

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

**PERSONALITY TRAITS AND
COGNITIVE PERFORMANCE
IN ELITE ATHLETES**

LIESELOTTE MARIA SCHOELER

HNNLIE001

MRC / UCT RESEARCH UNIT FOR
EXERCISE SCIENCE,
DEPARTMENT OF HUMAN BIOLOGY

Submitted in partial fulfilment
of the requirements for the
degree MSc in Exercise Science

University of Cape Town

Supervisor: Dr. Laurie Rauch

Cape Town, 18th May 2009

2. DECLARATION

I, Lieselotte Maria Schoeler (student number HNNLIE001), hereby declare that the work on which this dissertation / thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: _____

Date: _____

University of Cape Town

3. TABLE OF CONTENT	PAGE
1. Title page	1
2. Declaration	2
3. Table of content	3
4. List of tables and figures	5
5. Acknowledgements	6
6. Abstract	7
7. Introduction to the study and its research question	8
8. Literature Review	10
8.1. Personality development – when does it begin?	10
8.2. Personality assessments – a historical overview	11
8.3. The Five Factor Model: the ‘Big Five’ personality traits	13
8.4. The Five Factor Model as a valid measure of personality	14
8.5. The Five Factor Model and its applications	15
8.6. Personality traits in athletes	18
8.7. Personality traits and cognitive performance	19
8.8. The Brain Resource Company	21
9. Research design and methods	23
9.1. Participants	23
9.2. Testing protocol	23
9.2.1. General introduction to the participants	24
9.3. The ‘WebNeuro Sport’ online assessment	24
9.4. Statistical analysis	26
10. Results	27
10.1. Results on cognitive performance	27
10.2. Results on personality traits	28
10.3. Results on correlations between personality traits and cognitive performance	30

3. TABLE OF CONTENT

PAGE

11. Discussion and conclusion	33
11.1. Personality traits and the cognitive task of emotion recognition	33
11.2. Personality traits and the cognitive task of attention	36
11.3. Personality traits and the cognitive task of sensory-motor skills	38
11.4. Limitations to the study	40
11.5. Conclusion and answer to research question	41

12. References	42
----------------	----

Appendices

I.	Exclusion criteria according to the Brain Research Company
II.	Subject information
III.	Subject Informed Consent Declaration UCT / MRC
IV.	Subject Informed Consent Declaration Brain Resource Company
V.	Table 1: Overview of cognitive tests completed during the 'WebNeuro Sport' assessment
VI.	Table 2: Correlations between personality traits and cognitive functions
VII.	Example of feedback report from Brain Resource Company for The 'WebNeuro Sport' assessment
VIII.	Table 3: Descriptive data of participants (age and cognitive functions)

4. LIST OF TABLES AND FIGURES

Tables

- Table 1: Details of cognitive tests done during the assessment
- Table 2: Correlations of personality traits with cognitive functions
- Table 3: Descriptive Data of Participants (Age and cognitive function)

Figures

- Figure 1: Results on cognitive performance
- Figure 2: Results on personality traits defined by the Five Factor Model of Personality
- Figure 3: Correlations between personality traits and cognitive performance

5. ACKNOWLEDGEMENTS

Several people have contributed to completing this study. I would therefore like to express my sincere appreciation to each one of them. First of all, I would like to thank my subjects for their time and commitment in completing the assessments; especially since we ran these tests during their preparation time for the Olympic Games in Beijing. I would also like to thank Greg Clark. As the team coach he played a crucial role in supporting this study as well as assisting in organising the testing. Further, I would like to thank my supervisors Dr. Laurie Rauch and Dr. Mike Lambert for their inspiration, motivation, time, and support throughout, but especially during the final phases of my thesis. Dr. Angelique Brooks and the team of Brain Resource Company (Mimma, Erin, etc) have been amazing in providing me with the information and support whenever I needed it. Special thanks also go to the Brain Resource Company itself who has allowed me to use their online assessment 'WebNeuro Sport' for testing. I would also like to thank Dr. Amanda Claassen for her friendship and continuous support as well as everyone I haven't mentioned who encouraged and motivated me along the way. My parents have, as always, been a great source of wisdom and support for which I will always be thankful. And lastly, I would like to thank the most important person in my life, my husband Gunnar, for his continuous support and understanding but most of all for his love and friendship.

