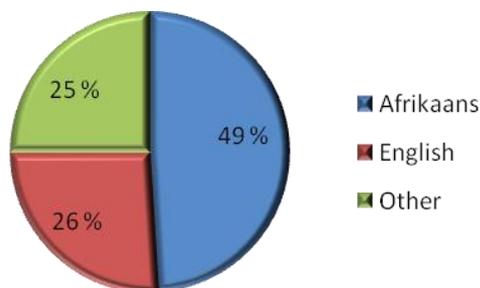


Figure 2. Home Language

#### 4.2.4 Education of Sample

The sample had a mean education in years of  $M = 13.22$  and  $SD = 0.58$ .

#### 4.2.5 Parents' Level of Education

For mothers education in years the  $M = 14.26$ ,  $SD = 2.77$ . For fathers education in years the  $M = 14.91$  and  $SD = 3.09$ .

#### 4.2.6 Handedness

For handedness of the sample, 93% were right-handed, 5% were left-handed and 2% was ambidextrous.

### **4.3 TCI AND EXECUTIVE TASKS**

The seven dimensions on the TCI (four temperament and three character dimensions) were correlated with the 14 neuropsychological tests from the University of Pennsylvania Computerized Neuropsychological Test Battery (PennCNP). IBM SPSS Statistic 19 was the program utilized.

To reiterate, the seven dimensions that comprise the TCI are divided into the dimensions of temperament - Harm Avoidance (HA), Novelty Seeking (NS), Reward Dependence (RD), Persistence (P) – and the dimensions of character - Cooperativeness (C), Self-Directedness (SD) and Self-Transcendence (ST).

The PennCNP comprises a general sensory-motor and familiarization trial (MPRAXIS) - which allows participants to become comfortable with the computer-based testing - and five computerized neuropsychological test batteries. These are the Penn Abstraction, Inhibition and Working Memory Task (AIM), which assesses abstraction and concept formation with and without working memory; The Letter-N-Back (LNB2), which assesses attention and working memory; the Penn Conditional Exclusion Task (PCET), which measures abstraction in executive function; the Penn Short Logical Reasoning Test (SPVRT), which measures verbal intellectual ability and Short Raven's Progressive Matrices (SRAVEN), which measures abstraction and mental flexibility.

#### **4.3.1 TCI Descriptors**

A comparison of the means of TCI dimensions of this student sample to control group data (n=1,145) from du Preez, Cassimjee, Ghazinour, Lauritz and Richter (2009), yielded no statistical differences between the means. Table 1 shows the comparison of means.

Table 2

*Temperament and Character Inventory Scores of Students and Control Group*

TCI dimensions	Students (N=422)		Controls <sup>a</sup> (N=1145)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Harm Avoidance	15.39	7.03	11.00	4.69
Novelty Seeking	20.41	6.25	15.61	3.31
Reward Dependence	16.02	3.69	15.25	3.09
Persistence	5.19	2.10	5.64	1.55
Cooperativeness	34.33	5.60	30.08	3.69
Self-Directedness	29.74	7.60	31.66	4.69
Self-Transcendence	19.66	5.65	21.86	3.72

<sup>a</sup>From Du Preez. et al (2009).

The descriptive performance indicators for the executive functioning battery of tasks are indicated in Table 3.

Table 3

*Descriptive Statistics for the Neuropsychological Test Battery*

Neuropsychological test battery	Students (N=422)	
	M	SD
Abstraction & concept Formation	23.92	3.46
Abstraction & concept formation -WM	24.49	3.29
Abstraction & concept formation RT	2125.10	565.45
Abstraction & concept formation WM RT	1492.40	413.93
Attention and working memory RT	425.00	95.38
Sensory-motor RT (Trial 1)	791.52	287.83
Sensory-motor RT (Trial 2)	597.84	101.74
Abstraction in executive functioning	37.94	7.63
Abstraction in executive functioning RT	1979.90	554.98
Executive perseverative Errors	14.85	8.73
Verbal reasoning	14.98	5.22
Verbal reasoning RT	8266.42	2970.77
Abstraction & mental flexibility	42.49	10.19
Abstraction & mental flexibility RT	17185.31	8118.96

*Note.* RT = reaction time; WM = working memory; -WM = without working memory

#### 4.4 CANONICAL CORRELATION ANALYSIS

In order to determine the direction and magnitude of relationship between the predictor and criterion variables the full canonical model has to be evaluated for statistical significance. In other words, there has to be an indication of a relationship between all the variables.

