

# **Temperament and character correlates of emotional processing**

**by**

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**A mini-dissertation submitted in partial fulfilment of the  
requirements for the degree**

**MA Clinical Psychology**

**in the Department of Psychology at the**

**UNIVERSITY OF PRETORIA**

**FACULTY OF HUMANITIES**

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**April 2013**

## Acknowledgements

My sincere thanks to

Prof N. Cassimjee,

Dr L. Fletcher,

and

Ms J. Sommerville,

with

special thanks to

Marybeth Rouse

## Abstract

A hypothesised association between personality and emotional processing was investigated within the framework of Cloninger's psychobiological theory. According to this model, personality development is based on the interaction between two domains: temperament and character. A non-experimental, correlational design was applied, using existing data from a sample of 630 South African first year psychology students who completed the Temperament and Character Inventory (TCI) and the University of Pennsylvania Computerised Neuropsychological Test Battery (PennCNP). Canonical correlation analysis yielded significant associations between character variables Self-Directedness, Cooperativeness, and Self-Transcendence as measured and defined by the TCI and items from Penn Facial Memory Test (CPF) and Penn Emotion Discrimination Task (ED40), respectively. In this exploratory study participants lower in Self-Directedness and Cooperativeness were more efficient in facial recognition compared to participants higher in these dimensions. Conversely, individuals higher in Self-Directedness and Cooperativeness were more accurate in the discrimination of happy and sad emotions, respectively. Participants with higher Self-Transcendence performed better in facial recognition but were less accurate in discriminating between happy and sad faces. These results affirm the importance of further research into the association between temperament and character and emotional processing.

**Key Terms:** character; emotional processing; psychobiological theory; personality; temperament

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## Chapter 1

### Introduction

Theoretical postulates have long asserted that a relationship exists between emotional states and personality (Brown, Svrakic, Przybeck, & Cloninger, 1992). These postulates have been investigated through the use of measures of personality and emotional stimuli (Berpohl et al., 2008; Kovalenko & Pavlenko, 2009; Peirson & Heuchert, 2001); longitudinal studies of emotional and personality development (Brown et al., 1992); and in terms of predisposing personality factors in psychopathology (Stadler et al., 2007). In this study, personality is operationalised using Cloninger's psychobiological model of personality which consists of temperament and character dimensions (Cloninger, Przybeck, Svrakic, & Wetzel, 1994; Cloninger, 1987). Emotional processing is a term used to describe how individuals' process emotional information, which includes the perception, expression and experience of emotion (Demaree, Everhart, Youngstrom, & Harrison, 2005).

Personality is a broad concept with researchers adopting a myriad of definitions and explanations including emotional, cognitive, behavioural, neurophysiological, developmental, and genetic aspects (cf. Allport, 1937; Cattell, 1950; Cloninger, Svrakic, & Przybeck, 1993; Eysenck, 1947; Gray, 1987; Zuckerman, 1991). Contemporary researchers have adopted dimensional models of personality in a move away from older models that employ fixed categories (Verweij et al., 2010), and many have investigated the neurobiological basis of personality (e.g., Bond,



2001; Depue & Collins, 1999; Gardini, Cloninger, & Venneri, 2009; Whittle, Allen, Lubman, & Yücel, 2006). Rapid progress has been made due, in part, to the availability of valid and reliable multi-dimensional personality inventories (Cloninger, 2000). Additionally, hypothesis-driven research has linked personality dimensions to results from the expanding fields of neurophysiology, neurochemistry, and neurogenetics (Cloninger, 2000).

A considerable amount of personality research has also investigated the role of personality in psychopathology. Numerous studies have linked personality profiles to specific psychopathologies, highlighting the role of personality in the aetiology of psychiatric disorders (e.g., Ball, Smolin, & Shekhar, 2002; Celikel et al., 2009; Hansenne et al., 1999; Nery et al., 2009). Advancements have also been made in the area of emotional processing, identifying distinct emotional constellations with specific psychopathologies (e.g., Addington, Saeedi, & Addington, 2006; Aigner et al., 2007; Mayes, Pipingas, Silberstein, & Johnston, 2009; Pomarol-Clotet et al., 2010; Surcinelli, Codispoti, Montebanocci, Rossi, & Baldaro, 2006). Yet few studies have investigated personality-related perceptual biases relating to emotional processing (Canli, 2004; Knyazev, Bocharov, Slobodskaya, & Ryabichenko, 2008; Leikas & Lindeman, 2009; Mayes et al., 2009). This aspect of personality research is under-represented in the literature. The present study aims to address this gap through an investigation into the associations between personality dimensions and emotional processing. This will expand the current data and contribute to understandings of the relationship between personality and emotion.

## 1.1 Problem Statement

The impetus behind attempting to relate the psychological domains of personality and emotional processing was based on two considerations. First, the established associations between temperament and character dimensions and psychopathology (Aigner et al., 2007; Ball et al., 2002; Bergvall, Nilsson, & Hansen, 2003; Black et al., 2009; Celikel et al., 2009, 2010; Ha, Kim, Abbey, & Kim, 2007; Joyce et al., 2003; Kohler, Bilker, Hagendoorn, Gur, & Gur, 2000; Marijnissen, Tuinier, Sijben, & Verhoeven, 2002; Nery et al., 2008, 2009; Peirson & Heuchert, 2001; Richter, Polak, & Eisemann, 2003; Sachs, Steger-Wuchse, Kryspin-Exner, Gur, & Katschnig, 2004; Schneider et al., 2006; Svrakic & Cloninger, 2010; Svrakic et al., 2002). Second, the distinct emotional processing profiles associated with specific psychiatric disorders (Aigner et al., 2007; Gotlib, Yue, & Joormann, 2005; Koenigsberg et al., 2009; Kohler et al., 2000; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; McLaughlin, Mennin, & Farach, 2007; Sachs et al., 2004; Schneider et al., 2006). Together, these findings suggest a theoretical link between temperament and character and emotional processing. This theoretical association is supported by findings from two studies: Yoshino, Kimura, Yoshida, and Nomura (2005) found an association between temperament dimensions and different patterns of unconscious emotional responses; and Bermpohl and colleagues (2008) reported a correlation between Novelty Seeking (a temperament trait) and the anticipation of emotional stimuli.

Specific temperament traits are also related to Gray's (1987) Behavioural Approach System (BAS) and Behavioural Inhibition System (BIS), respectively (Mardaga &

Hansenne, 2007). Briefly, BAS activates behaviour in response to reward cues, while BIS relates to responses to punishment, novelty and fear stimuli (Gray, 1991; Pickering & Gray, 1999). Cloninger (1987) posited that BAS/BIS are theoretically proximate to specific temperament traits, and subsequently have been shown to have similar neurobiological bases to temperament (Gerra et al., 2000; Hansenne et al., 1999). Thus, evidence linking BAS/BIS with emotional processing (e.g., Adams, Ambady, Macrae, & Kleck, 2006b; Gomez & Gomez, 2002; Heponiemi, Keltikangas-Järvinen, Puttonen, & Ravaja, 2003; Mardaga & Hansenne, 2009a) provides indirect support for the correlation between temperament and emotional processing, respectively.

## **1.2 Research Question**

The importance of this exploration is twofold: Research has shown that (1) specific psychopathologies have distinct emotional processing profiles; and (2) specific temperament and character traits predispose individuals to certain psychopathologies. Taken together this generates the question underlying this study: Does a relationship exist between temperament and character (predisposition to psychopathologies) and emotional processing (sub-clinical signs) in a non-clinical sample?

### 1.3 Research Aim

Within the personality literature, few studies have addressed personality-related biases in emotional processing, yet emerging data does support this association. The aim of this study is to elucidate the association between temperament and character and emotional processing and, in so doing, contribute to this nascent area of personality research. Broadly, this investigation will contribute to current understandings of the dynamic interactions between personality and emotion.

### 1.4 Chapter Synopsis

The following chapter (Chapter 2) locates this study within the broad field of personality research. Cloninger's psychobiological theory of personality provides the theoretical basis of the study and is discussed in the context of other biosocial models. Additionally, the construct of emotional processing is operationalised. The methods are presented in Chapter 3 which outlines the procedures used in this empirical investigation including sampling, psychometric instruments, research design, and ethical considerations. The results are presented and explained in Chapter 4. The data are analysed using descriptive and inferential statistics. The final chapter (Chapter 5) presents the discussion of the findings. The relevance of the results is discussed within the context of the theory and literature presented in Chapter 2. The limitations of this study are reviewed, followed by recommendations for further research. The chapter ends with the final conclusion to the study.

## Chapter 2

### Literature Review

This chapter provides the contextual background and outlines the theoretical framework for the present study. Theoretical postulates (e.g., Cloninger, 1987) and empirical evidence (e.g., Berman et al., 2008; Brown et al., 1992; Kovalenko & Pavlenko, 2009; Stadler et al., 2007) point to a theoretical association between personality dimensions and emotional processing. Current directions in personality theory posit dimensional models of personality (Verweij et al., 2010) and reflect the move toward understanding the neurobiological basis of personality (e.g., Bond, 2001; Depue & Collins, 1999; Gardini et al., 2009; Whittle et al., 2006). Personality dimensions have also been linked to results from the fields of neurophysiology, neurochemistry, and neurogenetics (Bond, 2001; Gardini et al., 2009; Nilsson et al., 2007; O’Gorman et al., 2006; Turner, Hudson, Butler, & Joyce, 2003; Vormfelde et al., 2006). Similarly, research has investigated the neurobiology of emotional processing (Baeken et al., 2009; Habel et al., 2007; Le Doux, 2003; Mayes et al., 2009; Yang et al., 2002). The focus of several studies has been the recognition and discrimination of facial emotions, which is considered essential for effective social communication and interaction (Adams et al., 2006; Kamio, Wolf, & Fein, 2006).

## 2.1 Overview

The concept of personality and interest in the human psyche dates back thousands of years (Henderson & Wachs, 2007). Recent constructs suggest that personality is a complex description of a person involving patterns of thinking, feeling, and behaving that is relatively consistent over time and context (Demaree et al., 2005). Human individuality is variously and, at times, analogously described as temperament, personality, or character. Several biosocial models of personality exist that attempt to describe the relationship between biology, genetics, and personality, such as Eysenck (1947, 1967, 1990), Gray (1991), and Cloninger (Cloninger et al., 1993; Cloninger, 1986, 1987). Contemporary theories tend to have dimensional models of personality and share, at least, a modest degree of overlap.

In this study, personality is operationalised using Cloninger's theory of personality as it incorporates concepts and research findings from several fields including the neuroanatomy of behaviour and learning; and developmental, social and clinical psychology (Cloninger et al., 1994, 1993; Cloninger, 1987). Moreover, Cloninger's theory with its corresponding psychometric instrument, the Temperament and Character Inventory (TCI), has been utilised in thousands of peer-reviewed studies, many with replicable findings in the fields of genetics, neurobiology, and psychopathology (de la Rie, Duijsens, & Cloninger, 1998). The validity and reliability of the TCI, both in its original form and several translations thereof, has been established (Goncalves & Cloninger, 2010). What follows is a brief overview of key

psychobiological perspectives of personality, followed by a detailed description of Cloninger's theory and its links to emotional processing.