6. ABSTRACT

Mental performance consists of cognitive components, such as memory capacity, motor function, or decision making, and psychological components, such as personality traits, psychological well-being, or coping strategies. While certain personality traits have been shown to be associated with specific strengths and weaknesses in an individual's cognitive abilities only few studies have been done to investigate this relationship in athletes. Our study therefore aims to investigate the correlations between certain personality traits and cognitive performance in a sample of elite hockey players. 25 male athletes completed the 'WebNeuro Sport' assessment by the Brain Resource Company. Data was first analysed for normality before each personality trait was correlated with the results of the cognitive assessment. The most distinct correlations were found between the personality traits of Conscientiousness and emotion recognition. Neuroticism further correlated with this cognitive function category. In addition, both personality traits correlated with attention and sensory motor skills. We conclude that this has practical implications for coaches and athletes as existing physical fitness can be combined with strengths in cognition and personality to further improve athletic performance.

7. INTRODUCTION TO THE STUDY AND ITS RESEARCH QUESTION

The body's ability to maximise sporting performance is influenced by the regularity of a training stimulus which ultimately leads to adaptation and improved physical fitness (32; 53; 63; 128). Training physiology is widely recognised and put into practice. However, even though most coaches and athletes believe that performance is limited by an individual's mental preparation (69; 99), this awareness is often neglected on a day to day basis during training and competition. Mental preparation can be tracked by neurophysiological and psychological measurements and by performance on cognitive tests. Cognitive tests include motor function, memory capacity, decision making, concentration and emotion recognition, to name just a few. The psychological component is mainly assessed by questionnaires to establish an individual's personality traits, psychological well-being, coping strategies, etc.

Certain personality traits have been shown to be associated with specific individual cognitive strengths and weaknesses (39; 54; 68; 122; 126). A personality assessment is able to give insight into an individual's emotional stability, his/her preferred interaction with their environment, their levels of experimental curiosity and their attitude towards others as well as their ability to work hard and be achievement orientated.

From a variety of questionnaires the Five Factor Model (FFM) of Personality has been shown to be the ideal framework within which to describe personality. Its different personality traits focus on five different levels in any individual, namely the emotional (Neuroticism), the interpersonal (Extraversion), the experimental (Openness to experience), the attitudinal (Agreeableness) and the motivational (Conscientiousness) level (46). Certain personality traits, such as Extraversion, Conscientiousness and Neuroticism have been shown to be most apparent in athletes (12; 38; 58; 78; 102; 109; 129; 135). However, the relationship between these personality traits and cognitive abilities has so far only been investigated in a normal or disease specific population (14; 52; 60; 105; 108; 136). The results, derived from these occupational environments or clinical settings, have been used to either improve job performance or treatment outcomes respectively. By

applying such assessments to a sporting environment, an athlete can be profiled on cognitive and personality strengths. Together with the information on existing physical fitness these results can be used as an integrative 'brain-body' approach to improve individual as well as team performance.

Therefore, the particular research question we aim to answer is as follows:

What are the correlations between different personality traits and cognitive performance in a team of elite hockey players?

We assessed both, the cognitive performance as well as the personality traits by using the WebNeuro Sport assessment tool provided by the Brain Research Company. In our literature review an overview is given on personality assessments and cognitive performance followed by a detailed description of our study design. We then present our results and discussion and finish with a final conclusion on our research question.

8. LITERATURE REVIEW

This literature review aims to give an overview on the scientific literature around personality assessments and cognitive function testing. We will begin with the history of personality assessments as a lead in to why we have chosen to use the Five Factor Model of Personality in our study. We will further continue with its practical applications and the relationship to certain cognitive functions in normal, disease specific and athlete populations. Lastly, we will introduce the Brain Resource Company whose assessment has been used to establish the personality traits and cognitive functions in our participants.