Wilks' Lambda - a multivariate test - was used to assess the significance of the canonical roots (Hair Jr. et al., 1998). Collectively, the full model (canonical function/variant 1) was found to be significant at the 10% level, which indicates a shared variance between the variable sets (Sherry & Henson, 2005) Thus, collectively, the full model across all functions was statistically significant using the Wilks'  $\lambda = 0.730$ ; Chi - SQ = 117.82; DF = 98.00;  $p < 0.1$ . The tests of significance showed that only the first variate pair was amenable to interpretation

Sherry and Henson (2005) caution that sample size impacts on statistical significance tests and large sample sizes can yield statistically significant results for very small effects. Based on this caveat, the Wilk's Lambda can be used as it represents the variance unexplained by the model. The formula  $1 - \lambda$  yields the full model effect size in a  $r^2$  metric equivalent. For the set of seven canonical functions, the  $r^2$  type effect size was 0.27, which indicates that the full model explained about 27% of the variance shared between the variable sets. It can therefore be concluded that the full model was moderately significant and had a moderate effect size (Cohen, 1988).

In order to evaluate the relationship between the variable sets that warrant interpretation, each canonical function needs to be observed in order to interpret only those that explain a reasonable amount of variance between the variable sets. Table 4 outlines the canonical correlation and squared canonical correlations.

Table 4

*Canonical Correlation and Squared Canonical Correlations*

Canonical Function	Canonical Correlation	Squared Canonical Correlation
1	0.36	0.13
2	0.25	0.06
3	0.19	0.04
4	0.16	0.03
5	0.15	0.02
6	0.14	0.02
7	0.09	0.01

In this study, only the first function will be interpreted as it accounts for almost 13% of the variance. The other functions - each explained less than 10% of the variance in their functions - were sufficiently weak so as to not warrant interpretation. To summarize: The analyses reveal that there is a relationship between the variables sets by evidence of statistical significance and effect sizes. Furthermore, this relationship was largely captured by the first function in the canonical model.

In order to understand which variables are contributing to the relationship between the variables sets in the first function, the standardized canonical coefficients, structure coefficients and squared structure coefficients for function 1 need to be examined. The squared structure coefficients represent the percentage of shared variance between the observed variable and the synthetic variable created from the observed variable's set (Sherry & Henderson, 2005). Table 5 shows the standardized canonical coefficient, structure coefficients and squared structure coefficients for function 1.

Table 5

*Canonical Correlation between the Executive Performance Domains and Dimensions of the TCI*

Variable	Function 1		
	Standardize <i>d</i> coefficient	Structure coefficient ( <i>rs</i> )	Squared structure coefficient %
TCI dimensions			
Novelty Seeking	-0.39	-0.21	4
Harm Avoidance	0.09	0.19	4
Reward Dependence	-0.61	-0.26	7
Persistence	0.28	0.17	3
Cooperativeness	-0.37	-0.14	2
Self-Directedness	0.22	0.04	0
Self-Transcendence	0.19	0.11	1
Executive skills/processes			
Abstraction & concept formation	-0.57	-0.74	55
Abstraction & concept formation RT	-0.16	0.22	5
Abstraction & concept formation – WM	-0.06	-0.60	36
Abstraction & concept formation WM RT	-0.09	0.08	1
Abstraction and mental flexibility	-0.07	-0.25	6
Abstraction & mental flexibility RT	0.40	0.29	8
Sensory-motor RT (Trial 1)	0.22	0.55	30
Sensory-motor RT (Trial 2)	0.26	0.47	22
Verbal reasoning	-0.25	-0.43	18
Verbal reasoning RT	-0.39	-0.27	7
Abstraction in executive functioning	0.13	0.10	1
Abstraction in executive functioning RT	0.15	0.22	5
Executive perseverative errors	-0.17	0.09	1
Attention & working memory RT	-0.11	0.16	3
Canonical correlation	0.36		
Percentage of variance	13%		