## **2.2 Psychobiological Perspectives of Personality**

Psychobiological perspectives are variously defined as biological, biosocial, or biopsychosocial. These theories of personality incorporate genetic, biological, and social factors. Commonly, biologically-orientated theorists use personality and temperament interchangeably within their models (e.g., Eysenck, 1967; Gray, 1987), but the descriptions of these terms vary between models. Different features have been attributed to personality which has been investigated through both top-down (e.g., Eysenck, 1967) and bottom-up (e.g., Gray, 1987) approaches. These theories are based on evidence from psychophysiological research and acknowledge genetic contributions to personality variance. In top-down approaches, identified personality traits are correlated with data from physiology, biochemistry, neurology, and genetics (Zuckerman, 2005). Bottom-up approaches draw on bio-behavioural knowledge from animal studies to create models of human personality and behaviour (Gosling, 2001).

Eysenck (1967), Gray (1973), and Strelau (1983) adopted the fundamental principles of arousal theory which has its basis in Pavlovian theory. Pavlov argued that properties of the central nervous system (CNS) regulate behaviour including motor actions, verbal activity, and emotional reactions (Strelau, Angleitner, Bantelman, &

Willbald, 1990). Pavlov's theory centres on individual differences in the ability to endure intense stimulation based on processes of excitation, inhibition, and mobility. Excitation refers the CNS capacity to withstand intense or enduring stimulation without exhibiting protective inhibition and maintaining this state of conditioned inhibition (Strelau et al., 1990). According to Pavlov's theory, individual differences in excitatory and inhibitory CNS processes determine individual approaches to external demands (viz., degrees of threat, risk & tension) and hence personality (Henderson & Wachs, 2007). Eysenck's concept of cortical arousal is linked to Pavlov's assertion of CNS strength (i.e., the capacity of the CNS to endure intense stimulation).

### **2.2.1 Hans Jürgen Eysenck (1916-1997)**

For Eysenck (1947), mechanisms of cortical arousal and activation are mediating factors in personality which generally correspond to Pavlov's concepts of CNS strength, excitation, and activation. Eysenck is considered a pioneer in his attempts to relate temperament to differences in cortical arousal (Whittle et al., 2006; Zuckerman, 2012). Eysenck (1967) developed a three-factor biosocial model of personality comprising of the factors psychoticism, extraversion, and neuroticism known as the PEN model. This represents a top-down approach as these factors were drawn from psychobiological and learning theory before being investigated empirically.



Eysenck's theory draws on Jung's concepts of extraversion and introversion. These terms were incorporated in Eysenck's theory; however, the meanings of these terms were altered. Jung used introversion to refer to the personality of persons with schizophrenia and extraversion to persons with hysteria (Eysenck, 1947, 1990). In Eysenck's (1967) terminology extraverts are described as individuals that are generally sociable, outgoing, active, and optimistic; in contrast, introverts tend to be quiet, passive, and careful. Thus, extraversion refers to an outward tendency toward the social environment and a dependence on external factors; whereas, introversion is inward focused and less dependent of the social environment (Eysenck, 1990). Differences in extraversion are associated with differences in cortical arousal, while differences in introversion are associated with autonomic arousal. Within the PEN model, neuroticism refers to individual differences in reactivity to negative stimuli; individuals high in this dimension tend to be more negatively reactive compared to their more "stable" counterparts (Zuckerman, 2005). Lastly, psychoticism is considered the opposite of impulse control and includes personality traits such as aggression, coldness, egocentrism, and impulsiveness (Strelau, 1998).

### **2.2.2 Jeffrey Alan Gray (1934-2004)**

Another prominent biosocial theory is Gray's Reinforcement Sensitivity Theory (RST). Gray (1973) had a profound impact on the way personality was conceptualised at the time; and his influence on other theorists and his contribution to the neuropsychology of personality is widely acknowledged (Matthews & Gilliland, 1999). Gray proposed that personality traits are motivational systems which are related to stimuli that are

associated with positive and negative enforcement (Depue & Collins, 1999). Personality differences reflect variation in the sensitivity to various stimulus classes (sensitivity corresponds to neurobiological reactivity). Gray explored biochemical, neuropsychological, and behavioural mechanisms of personality using data from neurobiological animal studies (conducted mainly on rats).

The advantage of Gray's animal research was that he could conduct experiments of brain function that is not possible in human subjects (Zuckerman, 2012). The observations of responses to stimuli of reward and punishment formed the basis of his animal learning paradigm (Corr, 2002). Gray's research thus represents a bottom-up approach in contrast to Eysenck's top-down approach. Animal-derived models of neurochemical function together with human findings form the basis of Gray's neurochemical structure of personality (Gosling, 2001). He developed neurobehavioral models consisting of several traits: This dimensional view of personality became the impetus for subsequent multi-dimensional models, including those of Cloninger (1986) and Zuckerman (1991).

Gray's revised theory focuses on the interactions between three behavioural systems: the behavioural activation system (BAS), the behavioural inhibition system (BIS), and the fight-flight-freezing system (FFFS) (Gray & McNaughton, 2000). According to this model, the BAS is activated in response to conditioned and unconditioned signals of potential reward or relief from punishment, and thus mediates behaviour. The BIS, in turn, is activated in response to concurrent conflicting goals. This system is responsible for behavioural inhibition and risk

assessment and is associated with anxiety. The BAS/BIS system is similar to Eysenck's PEN model as there is considerable overlap between BAS and extraversion on the one hand and BIS with neuroticism on the other. Lastly, the FFFS controls escape and active avoidance behaviour, mediating the emotions of fear and panic. Concerning neurological substrates to these systems, mainly the septohippicampal system has been implicated which includes noradrenergic and serotonergic pathways (Corr & Perkins, 2006).

### **2.2.3 Jan Strelau (1931- )**

Strelau (1983) developed the Regulative Theory of Temperament (RTT) based on Pavlovian principles of strength of excitation, strength of inhibition, and mobility. As mentioned above, Pavlov's seminal biological theories investigated the role of the CNS through individual differences in motivation and emotion (Henderson & Wachs, 2007). Compared to Eysenck and Gray, Strelau retained the emphasis on arousal: The construct of arousal is at once physiological and psychological, which corresponds with the aforementioned theories of Eysenck and Gray.

According to RTT, temperament is conceptualised as a regulatory process between individuals and their relationship with the external world. It refers to formal characteristics of behaviour which include two basic categories: energy (i.e., intensity of behaviour) and time (Strelau & Zawadzki, 1995). Two temperament traits were considered important to this regulatory process: reactivity and activity (Strelau, 1993).

RTT posits that there are stable differences between individuals in terms of these formal categories of behaviour (Strelau, 1996). Thus, Strelau's theory posits that endurance and emotional reactivity together modulate the psychological impact of various stimuli (Jamrozinski & Zajenkowski, 2012).

### **2.3 Cloninger's Psychobiological Theory of Personality**

The aforementioned theories have substantial overlap and provide the contextual milieu for Cloninger's theory. Eysenck's PEN model, Gray's three systems (BAS, BIS, and FFFS) and Strelau's RTT all posit a neurobiological basis of personality but differ in their varying conceptualisations of arousal. Additionally, these models all relate personality variance to differences in reactive and self-regulatory behaviours associated with the CNS.

Cloninger developed his theory around the same time as Strelau and aimed to deconstruct psychiatric disorders into quantifiable personality dimensions that for him represented the building blocks of both wellbeing and psychopathology. According to his theory, personality develops through the interaction between genes and the environment (Cloninger, 1986). Cloninger (1987) rejected factor analytic models on the basis that these approaches did not account for the complex genetic factors in personality development. Notably, he disagreed with Eysenck's postulate that phenotypic and genotypic personality structures are equivalent (Cloninger et al.,

1994; Cloninger, 1986). Cloninger's model (1986, 1987) incorporated information from several fields including genetics, psychology, and psychiatry.

An important influence in the development of Cloninger's theory was his early collaborations with Michael Bohman and Sören Sigvardsson. Their studies focused on the role of gene-environment interactions on personality development, and the important role of personality in psychopathology (Bohman, Cloninger, Sigvardsson, & von Knorring, 1982; Cloninger, Bohman, & Sigvardsson, 1981; Sigvardsson, von Knorring, Bohman, & Cloninger, 1984). Based on these collaborations, Cloninger integrated social and biological components into his theory (Cloninger et al., 1993; Cloninger, 1987) and postulated that personality development is based on the interaction between the domains of temperament and character (Cloninger et al., 1994, 1993; Cloninger, 1994).

According to Cloninger's model, temperament refers to individual differences in associative learning in response to novelty, danger, punishment, or reward. Temperament precedes character development, whilst character traits develop later in life through socio-cultural experience and person-environment interaction. Svrakic and Cloninger (2010, p. 158) describe the temperament dimensions as "the biological 'core' of personality" whereas the character dimensions are referred to as "the 'adaptive interface' of personality." The following sections elaborate on temperament and character. Additionally, specific sections address psychometric measures of personality, neurophysiological and neuroanatomical substrates, and psychopathology.

### 2.3.1 Temperament dimensions

Temperament refers to heritable personality traits which have a neurobiological basis (Gardini et al., 2009; Henderson & Wachs, 2007; Katsuragi et al., 1999). Temperament traits and associated behaviour habits develop in early life through associative learning and synaptic strengthening that creates stable affects, percepts, and procedural memory (Svrakic & Cloninger, 2010). There are four temperament traits: Harm Avoidance (HA), Novelty Seeking (NS), Reward Dependence (RD), and Persistence (P).

The temperament trait of HA refers to responsiveness to possible punishment (i.e., cautious, fearful, or pessimistic) and reflects an inhibitory response to signals of aversive stimuli that lead to avoidance of punishment and non-reward. Persons with high-HA are characterised by cautiousness and apprehensiveness, whereas individuals with low-HA are confident and energetic. The dimension NS reflects responsiveness to potential rewards (i.e., curious, avoidance of monotony, impulsive). This dimension is defined as the tendency to respond actively to novel stimuli in order to pursue rewards and avoid punishment, and is considered the dimension of behavioural activation. High-NS individuals are regarded as impulsive and excitable, whilst low-NS individuals are seen as stoic and rigid. The definition of RD is the tendency of individuals to maintain on-going behaviours in order to receive a positive response to conditioned signals of reward and denotes social dependency (i.e., compassionate, warm, sensitive). Lastly, P refers to behavioural perseverance

in spite of frustration and fatigue (Bergvall et al., 2003; Cloninger et al., 1993; Hansenne et al., 1999; Yoshino et al., 2005).

### **2.3.2 Character dimensions**

Character refers to individual differences in goals, values, and self-concepts; traits “involve conceptual and insight learning and higher cognitive processes of symbolic representation, logic, propositional memory, etc.” (Svrakic & Cloninger, 2010, p. 159). Character consists of three dimensions, Self-directedness (SD), Cooperativeness (C), and Self-Transcendence (ST). The SD dimension includes an individual’s maturity and self-acceptance and reflects an individual’s ability to act according to personal goals and values; C reflects social acceptance and identification with others; and ST captures spiritual acceptance and identification within the broader world (Bergvall et al., 2003; Celikel et al., 2010). These three dimensions, mature with the learning of self-concepts, and the influence of personal and social effectiveness in adulthood (Celikel et al., 2010). In contrast to temperament, the origins of the character dimensions are posited as environmental (i.e., socio-cultural), though possible genetic contributions are not rejected (Ando et al., 2002; Gillespie, Cloninger, Heath, & Martin, 2003). It is hypothesised that either character may have common genetic correlates, or character traits develop from temperament.

Executive functions, such as being responsible, purposeful and resourceful, are related to SD. Therefore, a low-SD individual is described as irresponsible, aimless, and inept. Part of C includes legislative functions of being tolerant, forgiving, and helpful; uncooperative individuals are described as hostile, aggressive, and opportunistic. Finally, ST refers to judicial functions, such as being intuitive, judicious, and aware. Those individuals low in ST display conventional and materialistically orientated behaviour with little or no concern for absolute ideas such as goodness and universal harmony (Cloninger et al., 1994; Cloninger, 1994).

### **2.3.3 Cloninger's psychometric instruments**

The availability of multi-dimensional assessments of personality has provided comprehensive methods of assessing personality through the use of self-report questionnaires (Cloninger, 2000; De Fruyt, Van De Wiele, & Van Heeringen, 2000). The Temperament and Character Inventory (TCI) is a psychometric instrument that was developed to measure temperament and character factors. Cloninger (1986) initially developed the Tri-Dimensional Questionnaire (TDQ), a 100 item self-report instrument which corresponds with the original three dimensions of temperament. The TCI followed in 1993, which expanded the TDQ to include character dimensions based on Cloninger's revised 7-factor model (Cloninger et al., 1994, 1993). Both temperament and character are operationalised in this self-report questionnaire.



The validity and reliability of the TCI (both in its original form and several translations thereof) has been established in the United States and several other countries including China, France, Germany, and Sweden. The TCI has also been widely used across cultures and in different contexts such as Belgium, Finland, Hungary, Netherlands, Poland, South Africa, South Korea, and Turkey (Brändström, Sigvardsson, Nylander, & Richter, 2008; Cho et al., 2008; Cloninger et al., 1994, 1993; de la Rie et al., 1998; du Preez, Cassimjee, Ghazinour, Lauritz, & Richter, 2009; Goncalves & Cloninger, 2010; Miettunen, Kantojärvi, Veijola, Järvelin, & Joukamaa, 2006; Pelissolo et al., 2005; Ravaja, Keltikangas-Jarvinen, & Kettunen, 2006; Richter, Brändström, Emami, & Ghazinour, 2007; Sung, Kim, Yang, Abrams, & Lyoo, 2002). The TCI has been utilised in thousands of peer-reviewed studies, many of which have replicable findings in fields such as genetics, neurobiology, and psychopathology (de la Rie et al., 1998; Goncalves & Cloninger, 2010).

The TCI is efficient in providing a description of personality or personality profile using TCI dimensions. Most research has utilised its seven higher order scale scores, rather than its 25 subscales (Goncalves & Cloninger, 2010). Clinical experience suggested that the distinctions between subscales contained valuable information, but the persistence dimension only consisted of one subscale. Consequently, the TCI was revised and amongst other changes, the TCI-R included additional subscales to P and RD without altering the original constructs of these dimensions. Test-retest reliability was validated by Pelissolo and colleagues (2005), and Martinotti et al. (2008).

### **2.3.4 Neurophysiological and Neuroanatomical Substrates**

Cloninger (1986) asserted that variations in temperament and character have neurobiological basis, a key aspect of his theory. Research has demonstrated that individual differences in particular character traits are associated with cerebral blood flow, neurochemistry, molecular genetics, and variations in brain structure (Cloninger, 2000; Urgesi, Aglioti, Skrap, & Fabbro, 2010; van Schuerbeek, Baeken, De Raedt, De Mey, & Luybaert, 2011). Likewise, temperament dimensions have several discernable biogenetic correlates (Ando et al., 2002; Gardini et al., 2009; Gillespie et al., 2003; Lidaka et al., 2006; Serretti et al., 2007). The TCI has facilitated research in this area contributing toward a better understanding of the relationship between personality dimensions and various brain structures and systems. The neurobiological underpinnings are discussed below in relation to neuroimaging, cerebral blood flow, regional brain glucose metabolism, and central neurotransmitter systems.

#### **2.3.4.1 Neuroimaging**

Advances in neuroimaging techniques have significantly contributed toward present understandings of the relationship between temperament dimensions and various brain structures and systems. Research in this area has indicated that NS is associated with perfusion in the cuneus, cerebellum and thalamus, and HA with perfusion in the cuneus, medial frontal gyrus and cerebellar vermis (O’Gorman et al., 2006). Additionally, NS has been positively correlated with grey matter volume in

frontal and posterior cingulate regions, and HA negatively correlated with grey matter volume in orbito-frontal, occipital, and parietal structures (Gardini et al., 2009). Persistence has been associated with specific areas in the lateral orbital and medial prefrontal cortex and the ventral striatum (Gusnard et al., 2003), as well as with grey matter volume in the precuneus, paracentral lobule, and parahippocampalgyrus (Gardini et al., 2009). Research has shown negative correlations of RD with grey matter volume in the caudate nucleus and in the rectal frontal gyrus (Gardini et al., 2009). Lastly, ST has been correlated with cerebral grey matter volume at the border of the temporal, parietal, and frontal cortices (Kaasinen, Maguire, Kurki, Brück, & Rinne, 2005).

#### 2.3.4.2 Cerebral blood flow

Turner, Hudson, Butler, and Joyce (2003) reported all seven character and temperament dimensions to be significantly related to regional cerebral blood flow (rCBF). Increased levels of each trait corresponded to activations and deactivations in specific brain areas. Regarding temperament traits, individual differences have been investigated in relation to specific differences in rCBF using single photon emission computed tomography (PET). For instance, Sugiura et al. (2000) found significant relationships between three temperament dimensions (i.e., NS, HA, & RD) and rCBF. The authors found NS to be mainly associated with activity of the paralimbic cortex; whereas, HA and RD are associated with the activity of both the neocortical regions and the paralimbic cortex. Additionally, NS is associated with rCBF values in the anterior cingulate, and anterior and posterior insula (Gardini et al.,

2009). The anterior cingulate is involved in modulating autonomic emotional responses and the regulation of social behaviour (Kim et al., 2009; Pujol et al., 2002); while, the insula is associated with emotional reactions to pain and may even be involved the perception of other people's emotions and the experience thereof (Mauguiere, 2010). Concerning HA, rCBF values indicate a negative association with the parahippocampal and fusiform gyri (Gardini et al., 2009). The former refers to part of the limbic system associated with the expression of emotional behaviour (Zillmer & Spiers, 2001) and the latter the perception of facial emotional expression (McCarthy, Puce, Gore, & Allison, 1997).

#### 2.3.4.3 Regional brain glucose metabolism

Researchers have also investigated the relationship between temperament and regional brain glucose metabolism using [<sup>18</sup>F] fluorodeoxyglucose positron emission tomography, which provides information on brain activity (Gardini et al., 2009; Hakamata et al., 2006; Youn et al., 2002). Patterns of brain glucose metabolism correspond with activity in specific brain areas. These studies reported significant correlations between temperament dimensions and specific brain regions; however, the results differed significantly in terms of the brain areas identified.

#### 2.3.4.4 Central neurotransmitter systems

Particular temperament and character dimensions have been linked to specific central neurotransmitter systems. For instance, HA has been associated with variance in serotonergic activity, although the nature of this association is unclear (Carver & Miller, 2006; Hansenne & Anseau, 1999; Moresco et al., 2002; Peirson et al., 1999). Hypothesised links between temperament dimensions and different neurotransmitters have also been investigated: dopamine for NS and noradrenaline for RD, though the results are not consistent across studies (cf. Ando et al., 2002; BERPohl et al., 2008; Herbst, Zonderman, McCrae, & Costa Jr, 2000; Munafò et al., 2003; Sugiura et al., 2000; Suhara et al., 2001; Youn et al., 2002). Lastly, ST has been related to the serotonergic and dopaminergic systems (Borg, Andree, Soderstrom, & Farde, 2003; Nilsson et al., 2007).

In sum, the neurological basis of Cloninger's theory has been widely researched. Several discernable biogenetic correlates have been identified in neuroanatomy, neurophysiology, and neurochemistry. Most of the studies to date have focused on the temperament dimensions, presumably as these traits have a well-established heritable base and remain relatively stable over time. Several methods have been utilised, including different types of brain imagery, cerebral blood flow, and brain glucose metabolism. Generally, temperament dimensions have been correlated with the limbic system, which plays an important role in emotional processing.

### **2.3.5 Temperament, character, psychopathology and emotional processing bias**

Cloninger's model is commonly used in contemporary psychiatric practice as a means to describe individual differences in psychopathological behaviour and is a valid measure of maladaptive facets of behaviour (De Fruyt et al., 2000). Numerous studies have considered the influence of temperament as an important component underlying or affecting psychopathology, including anxiety disorders (e.g., Aigner et al., 2007; Ball et al., 2002; Matsudaira & Kitamura, 2006; Wachleski et al., 2008); bipolar mood disorder (e.g., Di Nicola et al., 2010; Engström, Brändström, Sigvardsson, Cloninger, & Nylander, 2004; Loftus, Garo, Jaeger, & Malhotra, 2008; Nery et al., 2008); depressive disorders (e.g., Celikel et al., 2009, 2010; Hansenne et al., 1999; Marijnissen, Tuinier, Sijben, & Verhoeven, 2002; Nery et al., 2009; Richter, Polak, & Eisemann, 2003); eating disorders (e.g., Abbate-Daga, Gramaglia, Malfi, Pierò, & Fassino, 2007; Grucza, Przybeck, & Cloninger, 2007); and personality disorders (Black et al., 2009; Ha et al., 2007; Joyce et al., 2003; Joyce, Light, Rowe, Cloninger, & Kennedy, 2010; Kantojärvi et al., 2008; Korner, Gerull, Stevenson, & Meares, 2007; Svrakic & Cloninger, 2010; Svrakic et al., 2002). Similarly, character traits have been linked to anxiety disorders (Cruz-Fuentes, Blas, González, Camarena, & Nicolini, 2004; Raszka, Prako, & Kopřivová, 2009; Wachleski et al., 2008); depressive disorders (Balsamo, 2012; Haugan & Innstrand, 2012; Smith, Duffy, Stewart, Muir, & Blackwood, 2005); and personality disorders (Bergvall et al., 2003).