*Note.* RT = reaction time; WM = working memory; -WM = without working memory

Table 5 indicated for variate 1, the structure coefficients showed that the relevant criterion variables were primarily performance on abstraction and concept formation with and without working memory and verbal reasoning ability and reaction time on sensory-motor abilities. The conclusion was supported mainly by the squared structure coefficients, which indicated the amount of variance the observed variable contributed to the synthetic criterion variable. The canonical function coefficients were also consulted, and some of these executive skills tended to have the larger coefficients. The exception being for abstraction and mental flexibility with working memory, which had a moderate structure coefficient but a very small standardized coefficient. Furthermore, abstraction and mental flexibility and verbal reasoning reaction time had moderate standardized coefficients but small squared structure coefficients. This result was due to the multicollinearity that the variable had with the other criterion variables (Sherry & Henson, 2005). In essence, the linear equation that used the standardized coefficients to combine the criterion variables (on Function 1) only incorporated the variance of the abstraction and concept formation variables. Without this artifact, this variable could have contributed substantially to the created synthetic variable (as shown by the  $r_s$  and  $r_s 2$ ).

With the exception of abstraction and concept formation and verbal reasoning performance, all the other performance variables were positively associated.

With regard to the predictor set on variate 1, the results indicated that RD and NS were the primary contributors. The canonical function correlates supported this contribution with high and medium coefficients for these two temperament types. Of note is that these two temperament types were positively related to the primary performance variables (AIM-NM, AIM, SPVRT) and inversely related to reaction time on sensory motor function.

Canonical cross-loadings offer a direct measure of the dependent-independent variable relationships and are also used in the interpretation of canonical correlations (Hair Jr., Anderson, Tatham & Black, 1998). Confirming the canonical loadings, the relevant predictor variables were primarily RD (26%) and NS (21%) and therefore contributed more to the variates.

With regard to the criterion variables, cross loadings support the primary contributions of the abstraction and concept formation with working memory (22%) and without working memory (22%) performance to variate 1.

#### **4.4.1 Redundancy Analyses**

Redundancy is the percent of variance in one set of variable accounted for by the variate of another set. According to Levin (1977) a high redundancy indicates the independent variate accounts for a high percent of variance in the dependent set of original variables. This is distinct from the squared canonical correlation, which indicates the percent of variance in the dependent variate accounted for by the independent variate.

For the first variate, the independent canonical variable is able to predict only 14% in the original individual dependent variables. Furthermore, the dependent canonical variables predict only 18% of the variance in the original individual dependent variables. For the first variate the dependent canonical variable is able to predict only 2% in the original individual independent variables. Furthermore, the independent canonical variables predict only 18% of the variance in the original individual independent variables. Thus, the low redundancy indicates that temperament and character dimensions account for only a small percentage of the variance in the executive performance indices.

#### **4.5 CONCLUSION**

Canonical Correlation Analysis was used to explore the relationship between the TCI and the PennCNP. Overall the analyses revealed that there is moderate relationship between temperament, character and executive functioning. However, the temperament and character dimensions account for only a small percentage of the variance in the executive performance indices. The criterion variables were primarily performance on abstraction and concept formation with and without working memory and verbal reasoning ability and reaction time on sensory-motor abilities.

Furthermore, performance on abstraction and concept formation with and without working memory and verbal reasoning ability and reaction time on sensory-motor abilities were found to be the primary facets of executive functioning that contributed to the relationship between temperament, character and neuropsychological performance.

Of the TCI dimensions, RD and NS were found to be the primary contributors to this relationship and were found to be positively related to performance on abstraction and concept formation with and without working memory and verbal reasoning ability variables (AIM-NM, AIM, SPVRT respectively) and inversely related to reaction time on sensory motor function (MPRAXIS). These results are discussed in more detail in the following chapter.

## **CHAPTER 5**

### **DISCUSSION AND CONCLUSION**

#### **5.1 OVERVIEW**

The purpose of this study was to explore the association between temperament and character dimensions and participants' performance on computerized neuropsychological tasks. The previous chapter established that there is a moderate association and that temperament and character dimensions account for only a small percentage of the variance in the executive performance indices. For the purpose of a theoretical discussion, only those functions that explain a moderate amount of variance between the variable sets will be discussed. The significant results will be substantiated by relevant literature and the statistical results of the study. The chapter concludes with a section on the limitations of the study and recommendations for future studies.