### 2.3.5.1 Temperament and Character profiles and psychopathology

Research has shown that personality dimensions play a complex role in various psychiatric disorders. Temperament may predispose individuals to specific psychiatric illnesses and may modify the clinical presentation and course of the particular disorder via the interplay between temperament and character (Celikel et al., 2009). Specific TCI profiles are associated with particular disorders. For example, patients with depression have a unique profile of temperament and character dimensions presenting with higher HA and lower SD (Celikel et al., 2009, 2010) and higher ST and lower C compared to healthy controls (Hansenne et al., 1999; Nery et al., 2009). Similar profiles have been reported for other mood disorders (Nery et al., 2008), such as HA which has been reported to be the most important dimension associated with anxiety disorders (Ball, Smolin, & Shekhar, 2002).

A considerable portion of the literature focuses on the relationship between temperament and character and various personality disorders. Each personality disorder (PD) has a specific combination of temperament dimensions (Kantojärvi et al., 2008) and generally low scores on character dimensions (Bergvall et al., 2003; Svrakic et al., 2002). It has been shown that extreme temperament scores distinguish the four clusters of personality disorders: low-RD scores are associated with cluster A, high-NS with cluster B, and high-HA with cluster C (Goncalves & Cloninger, 2010). Similarly, low scores of SD and C have consistently found to indicate the presence of a personality disorder (Svrakic, Whitehead, Przybeck, &

Cloninger, 1999). Particular temperament traits may be risk factors to the development of personality and other psychiatric disorders, arguably, due to the heritable aspect of the temperament dimensions. Conversely, character dimensions are considered to be protective factors, because they may prevent possible maladaptive influences of temperament traits through personality development (van Schuerbeek et al., 2011).

### 2.3.5.2 Psychopathology and emotional processing bias

Disturbances in emotional processing are frequently found to be a feature of psychiatric disorders (Addington & Addington, 1998; Gotlib, Yue, & Joormann, 2005; Koenigsberg et al., 2009; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; McLaughlin, Mennin, & Farach, 2007). Individuals with schizophrenia, for instance, have deficits in the ability to recognise and discriminate facial affect in others, contributing to poor social cognition (Addington et al., 2006; Ando et al., 2002; Edwards & Pattison, 2002; Kohler et al., 2000; Mandal, Pandey, & Prasad, 1998; Pinkham, Penn, Perkins, & Lieberman, 2003; Takahashi et al., 2004). Impairments in the recognition of facial affect have also been demonstrated in several psychiatric disorders, such as obsessive-compulsive disorder (Aigner et al., 2007; Mancini, Gragnani, & D'Olimpio, 2001; Sprengelmeyer et al., 1997).



### **2.3.6 Summary**

Temperament refers to heritable personality traits that have a neurobiological basis which develops early in life through associative learning; creating stable percepts, affects, and procedural memories. Character develops later in life primarily through socio-cultural experience and person-environment interaction. In summary, character and temperament are seen as (1) aetiologically related (i.e. either they have shared biogenetic origins, or character develops from temperament); (2) developmentally related, as character development is dependent on antecedent temperament traits; (3) functionally interrelated through bi-directional, dynamic interaction (Svrakic & Cloninger, 2010); (4) are associated with variance in neurotransmitter systems (Carver & Miller, 2006; Suhara et al., 2001); and (5) are related to structural variance in specific brain areas (Gardini et al., 2009; Lidaka et al., 2006; Whittle et al., 2006).

## **2.4 Emotional processing**

This term denotes the processing of emotional information and generally refers to the perception, expression, and experience of emotion (Demaree et al., 2005). Emotion is thought to function at a biological level, directing an individual toward specific perceptions, cognitions, and behavioural responses (Cloninger, 1987; Svrakic, Przybeck, & Cloninger, 1992). Neuroimaging studies have identified several mechanisms involved in emotional processing, both in clinical and non-clinical samples. The most prominent finding is the central and complex role of the

amygdala in emotional processing (Baas, Aleman, & Kahn, 2004; Baeken et al., 2009; Grimm et al., 2012; Habel et al., 2007; Lidaka et al., 2006; Yang et al., 2002).

#### **2.4.1 Facial emotional processing**

Within the area of emotional processing, facial expression has received considerable attention. The focus of several studies is the recognition and discrimination of facial emotions. This body of research is based on the premise that people perceive emotions through facial expressions; therefore, the ability to accurately recognise facial emotions is considered essential for effective social communication and interaction (Adams et al., 2006; Kamio et al., 2006). Recognising facial affect relies on many psychological processes and neurological structures. Functional neuroimaging (e.g., fMRI) has uncovered some of the mechanisms that underlie these processes (Addington et al., 2006; Adolphs, 2002; Britton et al., 2006; Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002). Researchers have regularly used photographic images of various facial expressions as emotional stimuli. For example, participants have been required to differentiate happy, sad, and neutral faces and rate the emotional valence of the facial expressions (Habel et al., 2007; Sachs et al., 2004).

Numerous studies have investigated factors that may influence the recognition and discrimination of facial emotions, including personality variables. Data show impaired recognition of facial expression is a feature of several psychiatric disorders,

such as obsessive-compulsive, developmental, and personality disorders and schizophrenia (Adams et al., 2006; Aigner et al., 2007; Bergvall et al., 2003; BERPPOHL et al., 2008; Canli, 2004; Cremers et al., 2010; Kamio et al., 2006; Knyazev et al., 2008; Kohler, Turner, Gur, & Gur, 2004; Kohler et al., 2004; Mayes et al., 2009; Schneider et al., 2006).

Research has shown that facial emotional processing is associated with neural activity in cortical and subcortical structures linked to the amygdala (Adolphs, 2002; Adolphs et al., 2005; Canli et al., 2002; Cremers et al., 2010; Gur et al., 2002; Habel et al., 2007; Killgore & Yurgelun-Todd, 2001; Morris, deBonis, & Dolan, 2002). Evidence suggests that personality traits play a role in the ability to recognise or express facial emotions and may account for individual variation in amygdala activation (Adolphs, 2002; Baeken et al., 2009; Hamann & Canli, 2004; Iidaka et al., 2006; Knyazev et al., 2008; Whittle et al., 2006). For example, individual differences in neuroticism may have an important role in modulating functional connectivity of amygdala and prefrontal regions when processing negative facial emotions (Cremers et al., 2010; Haas, Omura, Constable, & Canli, 2007) and extraversion may account individual variability in amygdala activation in response to positive facial expressions (Canli et al., 2002).

## 2.4.2 Temperament and emotional processing

Personality disorders are associated with perceptual biases in emotionally laden stimuli (Bergvall et al., 2003; Canli et al., 2002; Gomez & Gomez, 2002; Grimm et al., 2012; Iidaka et al., 2006; Knyazev et al., 2008; Koenigsberg et al., 2009; van Schuerbeek et al., 2011). According to Cloninger et al. (1993), personality disorder subtypes and diagnoses are a function of the dynamic interaction and intensity of temperament and character traits. Studies investigating the perception of facial expressions have shown that personality traits (viz., TCI, introversion-extraversion, and BAS/BIS variables) influence the way individuals perceive different facial expressions in others (Baeken et al., 2009; Knyazev et al., 2008). Studies using functional magnetic resonance imaging (fMRI) indicate that individual differences in specific personality traits are correlated with activation of the amygdala. For instance, TCI temperament traits have been associated with the activation of the amygdala as well as differences in the grey matter concentration in the amygdala (Grimm et al., 2012; Iidaka et al., 2006). Taken together, these neuroimaging studies show links between personality traits and emotional processing associated with brain activation and morphology. These findings thus support the theoretical link between TCI personality traits and emotional processing. An emphasis on this association is likely to shed light on personality profiles and putative risk factors in psychopathology.

According to Cloninger's model, individual temperament dimensions are associated with specific emotions which are related to situational cues (Cloninger et al., 1994).

Temperament has been shown to modulate interactions between emotions and cognition (Heponiemi et al., 2003; Mardaga & Hansenne, 2009a; Roussos, Giakoumaki, & Bitsios, 2009): HA has been associated with fear and anxiety; NS with anger and impulsivity (Gardini et al., 2009). Mardaga and Hansenne (2009b) reported that HA and NS modulate the effect of a negative emotional context on auditory information processing. Similarly, Puttonen, Ravaja, and Keltikangas-Järvinen (2005) found that temperament dimensions, especially HA and NS, are significant predictors of individual differences in emotional experience. The authors reported that HA is associated with fear and unpleasant emotions, while NS is associated with dullness during monotonous and aversive situations. Elsewhere, HA and NS have been associated with differences in unconscious emotional perception (Yoshino et al., 2005).

## **2.5 Conclusion**

In the present study, personality is described within Cloninger's theoretical framework. This model incorporates concepts and findings from a range of fields including genetics, neuroanatomy, neurophysiology, psychology, and psychopathology. Extensive research supports the link between temperament and character and psychopathology; the latter characteristically associated with problems in emotional processing. This points to a theoretical link between temperament and character traits and emotional processing, which is the hypothesis underlying the present study. Available evidence supports this hypothesis, but the research is limited. The data reviewed in this chapter provide strong support for a neurological

basis for both personality and facial emotional processing. Additionally, evidence shows that individual differences in personality traits affect the ability to recognise or express facial emotions. Specifically, temperament modulates interactions between emotions, cognition, and different patterns of unconscious emotional responses, which translates into differences in behaviour.

## Chapter 3

### Method

The data reviewed in the preceding chapter indicate that specific temperament and character traits predispose individuals to particular psychopathologies. Additionally, particular psychopathologies have been associated with particular deficits in emotional processing. However, few studies focus on the possibility of an association between temperament and character dimensions and emotional processing. The aim of this study is to explore the relationship between temperament and character dimensions variables and performance on measures of emotional processing in a non-clinical sample. This chapter outlines the design of the study, sample selection, specific measuring instruments, statistical analyses employed, and ethical considerations.

This study forms part of a larger initiative funded by the National Research Foundation and the University of Pretoria Research and Development Fund (grant no.: TTK2006042400049). The original study comprised of data collected over a period of two years. The administration of the computerised neuropsychological test battery was approved and implemented in collaboration with the University of Pennsylvania, Brain-Behavior Laboratory. A computerised battery of tests was selected to facilitate group administration. With the technical support of researchers at the Brain-Behavior Laboratory, a web-interface was set up between the South African site and the United States site. The University of Pennsylvania

Computerised Neuropsychological Test Battery (PennCNP) comprises of four computerised neuropsychological test batteries (Emotions, Memory, Executive Function, and Abstract Reasoning and a full battery comprising all the tests from the four batteries).