#### **5.2 TEMPERAMENT, CHARACTER AND NEUROPSYCHOLOGICAL PERFORMANCE**

Within a multivariate framework, this study found significant associations between temperament and character dimensions, and accuracy and speed of performance on PennCNP tests of Executive Functioning and Abstract Reasoning. This is in line with research, which report relationships between personality dimensions and neuropsychological functioning (Bergvall et al., 2003; Cassimjee & Murphy, 2010; Henderson & Wachs, 2007; Keilp, Sackeim & Mann, 2005; Robinson, Wilkowski & Meier, 2006).

In this study, performance on abstraction and concept formation with and without working memory and verbal reasoning ability and reaction time on sensory-motor abilities were found to be the primary facets of executive functioning that contributed to the relationship between temperament, character and neuropsychological performance. RD and NS were found to be the primary contributors to the relationship. Furthermore, these two temperament dimensions were found to be

positively related to performance on abstraction and concept formation with and without working memory and verbal reasoning ability variables (AIM-NM, AIM, SPVRT respectively) and inversely related to reaction time on sensory motor function (MPRAXIS). These results are discussed in more detail below.

### **5.2.1 Reward Dependence**

RD entails a heritable bias in the tendency to respond to and maintain behavior in reaction to stimuli of social reward. High RD is characterized by several cognitive, emotional and social characteristics, encompassing improved learning from reward signals, persistence in recurring actions linked to rewards, high sociability, sentimentality, attachment, social sensitivity and dependence on others approval (Cloninger, Svrakic & Przybeck, 1993; Cohen, Shoene-Bake, Elger & Weber, 2009). RD has been theorized to involve postsynaptic sensitivity of neurons in the frontal cortex to noradrenergic projections from the locus ceruleus situated in the brainstem and is said to involve the “brain’s system for modulation of conditioned signals of reward” (Cloninger et al., 1994, p 138).

#### ***5.2.1.1 Penn Abstraction, Inhibition and Working Memory Task (AIM)***

The AIM assesses abstraction and concept formation with and without working memory. Immediate feedback is given to the participant in the form of a positive or negative message (correct or incorrect). The first part of the test does not involve working memory, however, the second part of test, requires the participant to keep the stimulus in mind as it only flashes for less than a second. The test is timed, and the participant has 10 seconds to respond.

The AIM taps into abilities that are associated with prefrontal cortex activity and involves facets of executive functioning, which include working memory, inhibition and switching, and sustained and selective attention. Together, these allow for the planning, initiation and regulation of goal-directed behavior (Bergvall et al., 2003; Cassimjee & Murphy, 2010; Henderson & Wachs, 2007). There are numerous studies that associate the aforementioned to the prefrontal cortex of the brain (Miller,

2000; Roberts et al., 1996; Smith & Jonides, 1999) and these abilities are reported to involve three primary frontal-subcortical circuits: (1) dorsolateral frontal cortex, which projects primarily to the dorsolateral head of the caudate nucleus, (2) ventromedial circuit, which is involved in motivation, starts in the anterior cingulate and projects to the nucleus accumbens, and (3) orbitofrontal cortex projects to the ventromedial caudate nucleus and is associated to socially appropriate behavior (Alvarez & Emory, 2006). Executive functions have also been found to involve the anterior cingulate gyrus, the basal ganglia and diencephalic structures, the cerebellum, deep white matter tracks, and some parts of the parietal lobes (Williams et al., 2009).

RD was positively associated with performance on the AIM. This association can be explained by the assumption that RD involves the individual being sensitive to (social) cues. The AIM, amongst other thing, taps into self-regulation of goal directed behaviors; it gives cues/feedback to the participant in the form of “correct/incorrect” cues (Cassimjee & Murphy, 2010; Henderson & Wachs, 2007). The possibility of a reward - “correct” - may cause behavior that will bring the individual nearer to the reward, such that the individual will more likely continue previously rewarded behaviors. An individual characterized as having high RD is said to have a greater ability to learn from reward cues, as well as perseverance in repeating behavior that is related with reward. This may require the individual to use internal monitoring in order to come into closer proximity to their goal. The added time pressure of the task may also motivate reward-dependent behavior (Cohen et al., 2008; Henderson & Wachs, 2007). Both RD and the AIM have been linked to the prefrontal cortex and share a common underlying neural base. Processing of reward-relevant information involves the orbitofrontal cortex, basolateral amygdala, lateral hypothalamus, and the nucleus accumbens of the ventral striatum (Bergvall et al., 2003; Henderson & Wachs, 2007).

van Leijenhorst, Crone & Bunge (2006) distinguished between risk estimation and processing performance in the decision-making process of an individual. Decision making tasks, such as the AIM entails an estimation of risk and the ability to process performance feedback. Neuropsychological studies in healthy adults found that the orbitofrontal cortex and the anterior cingulate cortex are implicated in risk anticipation

and the ventrolateral prefrontal cortex is implicated in the process of receiving negative feedback.

### **5.2.1.2 Short Penn Logical Reasoning Test (SPVRT)**

The SPVRT is a measure of verbal intellectual ability. It is a multiple-choice task in which the participant must answer verbal analogy problems. The participant must click with the computer mouse on one of the four choices that he/she thinks best fits the analogy presented. It is a forced-choice task (the question will remain on the computer screen until the participant chooses one of the four answers). No feedback is given in terms of correct or incorrect responses. Total number correct and reaction time for correct responses were selected as performance measures.

A positive association was found between RD and reaction time on the SPVRT, which suggests that individuals with higher RD are likely to have slower reaction times on the task of verbal analogical reasoning. This result is in accordance with findings by Cassimjee and Murphy (2010), who explained this relationship by the neurotransmitter noradrenaline and its association with the prefrontal cortex. According to Cloninger et al. (1994), individuals with higher RD are thought to have lower basal rates of noradrenaline in the projections between the locus cereulus and the prefrontal cortex as well as lower cortical arousal levels.

A relationship has been found between variations in brain structure and how it can reflect performance variation in skills and abilities (Johansen-Berg, 2010; Scholz, Tomassini & Johansen-Berg, 2009). Numerous studies have established that the relationship between the brain and personality can be notably specific. Repetitive transcranial magnetic stimulation studies have established the relationship between analogic reasoning and activity in the prefrontal cortex (Boroojerdi et al., 2001). A study by Cohen, Shoene-Bake, Elger and Weber (2009), demonstrated how reward dependence was associated with strength of connection between the striatum and the prefrontal cortex. Neuropsychological and neuroimaging studies have recognized the main role the dorsolateral prefrontal cortex plays in problem solving and working memory. The anterior DLPFC has particularly been shown to be important in difficult

analogous relationship reasoning tasks (Kroger et al., 2002). Functional magnetic resonance imaging was used in a study by Luo et al. (2003) to identify brain areas that are involved in reasoning tasks. They found that activity in the prefrontal cortex and more specifically the dorsolateral prefrontal cortex was associated in analogic reasoning tasks.

Deficits in executive functioning and motivational/reward processes have been found in neuropsychological attention-deficit/hyperactivity disorder (ADHD) studies. Frank, Santamaria, O'Reilly and Willcutt (2007) found that individuals with ADHD have variability in their reaction times and linked it to a dysfunctional noradrenaline process. They showed how selective NA transporter blockers improved deficits in response inhibition; such that NA transporter blockers slow reaction time in responding to tasks. Consequently, this slowing may enable individuals to perform more accurately on tasks. Furthermore, in a study on the effect of cortical noradrenaline depletion on sustained attention performance, Milstein, Lehmann, Theobald, Dalley and Robbins (2007) found that selective cortical NA depletion produced deficits in sustained attention, a prominent feature in ADHD individuals.

A positive association was found between RD and performance accuracy on the SPVRT, which suggests that individuals with higher RD have better performance accuracy. The SPVRT does not give feedback to the participant as to whether their answer was “correct” or “incorrect”. Individuals who are high on RD are said to be socially sensitive and dependent on others approval. Participants who have high RD may take longer on the task but have higher performance accuracy, as it is probably more important for these individuals to choose the right response, thus taking longer on each question.

### **5.2.1.3 Motor Praxis (MPRAXIS)**

The MPRAXIS measures sensory-motor ability. It was utilized in this study to familiarize the participants with the computer mouse. This task has a time aspect to it as the ever-shrinking green box which the participant has to click on, only appears on the screen for 5 seconds before it appears at a different location on the screen.

The total correct responses on the test trial and reaction time for correct responses were found to be inversely related to RD. Participants high on RD seem to have a poorer performance accuracy and perform faster on this task. In a study by Roitman and Shadlen (2002), who studied how the brain transforms motion stimuli into a categorical direction decision, found that response time was inversely related to accuracy.