### **3.1 Research Design**

A non-experimental, correlational design was applied using existing data from the original research conducted on a sample of 630 participants who completed the TCI and PennCNP Emotions Test Battery. The data set used in the present research comprised of raw scores on the relevant measuring instruments.

### **3.2 Sample**

The data were collected from a sample comprising of first year psychology students at a residential university in South Africa. Six hundred and thirty students, from the 1124 registered students invited to participate in the study, agreed to take part. Participants with incomplete neuropsychological test and TCI data, and those with past medical and psychiatric histories, were omitted from the final data analyses. The processing of the data yielded a realised sample of 388.



An appropriate sample size is always a concern in research because it is a key determinant of statistical power as insufficient statistical power increases the risk of Type II errors (Cohen, 1988). Additionally, small sample sizes are associated with inconsistent and variable research findings. The sample of 388 is considered sufficiently large for the statistical technique of canonical correlation analysis selected for this study (Naylor, Lin, Weiss, Raby, & Lang, 2010).

### **3.3 Measuring Instruments**

#### **3.3.1 Socio-demographic questionnaire**

At the commencement of the battery a socio-demographic questionnaire was administered to each participant. The socio-demographic questionnaire yielded data on age, gender, home and schooling language, parental education level, handedness, and past and current medical and psychiatric history.

#### **3.3.2 The Temperament and Character Inventory**

The TCI is derived from Cloninger's psychobiological personality theory. Notably, it has been used in 377 original peer-reviewed studies published between 1988 and 2002 (Pelissolo et al., 2005). The TCI's validity and reliability form and several has been well established across several populations and is widely used (Brändström et al., 2008; Cloninger et al., 1993; de la Rie et al., 1998; Miettunen et al., 2006;

Pelissolo et al., 2005; Richter et al., 2007; Sung et al., 2002). Additionally, the TCI has been utilised using South Africa samples (Cassimjee & Murphy, 2010; du Preez et al., 2009; Lochner, Simeon, Niehaus, & Stein, 2002; Peirson & Heuchert, 2001; Rushton & Irwing, 2009). The TCI assesses the four independent temperament traits (NS, HA, RD, & P) which are largely genetically determined and the three character dimensions (SD, C, & ST) that are predominantly determined by socialisation processes during the life-span by means of a 238 item forced choice true-false standardised self-administered questionnaire (Cloninger et al., 1994). Internal consistency coefficients range from .70 to .89 for the seven factors in a non-clinical sample (Cloninger et al., 1994).

### **3.3.3 University of Pennsylvania Computerised Neuropsychological Test Battery**

The PennCNP begins with a general sensory-motor and familiarisation 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. The Emotions battery consists of the following tests: the Penn Facial Memory Test (CPF), the Penn Emotion Discrimination Task (EDF40), the Penn Emotion Recognition Task (ER40) and the Penn Emotional Acuity Test 40 (PEAT40). The tests from the Emotions Battery were administered in a set order (CPF, EDF40, ER40 and PEAT40). Descriptions of MPRAXIS and each of the tests of emotion follow:

### 3.3.3.1 Motor Praxis (MPRAXIS)

The MPRAXIS is a measure of sensory-motor ability; it is designed to familiarise 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 every time. If participants cannot complete the MPRAXIS, it is likely they will not be able to complete any other PennCNP task. This is presented 20 times, in a non-randomised manner. 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.

### 3.3.3.2 Penn Facial Memory Test (CPF)

The CPF assesses facial memory. In the first part of the test participants are shown 20 faces that they will be asked to identify later during both immediate recall (CPF) and delayed recall (CPFdelay). During the immediate recall CPF, participants are shown a series of 40 faces one at a time. The series includes the 20 faces they were asked to memorise mixed with 20 novel faces. All facial stimuli are black and white photographs of faces rated as having neutral expressions, balanced for gender

and age (Gur et al., 2001). Faces are pasted on a black background with hair blending into it as to remove the hair's identifying characteristics. The participants' task is to decide whether they have seen the face before by clicking with the mouse on one of four buttons, presented in a 4-point scale: "definitely yes", "probably yes", "probably no" and "definitely no." The total number of true positive responses for each of the trials (CPF and CPFdelay) and reaction time for true positive responses on CPF and CPFdelay trials were selected as performance measures.

### 3.3.3.3 Penn Emotion Discrimination Task (ED40)

The EDF40 is a measure of emotion discrimination. Participants are shown 40 pairs of faces, one pair at a time. Each pair of faces consists of two pictures of the same person with or without a subtle, computer-generated difference in emotion expression, which may or may not represent a difference in the intensity of the emotion between the two faces. All facial stimuli are black and white photographs of Caucasian actors and actresses analysed and reviewed as described in Erwin et al. (1992). For each pair, the participant must decide which face expresses the given emotion more intensely or whether they are equally emotional. There are a total of 40 questions: 18 questions where one of the faces is happier; 18 where one of the faces is sadder; and four questions where the faces are equally happy or equally sad. The total number correct and reaction time for correct responses were selected as performance measures.

#### 3.3.3.4 Penn Emotion Recognition Task (ER40)

The ER40 is a measure of emotion recognition. Participants are shown a series of 40 faces, one at a time, and asked to determine what emotion the face is showing for each trial. There are five answer choices: happy, sad, anger, fear and no emotion. Participants respond to each trial by clicking with the mouse on the word describing the emotion each face expresses. There are four female faces for each emotion ( $4 \times 5 = 20$ ) and four male faces for each emotion ( $4 \times 5 = 20$ ). The faces are colour pictures taken, analysed and rated as described in Gur et al. (2002) and Kohler, Turner, Gur, and Gur (2004). They were derived from the University of Pennsylvania Emotion Recognition Task, 96 faces are balanced for equality and intensity of emotion, age, gender and ethnicity (Kohler et al., 2004). The total number correct for each of the trials (Anger, Fear, Happy, Neutral and Sad) and reaction time for each of the correct responses were selected as performance measures.

#### 3.3.3.5 Penn Emotional Acuity Test (PEAT40)

The PEAT40 is a measure of emotion recognition and discrimination. The task presents 40 faces, one at a time, composed of five happy, five sad, and 10 neutral, male and female faces, respectively (Sachs et al., 2004). The presentation takes place in two blocks, the first of which contains sad and neutral faces (sad-neutral block); the second, happy and neutral faces (happy-neutral block). The faces are presented randomly within the blocks. Participants are asked to rate the emotional valence of the expression on each face on a seven-point scale: very sad, moderately

sad, somewhat sad, neutral, somewhat happy, moderately happy, and very happy (Sachs et al., 2004). Choices are entered by clicking with the mouse on one of the seven emotion descriptions. Face stimuli were acquired as described in Erwin et al.(1992). Total correct and total within-1 correct responses for each of the trials (very happy, neutral-happy, neutral, neutral-sad and very sad) and reaction times for each of the correct responses and within-1 correct responses were selected as performance measures.

### **3.4 Procedure**

Participants were given a brief overview of the study, and all participants completed informed consent forms prior to commencement of data collection. A web-interface between the computer laboratory at the University of Pretoria and the Brain-Behavior Laboratory at the University of Pennsylvania was established which facilitated the group administration of tests and large scale data collection. Participants were given the opportunity to select a session from 30 scheduled group sessions. A maximum of 25 participants comprised each group session, which was facilitated by three attending researchers and eight research assistants each of whom were trained in the administration of the battery. The research assistants were each tasked with monitoring four participants, and upon completion of the battery, were required to submit the test status code in electronic format (C-complete, I-incomplete) and the number 1 (good data), 2 (questionable data) or 3 (bad data) for each of the tests comprising the battery.

### **3.5 Analysis**

The data were analysed using both descriptive and inferential statistics. Biographical data were recorded as frequencies and percentages for home language, age, gender, handedness, and education levels. Additionally, descriptive statistics were used to indicate the sample performance on the TCI and the tests of emotion recognition and discrimination.

#### **3.5.1 Canonical correlation analysis**

The multivariate statistical technique, Hotelling's (1935, 1936) canonical correlation analysis (CCA), was selected and applied in order to confirm the hypothesised relationship between TCI variables and neurological test performance on PennCNP emotions tasks. Canonical correlation analysis is designed to accommodate the estimation of correlation coefficients between sets of variables, and also provides an indication of which variables contribute the greatest to each linear combination (Davis, Pierson, & Finch, 2011). Generally, CCA is an appropriate technique for psychological research as typically human behaviour research investigates variables with multiple probable causes and effects (Sherry & Henson, 2005). Thus, it is considered theoretically consistent with the purpose of the present research. Moreover, examining singular cause and effects would likely distort the complexity of personality and miss important multivariate relationships.

As a multivariate technique, CCA is advantageous as it reduces the probability of committing Type I (experiment-wise) error as it allows for simultaneous comparisons among the variables rather than requiring several statistical tests to be performed. This approach was selected as the data consist of multiple dependent and independent variables. Unlike multiple regression, which is used to predict a single dependent variable from a set of multiple independent variables, CCA simultaneously predicts multiple dependent variables from multiple independent variables (Hair, Anderson, Tatham, & Black, 1998). The statistical procedure involves finding pairs of linear combinations within the variable sets in order to maximise the correlation among them (Sheskin, 2004). The results provide an estimation of the correlation between the variable sets and also an indication of the variables that most contribute to each linear relationship (Davis et al., 2011).

Since CCA addresses the association between composites of sets of multiple dependent and independent variables, it develops several independent canonical functions to maximise the correlation between linear composites (Hair et al., 1998). Each canonical function is based on the correlation between two canonical variates (synthetic variables): one variate for the dependent (criterion) variables and one for the independent (predictor) variables. However, this designation is essentially arbitrary as CCA is a correlational method (Sherry & Henson, 2005). The correlation between dependent and independent variates is weighted based on the relationships between variables within the sets in order to maximise their function. Therefore, CCA can be conceptualised as a simple, bivariate correlation (viz. Person's  $r$ ) between the two variates. Figure 3.1 is an example of the variable relationships in a CCA with three predictor and two criterion variables. In each set, variables are



combined into one synthetic variable called a canonical variate by applying a linear equation between observed variables and their respective variates. The total number of canonical functions (pairs of canonical variates) that can be derived is equal to the number of variables in the smaller of two variable sets.