In contrast to the other neuropsychological tests that measures executive functioning and abstract reasoning, the MPRAXIS measures sensory-motor ability, which may involve different underlying neuropsychological circuits. The lateral prefrontal cortex as well as the orbitofrontal cortex has been associated with the anticipation of a reward involving sensory-motor tasks (Gold & Shadlen, 2002). According to Wickens, Reynolds and Hyland (2003) reward is significant in motor learning. Furthermore, behavior that requires movement is influenced by context. This test does not provide the participant with any form of reward. Thus, with participants high on RD could result in a faster performance and consequently a poorer performance, as completing the test may be reward in itself.

### **5.2.2 Novelty Seeking**

NS entails a heritable bias in the activation of behavior in response to novel stimuli. It is reflected as exploratory activity in reaction to novelty, impulsiveness, excessiveness in approach to stimuli of reward, and active avoidance of frustration (Cloninger et al., 1993). Individuals high on the NS dimension are said to be “quick-tempered, excitable, exploratory, curious, enthusiastic, exuberant, easily bored, impulsive, and disorderly” (Cloninger et al., 1994, p.22). In a study by Cohen et al. (2009) an association between individual differences in novelty seeking behavior was linked to the strength of connection between the striatum and the hippocampus/amygdala.

### **5.2.2.1 Penn Abstraction, Inhibition and Working Memory Task (AIM)**

The AIM assesses abstraction and concept formation with and without working memory. Christoff et al. (2009) studied the organization of the prefrontal cortex according to levels of abstraction. They found that concrete, moderately abstract, and highly abstract information was associated with increased involvement in the ventrolateral, dorsolateral and rostralateral prefrontal regions of the brain respectively. This study demonstrates the central role of the prefrontal cortex in executive functioning (higher mental functioning) by maintaining working memory representations of recent pertinent information, which allows for the processing of such information. Impairments in executive function tend to be global, however, specific abilities such as approaching, planning, self-control (i.e. impulsivity and difficulty making shifts in attention and in ongoing behavior) and defective monitoring of performance are a few of the predominant manifestations of executive functioning that is impaired (Lezak, Howiesen & Loring, 2004).

A significant positive association was found between the AIM, with and without working memory and NS, which indicates that participants high in NS display more accurate performance on these tasks. This is a surprising finding as one would expect the contrary. Cassimjee and Murphy (2010) found that individuals high on NS performed more poorly the LNB2 task, which assess attention and working memory. Keilp et al. (2005) found that individuals high in NS tend to display less accurate performance on tasks that measure sustained attention, such as the Continuous Performance Test. Individuals high on NS are said to be impulsive (amongst other things), which has shown to affect attention needed to hold onto significant information and inhibit extraneous information (Cassimjee & Murphy, 2010; Cloninger et al., 1994). However, this was not found in the present study.

Gray's behavioral approach system (BAS) has been theoretically linked to Cloninger's temperament trait NS. BAS/NS is said to be triggered by stimuli of reward or relief of punishment and initiates behavior. The AIM provides the participant feedback in the form of "correct/incorrect" message. The activation of BAS/NS is said to influence ones behavior in such a way as to bring individuals "into

closer proximity to desired goals and in the presence of cues of rewards, it creates positive feelings” (Henderson & Wachs, 2007). Thus, a possible reason for a more accurate performance may be translated from the need to reach a desired goal and may be intricately linked to emotion, which this study does not take into account. According to Henderson and Wachs (2007), we may be oversimplifying the dynamic nature of neural contributions by categorizing temperament, emotion and cognition into separate domains. Such that the activation of BAS invokes positive feelings, as the individual reaches goals or receives a desired feedback (i.e. correct). From the results it can also be seen that participants high in NS have a slower reaction time on these tasks. Following in the same vein, individuals high in NS may take more time on items of the test, as to ensure reaching a desired goal and/or receiving potential reward in the feedback of “correct”. Furthermore, Bechara (2003) argues that decision-making and impulsiveness may be separate both cognitively and anatomically.

The latter part of the AIM is timed and therefore assesses working memory. One would expect that impulsive individuals would perform faster on timed tasks compared to non-impulsive individuals. In a study by Keilp et al. (2005), who explored the relationship between the trait impulsiveness and performance on neuropsychological tests, the contrary was found; impulsive individuals perform slower when information processing demands and response complexity are increased. This is in line with the role of NS in initiating behavior in reaction to a target signal of reward. A slower performance on the AIM may be due to the novel nature of the situation, as individuals high in NS tend to approach novel stimuli. Since feedback is given to the participant and individuals high on NS had a more accurate performance, this may have motivated these individuals to take more time on the test as to insure receiving positive feedback, as individuals high in NS tend to avoid aversive stimuli (Cloninger et al., 1994).