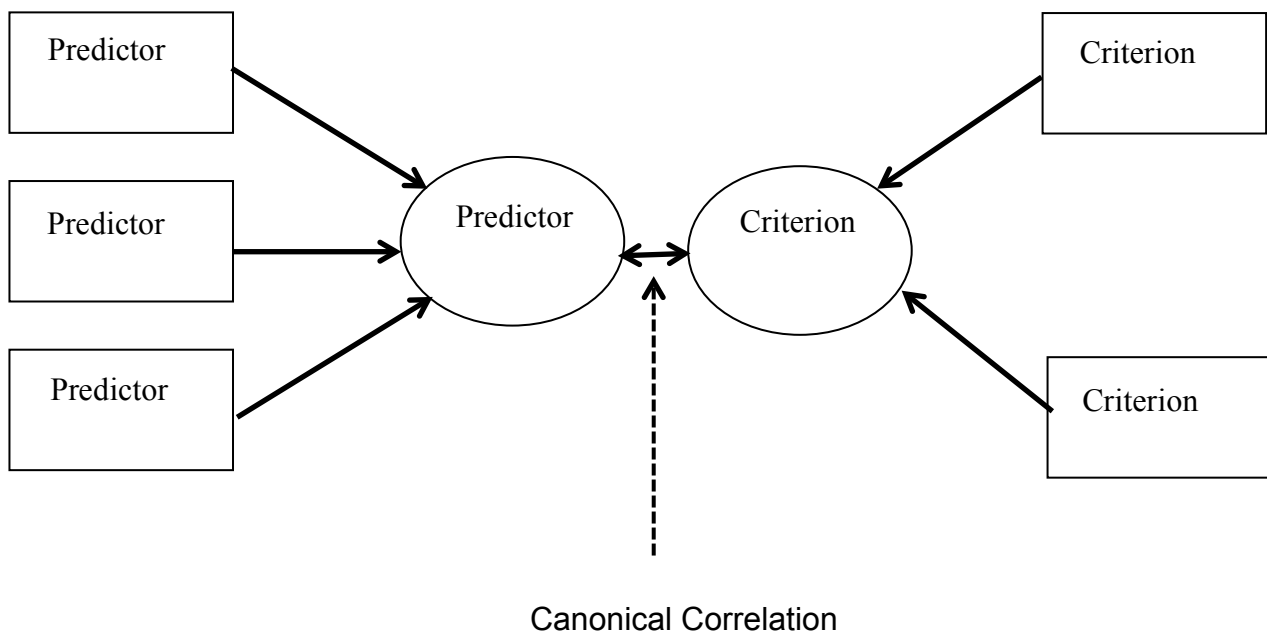


Figure 3.1

An example of the first function in a canonical model with three predictors and two criterion variables (adapted from Sherry & Henson, 2005).

The steps of the CCA are outlined below:

1. An inter-correlation matrix is generated. This matrix consists of Pearson's product-moment correlations ( $r$ ) both within and between variables.
2. The generation of successive pairs of canonical variates. The first pair of canonical variates has the highest inter-correlation between the two sets of variables as successive pairs of canonical variates are based on residual variance (Sherry & Henson, 2005).
3. Significance tests (e.g., Chi-squared) are conducted on the full model to determine the significance of the canonical correlations.
4. Dimension reduction analysis is used to test the hierarchical arrangement of functions for statistical significance.
5. Canonical correlations provide a structure coefficient ( $r_s$ ), which may be interpreted as a Pearson's  $r$  (Hair et al., 1998).
6. Squared canonical correlations ( $r_s^2$ ) or eigenvalues are calculated to denote shared variance (Tabachnick & Fidell, 2007).
7. The two matrices of independent and dependent canonical coefficients are used to determine the scores on canonical variates. This establishes a matrix of canonical structure that indicates the correlation of the original variables with the canonical variates.
8. A redundancy analysis is calculated to determine an alternative measure of shared variance.
9. Interpretation of variates involves the assessment of correlations for all significant variates. Only loadings above .30 are generally considered significant (Tabachnick & Fidell, 2007).

### **3.5 Ethical Considerations**

The original study (grant project no.: TTK2006042400049) providing the data used in this project was approved by the dean of students, the dean of the Faculty of Humanities, the head of the Department of Psychology, and the faculty Research and Ethics Committee. The data set utilised for this study comprises the raw scores on relevant measuring instruments, and no personal identifiers are included in the data files. The collected data has not been analysed previously. The Ethical Committee of the Faculty of Humanities at the University of Pretoria granted ethical approval for use of the data from the original study.

### **3.6 Conclusion**

Although CCA is one of the least used multivariate techniques, this approach is uniquely suited to address the multiple relationship dimensions in this study. Unlike other statistical analyses, CCA provides a means for determining the degree of the relationship between multiple independent and dependent variables when no covariate exist among continuous variables (Tabachnick & Fidell, 2007). This statistical procedure is thus well suited to psychological research as typically human research involves variables with multiple causes and effects (Sherry & Henson, 2005). Furthermore, CCA is well matched to the present study as the data consist of multiple dependent and independent variables, and it has a sufficiently large sample size (i.e., realised sample of 388). However, this technique has two important limitations: Firstly, linear associations between composite variables do not

necessarily lead to the interpretability of the principal dimensions (Tabachnick & Fidell, 1983); secondly, inter-correlations within the sets are not identified. The following chapter presents the results of these analyses.

## Chapter 4

### Results

In this chapter the results are reported and discussed. Firstly, the obtained demographic data for the student sample are provided. Secondly, relevant neuropsychological and emotional processing variables are presented. Thirdly, canonical correlation analysis (CCA) elucidates the relationship between temperament and character dimensions and emotional processing variables.

#### 4.1 Participants

A sample consisting of 630 students at a residential university in South Africa participated in this study. Participants completed a socio-demographic questionnaire as part of the procedure. Subjects with past medical and psychiatric histories, and those with incomplete neuropsychological and TCI data, were omitted from the final data analyses. Processing of the data yielded a realised sample of 388, comprised of 329 females and 58 males. The sample consisted mainly of first year (323) and second year (47) students. The average number of years of education was 13.22 ( $SD = 0.57$ ). Ages ranged from 17 to 26 with a mean age of 19.61 ( $SD = 2.00$ ). Fifty per cent of the sample indicated that Afrikaans was their home language, 26% stated English was their home language, and 24% spoke an African language at home.

## 4.2 Descriptive Statistics

The descriptive statistics for the TCI dimensions appear in Table 4.1. In the absence of South African norms for the TCI, the mean scores are compared to a South African sample. The du Preez, et al. (2009) sample consisted of 1145 police trainees at a South African police academy; the groups are comparable in terms of age. Table 4.2 indicates the sample means and standard deviations for specific tasks of the University of Pennsylvania Computerised Neuropsychological Test Battery (PennCNP). Only those variables used in the analysis are represented. The performance measures are reflected in total correct responses (i.e., accuracy) and reaction time for correct responses (i.e., speed).

Table 4.1

*TCI Scores of Students and Control Group*

TCI dimensions	<u>Students</u> ( <i>N</i> = 388)		<u>Controls<sup>a</sup></u> ( <i>N</i> = 1145)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Harm Avoidance	15.52	6.97	11.00	4.69
Novelty Seeking	20.42	6.18	15.61	3.31
Reward Dependence	16.01	3.75	15.25	3.09
Persistence	5.19	2.08	5.64	1.55
Self-Directedness	29.65	7.57	31.66	4.69
Cooperativeness	34.22	5.68	30.08	3.69
Self-Transcendence	19.72	5.58	21.86	3.72

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

Table 4.2

*PennCNP Descriptive Performance Data*

	<u>Students</u>	
	(N = 388)	
Neuropsychological measures	M	SD
<i>Penn Emotion Recognition Task</i>		
Correct Anger Identifications	5.36	1.37
Correct Mild Identifications	12.64	1.65
<i>Penn Emotional Acuity Test</i>		
Sad Neutral Correct	10.03	2.21
Very Sad Correct	3.57	1.27
<i>Penn Emotion Discrimination Task</i>		
Correct Responses for Happy Trials	11.74	3.31
Correct Response for Sad Trials	13.67	2.46
<i>Penn Facial Memory Test</i>		
True Positive	16.75	2.38
True Positive Median Response Time	1500	389.7

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*Note.* Response times are indicated in milliseconds



### 4.3 Canonical Correlation Analyses

The aim of this study is to investigate a relationship between two sets of variables. The statistical model, CCA was selected as an appropriate multivariate technique as it facilitates the study of interrelationships among sets of multiple dependent and independent variables (Hair et al., 1998; Tabachnick & Fidell, 2007). Although variable normality is not strictly required, it is preferable for it standardises a distribution, which thus accommodates a higher correlation between the variables (Hair et al., 1998). Therefore, variables that were highly skewed were omitted from the analysis. None of the variables warranted exclusion from the TCI set, and hence comprises of all seven TCI dimensions namely, Harm Avoidance (HA), Novelty Seeking (NS), Reward Dependence (RD), Persistence (P), Self-Directedness (SD), Cooperativeness (C), and Self-Transcendence (ST). After skewed data were omitted, the second set comprised of eight PennCNP emotional processing variables. As shown in the table above, these include variables of emotional recognition (Correct Anger Identifications [ER40ANG] & Correct Mild Identifications [ER40MILD]); emotional acuity (Neutral Correct [SNC] & Very Sad Correct [VSNC]); emotional discrimination (Correct Responses for Happy Trials [HAP\_CR] & Correct Response for Sad Trials [SAD\_CR]); and facial memory (True Positive [CPFTP] & True Positive Median Response Time [CPFTPRT]).

For the purposes of this analysis, the seven TCI variables are designated as the personality set of predictor variables, whilst the PennCNP variables are specified as the emotional processing set of criterion variables. The aim is to explore possible

latent relationships (i.e., relationships between composites of variables) between personality and emotional processing variables. The steps involved in the analysis included the generation of (1) an inter-correlation matrix; (2) canonical variates; (3) tests of significance; (4) dimension reduction analysis (5) structure coefficients; and (6) squared canonical correlations. These processes are discussed in the paragraphs below, followed by an interpretation of relevant variables for set one and two.

#### **4.3.1 Pearson Product-Moment Correlations**

The first step in the analysis involved the calculation of inter-variable matrix to determine if any relationship existed between the individual variables of each set. Table 4.3 shows that TCI scales correlate approximately  $|.10|$  with six of the eight PennCNP emotional processing variables. Individually, these correlations are not practically significant relationships. However, CCA optimises these linear combinations by creating composite measures for each set of variables. The aim of the next step is to determine whether a significant relationship exists between these composite variables.