#### **5.2.2.2 Short Penn Logical Reasoning Test (SPVRT)**

The SPVRT is a measure of verbal intellectual ability. It is a multiple-choice task in which the participant must answer verbal analogy problems. Feedback in the form of

“correct”/“incorrect” is only given during the trial, however thereafter, no feedback is given to the participant. A positive association was found between NS and performance accuracy on the SPVRT, indicating that individuals who are high on NS have better performance accuracy. A positive association was found between NS and reaction time on the SPVRT, which suggests that individuals with higher NS are likely to have slower reaction times on the task of verbal analogical reasoning. According to Keilp et al. (2005) impulsive individuals (individuals high on novelty seeking), tend to perform slower on tasks when there is an increase in information-processing demands. Furthermore, they believe that the trait of impulsiveness is especially associated with verbal abilities, which may be why NS showed a significant association with the SPVRT. The SPVRT may also have posed as a novel situation, which individuals high on NS will tend to be explorative of the situation. The test session only involves eight questions which may not give the participant high on NS enough time to become bored and act impulsively on this task.

The mesolimbic dopaminergic activity is theorized to be involved for the controlling of motor habits and skills. Individuals high on NS are considered to have low basal dopamine release and therefore a compensatory high postsynaptic sensitivity to dopamine in the striatum (Cloninger et al., 1994). Cloninger et al. (1994) reports that high risk Parkinson’s disease individuals perform poorly in NS activities, which can be linked to the role of dopamine in triggering motivation in pleasurable behavior. NS has been found to be negatively correlated with striatal dopamine transporter binding (Cloninger, 2000). Patients with Parkinson’s disease who have never been medicated display noticeably diminished NS, whereas dopamine agonists increase NS behavior. Therefore, the transmission of dopamine in the striatum and its cortical projections - primarily to areas of lateral and orbital regions of the prefrontal cortex – plays a significant role in the manifestation of NS behavior (Amodio et al., 2008; Bódi et al., 2009; Cohen et al., 2009; Wittmann et al., 2008). This study involved a non-clinical sample, whereby only individuals who had no prior medical or psychiatric history were eligible for participation. NS has been reported to be positively associated to the paralimbic cortex, particularly the left cingulate and right insula (Cloninger, 2000). According to Amodio et al. (2008) the left prefrontal cortex is associated with initiation of responses and processing of information that is verbal

and concrete. Furthermore, activity in the left prefrontal cortex has been associated with BAS scores, which consequently may be reflected in high NS scores (McNamara et al., 2008).

### **5.2.2.3 Motor Praxis (MPRAXIS)**

According to Cloninger et al. (1994) NS is foreseen to be related to better behavioral productivity in response to target stimuli. Individuals high in NS have been found to perform slower in finger tapping tasks. However, this study found that individuals high in NS performed faster in the MPRAXIS trial, which measures sensory-motor ability. Furthermore, individuals high in NS had poorer performance accuracy. As already mentioned, the study by Roitman and Shadlen (2002) found that response time was inversely related to accuracy. Therefore, the faster an individual performs the poorer their performance. As previously mentioned, Keilp et al. (2005) found that individuals high in NS display less accurate performance on tasks that measure sustained attention. Impulsiveness, which affects attention, has been associated with individuals high in NS (Cassimjee & Murphy, 2010; Cloninger et al., 1994). Furthermore, controlling for attention is an essential component of “sensory-motor transformation signals in association areas of cortex” (Gold & Shadlen, 2002, p306).

### **5.2.3 Harm Avoidance**

Surprisingly, the temperament dimension HA did not show a significant relationship to executive function and abstract reasoning abilities. The HA dimension dominates research that links temperament and character with neuropsychological functioning (Bergvall et al., 2003; Bond, 2001; Carver & Miller, 2006; Cassimjee & Murphy, 2010; McNamara et al., 2008; O’Gorman et al., 2006; Paulus, Rogalsky, Simmons, Feinstein & Stein, 2003). HA and NS reflect Gray’s BIS and BAS respectively. As already discussed, NS was shown to be significantly associated to executive functioning and one would expect HA to have also been significant on the premise that they are both aspects of the same behavioral system. The neuropsychological battery utilized in this study, may be too specific. Another possible explanation could be that studies that have found HA as the predominant temperament trait had a

small sample size in comparison to this study. Moreover, this study utilized a non-clinical homogenous sample and the limited range in performance and HA levels may have contributed to this.

#### **5.2.4 Character**

In contrast to this study, Bergvall et al. (2003) and Boeker et al. (2006) found a significant association between Cloninger's character dimensions and neuropsychological performance, while no significant association was found between the temperament traits and accuracy of performance on the neuropsychological tests. Character is believed to be environmentally influenced (acquired rather than innate), dependent on an individual's experiences and influenced by cultural and social influences (Prosnick et al., 2003). Contextual and psychosocial factors were not taken into consideration in this study, which could have confounded the relationship between the character dimensions of the TCI and neuropsychological performance. According to Mardaga and Hansenne (2007) who researched the connection between Cloninger psychobiological model of personality with Gray's BIS and BAS system, found that Cloninger's character dimensions did not correlate with the BIS/BAS scales. They concluded that only Cloninger's temperament dimensions can be linked to innate and neurobiological underpinnings. Due to the focus on executive functions, character may be associated with other neuropsychological components not tested with this studies specific executive functions tasks.

### **5.3 LIMITATIONS OF THE RESEARCH PROJECT**

The computerized PennCNP battery utilized in this study measured specific aspects of executive functions and abstract reasoning. It comprises one set of executive functions tests, which may or may not represent executive functioning solely. Both personality - as defined by Cloninger - and executive functioning are multifaceted and complex constructs that involve complex and intricate relationships in the brain. Therefore, a more extensive selection of neuropsychological tests that assess different aspects of neurological performance will be advantageous in furthering this domain of research. Furthermore, executive functions rely on functioning "lower-

level” aspects of cognition, for example visual-spatial perception, short term memory and long term memory, which were not assessed or taken into account in this study.

Despite the benefit of having a large sample in this study, the socio-demographics of the sample is for the most part homogenous, particularly in regard to age and level of education reached. Furthermore, the sample may be biased as it only involves a tertiary population and does not take into account the participants overall cognitive ability and how that may influence the data. In the same vein, this sample excluded participants with any history of psychiatric or medical illnesses and therefore this study only applies to a non-clinical population. This study involved a single test situation, where individual performance may have been influenced by external/contextual factors that were not taken into account.

The sample is further restrictive as it comprises of young varsity students, which makes the study not completely generalizable to a more cognitive diverse samples, including young children, the uneducated and the elderly for example.

#### **5.4 RECOMMENDATIONS FOR FUTURE RESEARCH**

This research study found a moderately significant association between temperament, character and executive functioning, which provides motivation for further research. It is therefore recommended that future larger scale studies include:

- Both clinical and non-clinical samples, with more heterogeneous socio-demographics given the influence of psychosocial aspects on the performance on neuropsychological tests.
- Utilize a wider selection of neuropsychological tests that involve different aspects of executive ability and performance.
- Utilize neuropsychological tests that assess other neuropsychological functions including emotion processing, which has been theoretically associated with character dimensions.

## 5.5 CONCLUSION

This explorative study found a moderate association between temperament and character dimensions and participants' performance on computerized neuropsychological tasks. Furthermore, it found that temperament and character dimensions account for only a small percentage of the variance in the executive performance indices. In particular performance on abstraction and concept formation with and without working memory and verbal reasoning ability and reaction time on sensory-motor abilities were found to be the primary facets of executive functioning that contributed to the relationship between temperament, character and neuropsychological performance. RD and NS were found to be the primary contributors to the relationship. Furthermore, these two temperament dimensions were found to be positively related to performance on abstraction and concept formation with and without working memory and verbal reasoning ability variables (AIM-NM, AIM, SPVRT respectively) and inversely related to reaction time on sensory motor function (MPRAXIS).

Through available literature these results were explained and linked to the initial premise that temperament and executive functioning share common underlying neuroanatomical sites and processes, as well as common neurotransmitter involvement. This explorative study will append to the scant neuropsychological research in South Africa, particularly the neuropsychological research involving cognitively intact individuals. Lastly, this study verifies the need for more neuropsychological research, particularly in South Africa.

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