Table 4.3

*Correlation Matrix of TCI and PennCNP Variables*

	ER40A NG	ER40MIL D	SNC	VSN C	HAP_ CR	SAD_ CR	CPFT P	CPFTP RT
HA	.09	.06	-.06	.07	<-.01	.01	.06	.05
NS	.05	.09	.04	-.01	-.03	.04	-.02	-.03
RD	.05	.10	.07	.12	.11	-.11	-.01	-.01
P	-.10	-.07	<.01	.04	.01	.01	.05	-.11
SD	-.12	-.07	.03	.07	.05	.07	-.09	.09
C	<.01	.08	.07	.08	.12	.09	-.02	.09
ST	-.12	-.07	.03	.07	.05	.07	-.09	.15

*Note.* HA = Harm Avoidance; NS = Novelty Seeking; RD = Reward Dependence; P = Persistence; SD = Self-Directedness; C = Cooperativeness; ST = Self-Transcendence; ER40ANG = Correct Anger Identifications; ER40MILD = Correct Mild Responses; SNC = Sad Neutral Correct; VSNC = Very Sad Correct; HAP\_CR = Correct Responses for Happy Trials; SAD\_CR = Correct Responses for Sad Trials; CPFT = True Positive; CPFTPRT = True Positive Median Response Time

### 4.3.2 Deriving canonical functions

The CCA yielded seven pairs of canonical variates; each pair is known as a canonical function (Table 4.4). Each function consists of two variates: one variate representing the temperament set and the other the emotional processing set. The linear relationship between the variates within each function is referred to as a canonical correlation ( $R_c$ ). The squared canonical correlation ( $R_c^2$ ) represents the shared variance between the variates. (A squared canonical function is also known as an eigenvalue.)

Table 4.4

#### *Canonical Correlations*

Function	$R_c$	$R_c^2$
1	.33	.11
2	.23	.05
3	.19	.04
4	.18	.03
5	.12	.01
6	.07	<.01
7	.03	<.01

*Note.*  $R_c$ = canonical correlation;  $R_c^2$ = squared correlation (eigenvalue).

### 4.3.3 Significance of the canonical model and dimension reduction

The full canonical model was evaluated for statistical significance. Wilks' lambda ( $\lambda$ ) was selected for its general applicability (Sherry & Henson, 2005). As indicated in Table 4.4, the full model was statistically significant with a Wilks'  $\lambda = .77$  criterion,  $\chi^2 (56) = 97.74, p < 0.001$ . Thus, the null hypothesis that states there is no relationship between variable sets is rejected, which indicates that the sets are indeed related (Johnson & Wichern, 2002). Since Wilks'  $\lambda$  represents the variance not shared between the variable sets,  $1 - \lambda$  yields the full model effect size in an  $r^2$  metric (Sherry & Henson, 2005). Therefore, for the set of seven functions the effect size of .23 (i.e.,  $1 - 0.77$ ) was determined. This shows that the full model explains about 23% of the variance shared between sets.

Dimension reduction analysis was used to test the hierarchical arrangement of functions for statistical significance. Each canonical function was evaluated in order to determine its contribution to the cumulative variance. Successive canonical pairs have decreasing canonical correlations as they are based on residual variance, and are therefore independent of each other. When the first variate was removed, Functions 2 to 7 were not statistically significant,  $\chi^2 (42) = 54.84, p = .088$  (Table 4.5). Thus, the remaining six variate-pairs were not amenable to interpretation; hence, only the first function was found to be statistically significant. This finding is supported by the strength of the correlation of Function 1 with a canonical correlation ( $R_c$ ) value of .33 (Table 4.4); correlations with a magnitude of  $R_c = .30$  and above are considered statistically significant for a sample of this size (Stevens, 1986).

Table 4.5

*Hierarchical Tests of Significance*

<i>Functions</i>	<i>Wilks <math>\lambda</math></i>	<i><math>\chi^2</math></i>	<i>DF</i>	<i>Significance of <math>\chi^2</math></i>
1 to 7	.77	97.74	56.00	<.001
2 to 7	.87	54.84	42.00	.088
3 to 7	.92	33.63	30.00	.296
4 to 7	.95	19.32	20.00	.501
5 to 7	.98	7.05	12.00	.854
6 to 7	.99	1.89	36.00	.929
7 to 7	1.00	.24	2.00	.888

Table 4.5

*Canonical Solution*

Variable	Function 1		
	<i>Coef</i>	$r_s$	$r_s^2$
HA	-.48	-.08	.01
NS	-.28	<.01	<.01
P	.22	.22	.05
RD	-.11	-.24	.06
SD	-.75	<u>-.57</u>	.32
C	-.31	<u>-.48</u>	.23
ST	.58	<u>.54</u>	.29
ER40ANG	.11	-.10	.01
ER40MILD	-.11	-.22	.05
SNC	-.28	-.18	.03
VSNC	-.25	-.03	<.01
HAP_CR	-.22	<u>-.36</u>	.13
SAD_CR	-.13	<u>-.33</u>	.11
CPFTP	.19	<u>.45</u>	.20
CPFTPRT	-.76	<u>-.87</u>	.75

*Note.* HA = Harm Avoidance; NS = Novelty Seeking; RD = Reward Dependence; P = Persistence; SD = Self-Directedness; C = Cooperativeness; ST = Self-Transcendence; ER40ANG = Correct Anger Identifications; ER40MILD = Correct Mild Responses; SNC = Sad Neutral Correct; VSNC = Very Sad Correct; HAP\_CR = Correct Responses for Happy Trials; SAD\_CR = True Responses for Sad Trials; CPFTP = True Positive; CPFTPRT = True Positive Median Response Time. Structure coefficients ( $r_s$ ) greater than |.32| are underlined. Coef = standardised canonical function coefficient;  $r_s$  = structure coefficient;  $r_s^2$  = squared structure coefficient.

#### 4.3.4 Interpretation

Structure coefficients ( $r_s$ ), squared structure coefficients ( $r_s^2$ ), and standardised canonical function coefficients (*Coef*) are presented in Table 4.6. Structure coefficients represent linear correlations between the original variables and their respective variates (Hair et al., 1998) and squared structure coefficients reflect the percentage of shared variance between each observed variable and its variate (Sherry & Henson, 2005). Structure coefficients are used to determine which variables are relevant for the model: Those with correlations above .32 are considered to have the highest level of usefulness in the model (Tabachnick & Fidell, 2007). Standardised canonical function coefficients (viz., canonical weights) provide an estimate of the shared variance between individual variables and variates, but they are less valid than structure coefficients (Hair et al., 1998). A redundancy index was calculated for the independent and dependent variate of the first function. This provides an alternate measure of shared variance. The redundancy index for the PennCNP and TCI variables is .018 and .015, respectively. This low redundancy is most likely a consequence of the low shared-variance of 23%.

A review of the coefficients in Table 4.6 shows that CPFTP and CPFTPRT were the primary contributors to the criterion variate. The former is a measure of facial recognition (memory) and the latter indicates the time it takes to recall the previously seen faces (speed). Secondary contributions were made by emotional discrimination variables: HAP\_CR and SAD\_CR; these refer to the discrimination of happy and sad faces, respectively. Additionally, CPFTP is positively related to the



personality variables, while the remaining three variables have negative signs and are thus inversely related.

On the other side of the equation, the relevant criterion variables were character variables SD, C, and ST. Concerning facial memory and recognition: SD and C are negatively related to CPFTP and positively related CPFTPRT. Thus, participants with higher SD and C dimensions had (1) weaker facial memory recall and (2) were slower in recognising faces (SD & C). Conversely, ST is positively related to CPFTP and negatively related to CPFTPRT. Therefore, participants with higher ST (1) performed better in the recall of faces and (2) were faster in recognising faces. Moving on to the emotional discrimination variables, SD and C have positive relationships with the discrimination of happy (HAP\_CR) and sad (SAD\_CR) faces. In other words, the participants with higher SD and C character traits were more accurate in discriminating between base emotions than those with lower C and SD. Lastly, since ST has a negative relationship with both HAP\_CR and SAD\_CR, it can be deduced that participants higher in ST are less accurate in discriminating between happy and sad faces.

#### **4.4 Conclusion**

A canonical correlation analysis was conducted using all seven TCI variables as predictors of the eight PennCNP emotional processing variables to evaluate the shared multivariate relationship between the two variable sets. The analysis yielded

seven functions, which collectively were statistically significant, yet only Function 1 was amenable to interpretation. Structure coefficients determined the relevant variables in this model. From the predictor set these were the character dimensions Self-Directedness, Cooperativeness, and Self-Transcendence. On the other side of the equation, these were the variables for facial recognition (True Positive & True Positive Median Response Time) and emotional discrimination (Correct Responses for Happy Trials & Correct Response for Sad Trials). The analysis yielded the following results:

#### Facial Recognition

- Participants with higher Self-Directedness and Cooperativeness were weaker facial memory recall and slower in recognising faces, compared to their lower counterparts.
- Participants with higher Self-Transcendence performed more effectively in facial memory recall and were faster in recognising faces compared to those individuals with lower Self-Transcendence

#### Emotional Discrimination

- Participants with higher Self-Directedness and Cooperativeness were more accurate in discriminating between happy and sad emotions in comparison to their lower counterparts.
- Participants higher in Self-Transcendence were less accurate in discriminating between happy and sad faces.

Chapter 5 elaborates on the interpretation of results and includes a discussion on the possible mechanisms underlying this correlation between character dimensions and facial recognition and emotional discrimination.

## **Chapter 5**

### **Discussion**

The present study sought to establish whether a relationship exists between personality (temperament and character) and emotional processing. The previous chapter affirmed associations between character variables and measures of facial emotional processing. The findings did not support an association with the temperament dimensions. Canonical correlational analysis demonstrated that character dimensions are significantly associated with (1) facial recognition and (2) the discrimination of facial emotions. On account of these findings, this discussion begins with a review of character, and then the lack of association with temperament dimensions is discussed. Thereafter, emotional processing is considered and individual associations are examined. There are two further sections: the first discusses the limitations of this study and the second provides recommendations for further research. The chapter ends with a conclusion to the complete study.

#### **5.1 Character dimensions**

The results showed that the character dimensions Self-Directedness (SD), Cooperativeness (C), and Self-Transcendence (ST) were significantly associated with the emotional processing variables in this study. In brief, character dimensions consist of (1) an emotional perspective that refers to individual differences in goals,

values, and self-concepts and (2) a cognitive perspective of self and others which is associated with insight learning and higher cognitive processes.

Regarding emotional aspects, SD refers to individual maturity, self-acceptance, and the ability to act in accordance with personal goals and values; C reflects personal acceptance and identification with others; and ST includes spiritual acceptance and identification with others. Character dimensions SD and C have been reported to mediate the expression and control of anger in persons with eating disorders, for instance (Krug et al., 2008).

In support of the executive functions and insight learning, Bergvall et al. (2003) found a significant relationship between character dimensions and a set-shifting task. The executive functions of each character dimension are as follows: SD is associated with being responsible, purposeful and resourceful; C includes legislative functions of being tolerant, forgiving, and helpful; and ST refers to judicial functions, such as being intuitive, judicious, and aware. In another study, SD and C were associated with neurological tests measuring cognitive inhibition, working memory, perseveration and decision-making tasks (Black et al., 2009).

## 5.2 Temperament

To recapitulate, temperament is the personality dimension that refers to the biological core of personality because it is considered the genetic basis of personality and provides a platform for character dimensions to develop. Furthermore, temperament reflects individual differences in associative learning in response to novelty, danger, punishment, and reward. Studies by Yoshino et al. (2005), Bempohl et al. (2008), and Roussos, Giakoumaki, and Bitsios (2009) have shown that specific temperament dimensions are associated with various emotional processing variables. The present results do not support these findings. Although the present study is comparable to these studies, there is a notable difference: The researchers in all three studies investigated emotional responses to immediate physiological and behavioural stimuli rather than emotional recognition of facial expressions, which may have bearing on the contrasting outcomes.

The lack of association of temperament dimensions may be explained using Britton and colleagues' (2006) distinction between social and non-social emotional processing: The former refers to complex human interaction including language, meaning, and social intentionality, and the latter to biological emotional responses to stimuli that have direct physiological relevance. According to Britton et al. (2006), facial emotional processing is a dimension of social emotional processing since it is integral to social interactions. In contrast, the emotional variables in the studies by Yoshino et al (2005), Bempohl et al. (2008), and Roussos, Giakoumaki, and Bitsios (2009) are more in line with non-social forms, as the researchers in each respective

study investigated emotional responses to stimuli that have direct physiological relevance and do not involve direct social interaction. The finding reported Britton et al. (2006) indicates that social emotional processing is neurologically distinct from non-social emotions. This suggests that facial emotional processing may be an aspect of emotional processing distinct from the immediate physiological and behavioural responses to emotional stimuli. Hence, this distinction may account for the disparity between the present results and those reported in the studies above.

### **5.3 Emotional Processing**

Broadly, emotional processing refers to how individuals process emotional information, which includes the perception, expression, and experience of emotion (Demaree et al., 2005). The present study focused on facial expressions, which are an essential part of non-verbal human communication (Adams et al., 2006; Kamio et al., 2006). Facial expressions provide vital information about an individual's emotion states, intentions, reactions to others, and responses to the environment (Whalen et al., 2013). The ability to recognise and discriminate emotion from facial expressions is a complex process that begins during infancy with a rudimentary ability to recognise and distinguish emotion from facial expressions and continues to develop during adulthood (Adolphs, 2002).

Theoretically, it follows that primitive facial emotional processing may be temperament-related as temperament is genetically determined and develops in

early life. Likewise, character may be directly related to adult emotional processing as both character and facial emotional processing develop through socialisation and life learning (e.g., Lau et al., 2009). Together this may account for disparity between the present results and the studies by Yoshino et al (2005), Bermpohl et al. (2008), and Roussos, Giakoumaki, and Bitsios (2009), but this has not been tested empirically.

Several personality-linked biases in the perception of emotional facial expressions have been identified empirically (Knyazev et al., 2008). Though, the available data concerning temperament and character biases in emotional processing are mostly extrapolated from studies investigating personality disorders; these disorders are characterised by extreme expressions of temperament and immature character. Low SD and C consistently correlate with personality disorders (Cloninger et al., 1993; Svrakic & Cloninger, 2010; Svrakic et al., 2002).

In the present study four emotional variables are significantly associated with the character dimensions. The relevant emotional variables were CPFTP, CPFTPRT, HAP\_CR, and SAD\_CR. The first two variables CPFTP and CPFTPRT together constitute the PennCNP Facial Memory Test. This is a test of facial recognition, which measures facial recall (CPFTP) and facial recall response time (CPFTPRT). The findings pertaining to these variables are discussed below as facial recognition variables. The second pair of variables (HAP\_CR & SAD\_CR) was also found to be significantly associated with the character variables. These variables are measures of facial discrimination extracted from PennCNP Emotion Discrimination Task.



### 5.3.1 Facial recognition

Facial recognition requires prior knowledge and therefore relies on memory (Adolphs, 2002). As stated above, the analysis indicated that the relevant facial recognition variables are items of the Penn Facial Memory Test (CPF). Facial memory refers to the ability to hold visual information that can be subsequently transferred onto another image. During the administration of the CPF participants were asked to memorise 20 faces, and thereafter identify these faces from a series of 40 that include 20 novel faces during immediate and delayed recall. The variable CPFTP is a measure of the true responses for both immediate and delayed recall and CPFTPRT reflects the reaction time for true positive responses.

In the present study, SD and C were negatively correlated to CPFTP; this indicates that participants higher in SD and C were out-performed by participants with lower SD and C on facial recall. These participants were also comparatively slower in responding to the tasks of immediate and delayed recall compared to the participants with lower SD and C. These are unexpected findings given that low SD and C are characteristically associated with personality disorders, which are mostly associated with deficits in facial emotional processing. Theoretically, the disparity between the results may be because the absolute range between high and low character is narrower in healthy individuals than those found in clinical samples. Moreover, the relationship between character and emotional processing has not been investigated directly in previous studies.

The character trait ST was positively associated CPFTP, which denotes that participants higher in ST performed better on facial recall. This trait refers to spiritual acceptance and identification within the broader world. Additionally, ST includes judicial functions, such as being intuitive, judicious, and aware (Celikel et al., 2009). It corresponds that individuals, who are judicious and sensitive to other people's needs, may be more adept with facial memory. Similarly, it follows that higher in ST were also faster in recognising faces (ST was negatively related to CPFTPRT).

### **5.3.2 Emotional discrimination**

Facial recognition and expression are important forms of social communication. The former involves facial memory and draws on all the relevant knowledge that relates to the concept of that emotion; the latter conveys various degrees of emotional responses. For example, recognising a sad expression requires that the perceptual properties of the facial stimulus be linked the knowledge components of the concept of sadness (Adolphs, 2002).

The relevant emotional discrimination variables in the present study are HAP\_CR and SAD\_CR. These variables are subtests of the Penn Emotion Discrimination Task. During the administration of these tasks, participants were shown pairs of faces, each pair showing the same individual with either the same intensity of expression or a subtle, computer-generated difference in the intensity of the emotion. Participants were asked to discriminate facial expressions from their respective

neutral counterparts.

The present findings indicate that higher SD and C were positively related to both HAP\_CR and SAD\_CR. Participants higher in SD and C were thus more accurate in discriminating the intensity of happy and sad faces compared to participants lower in SD and C. The accurate discernment of facial emotions requires the recognition of subtle differences in the range of expressions for particular emotions. Character dimensions were correlated with the correct discrimination of happy and sad emotions, respectively. This suggests that the accurate discernment of emotional expressions is an ability that develops gradually through maturation and socio-cultural factors from the basic identification of facial expressions observed in infancy to the ability to recognise a broad range of emotional facial expressions and variance within specific emotions. This is important for effective interpersonal communication and identification with others. In contrast, ST was negatively associated with HAP\_CR and SAD\_CR; therefore, these participants were less accurate with emotional discrimination of happy and sad faces compared to those with lower ST.

### **5.3.3 Summary**

Significant associations were found between character variables on the one hand and facial recognition and discrimination on the other. Regarding facial recognition, participants higher in SD and C were out-performed by participants with lower SD

and C on facial recall. Participants higher in ST performed better on facial recall and were also faster in recognising faces. Concerning facial recognition, participants higher in SD and C were more accurate in discriminating the intensity of happy and sad faces compared to participants lower in SD and C. In contrast, those participants higher in ST were less accurate with emotional discrimination of happy and sad faces, compared to those with lower ST. Contrary to findings reported in other studies no association was found between temperament dimensions and facial emotions.

#### **5.4 Limitations**

The current study has a few limitations. In terms of sampling, the normal undergraduate sample affects external validity (Highhouse & Gillespie, 2008). For example, it restricts the ability to extrapolate the findings to non-student and clinical populations. Additionally, the sample has a high female to male ratio; a common problem in student sample comprised of psychology students (van Berkel, 2009). Otherwise, the sample is largely homogeneous for age and level of education, which yields valid results for abovementioned cohort, but may be less applicable to other populations. Thus, the findings may be biased in terms of sex and to the degree that students are not representative of the broader population or if personality and emotional variables manifest differently in healthy students (Shen et al., 2011).

Regarding measuring instruments, the computerised PennCNP emotions battery used is a specific measure of facial emotional processing variables. This test battery was selected based on other studies (e.g., Aigner et al., 2007; BERPohl et al., 2008; Britton et al., 2006; Schneider et al., 2006), and because the validity and reliability is well established (Rojahn, Gerhards, Matlock, & Kroeger, 2000). Furthermore, It has also been used in South African studies (Cassimjee & Murphy, 2010; Murphy, Cassimjee, & Schur, 2011), though the absence of South African norms is a disadvantage.

The PennCNP measures emotional processing through facial recognition, memory, discrimination, acuity, and memory. Although not necessarily a limitation, there are alternatives to the present operationalisation. Emotional processing can be assessed through different systems including emotional self-report inventories, physiological reactivity (e.g., autonomic nervous system, startle response measures and brain states), and behaviourally (e.g., facial behaviour, whole body behaviour, observer ratings) (Bradley & Lang, 1994; Mauss & Robinson, 2009).

## **5.5 Recommendations**

The present data should be considered as exploratory. Replication with demographically heterogeneous samples or alternative cohorts is recommended. Further investigations into the association of personality and emotion in both healthy and clinical samples would improve the understanding of the complex interaction

between emotion and personality. Replication ought to be considered should South African normative data become available for the instruments used in this study. It is also recommended that future studies employ additional measures of emotional processing, such as alternative visual stimuli, auditory and situational cues, and skin conductance responses. This may elucidate why in the present research (contrary to other studies) no association was found between temperament dimensions and emotional processing variables.

## **5.6 Conclusion**

Personality and emotional processing were explored primarily in the context of Cloninger's psychobiological theory. Part of the motivation for this study was the paucity of research exploring personality-related biases in facial emotional processing. The impetus behind the study was the established links between personality traits and psychopathology, and between psychopathology and emotional processing, respectively. The present study investigated the association between temperament and character variables (as measured by the TCI) and performance on a neuropsychological emotions battery (PennCNP). The results provided evidence of a relationship between character variables and the recognition of faces and emotional discrimination of base emotions: happy and sad. Participants lower in SD and C were more efficient in facial recognition compared to participants higher in these dimensions. In contrast, individuals higher in SD and C were more accurate in the discrimination of happy and sad emotions, respectively. Participants with higher ST performed better in facial recognition but were less accurate in

discriminating between happy and sad faces. The association between emotional processing and temperament was not supported. However, the findings reported in other studies are not necessarily comparable to the present study as researchers have investigated emotional responses to immediate physiological and behavioural stimuli rather than emotional recognition of facial expressions. In another line of argument, the processing of emotional facial expressions may be more related to character than temperament, but this has not been empirically tested. The results of this exploratory study confirmed the association between character and facial emotional processing, which highlights the relevance of future research in this area. This expands the current data and contributes to current understandings of the relationship between personality and emotion.

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