8.1 Personality development - when does it begin?

Research shows that the development of personality starts with certain behavioural traits in infants and children and their reaction to the environment. A child's reaction to unfamiliar places, people and situations is regarded by many as an obvious temperamental trait (6). Kagan et al (76) for example observed infants at the age of 4 months by measuring their reactivity in response to their environment. He then followed up on these children at the age of 4 to determine how much of the earlier behaviour profiles, measured as high or low reactivity, would be preserved into later stages of development. His results show that high reactive infants have a different neurochemistry to those less excitable. He further found that certain of the early behaviour profiles observed were preserved up to the age of 4 years. Kagan concluded that early behavioural traits can, to a certain degree, predict future psychological profiles. Caspi & Silva (17) took this a step further. Their longitudinal study investigated behavioural profiles of 3 year old children which were then followed up at the age of 18. Their results revealed that children rated as shy at the age of 3, reported themselves to be more cautious, less aggressive, and more likely to avoid dangerous situations at the age of 18 in comparison to those rated sociable at an early age. These two studies indicate that the development of personality traits starts at an

early stage of human development and that it is likely that certain aspects of these behavioural profiles are preserved into later stages of life.

8.2 Personality assessments – a historical overview

Personality can be defined as a 'dynamic and organized set of characteristics possessed by a person that uniquely influences his or her cognitions, motivations, and behaviours in various situations' (118). Some researches (41; 44; 93) even suggest that personality may have a biological or even genetic basis. Even though there are several definitions and concepts of personality most researches in the area of personality psychology agree that 'personality is a concept of enduring and constant individual-level differences in the way an individual shows thoughts, feeling and actions' (McCrae 194).

The personality trait psychology has a long history (35; 87) with many different theories being put forward. The psychologist Hans Juergen Eysenck, for example, was a major contributor to the modern scientific theory of personality. His investigations suggested two main facets of personality: Neuroticism, defined as the tendency to experience negative emotions and Extraversion, defined as the tendency to enjoy positive events (40). Eysenck later added the trait of Psychoticism as the third dimension (43). The most common scales based on Eysenck's theory are the Eysenck Personality Inventory (EPI) and Eysenck Personality Questionnaire (EPQ).

Based on the typological theories by Carl Gustav Jung (four cognitive functions of thinking, feeling, seeing and intuition) (75) the Myers-Briggs Type Indicator (further referred to as MBTI) (98) assesses psychological preferences in how people perceive the world and make decisions. However, Jung's theories were criticised for its lack of scientific evidence (16) and convincing validity data (62; 84; 86; 124). On the other hand, many scientists believe that the MBTI has met or exceeded the reliability of other psychological instruments (21; 86) and is reported to give the same results

when administered to a person more than once (80). Today it is mostly used in career counselling, group dynamics, employee and leadership training as well as life and executive coaching.

The Minnesota Multiphase Personality Inventory (MMPI) is another personality assessment frequently used in mental health (57).

However, out of all these different personality assessments, the NEO-PI has been researched most extensively. Rather than being based on a theory of one particular psychologist it is based on language, the natural system people use to communicate their understanding of one another. Sir Francis Galton was the first to recognise that personality differences are encoded into language. In 1936 his idea was picked up by G. Allport and H. Odbert who worked through the most comprehensive dictionaries at that time and eventually came up with 4504 adjectives they believed were descriptive of relatively permanent traits (3). By using the statistical method of factor analysis Raymond Cattell further reduced this list to eventually sixteen major personality traits, which he believed individuals would use to describe themselves and others. Today this list of traits is known as the 16 Personality Questionnaire (further referred to as 16PF) (18) and is commonly used across different fields. In 1961 Tupes and Christal further analysed Cattell's sixteen traits and found five recurring factors (133) which Norman confirmed later to be the factors of Surgency, Agreeableness Conscientiousness, Emotional Stability and Culture (101). The following two decades showed hardly any research in the area of personality until Lewis Goldberg independently found the five factors again and later labelled them as the 'Big Five' personality factors (45). This was shortly followed by Costa and McCrae's publication on the revised NEO-PI (Neuroticism, Extraversion, Openness Personality Inventory), also known as the NEO-PI-R (Neuroticism, Extraversion, Openness Personality Inventory Revised) (23) from which they later created the Five Factor Model of Personality. The 'Big Five' (46) personality traits as they are known today are Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A), and Conscientiousness (C) which all make up the Five Factor Model of Personality traits (FFM).

8.3 The Five Factor Model: the 'Big Five' personality traits

Neuroticism describes an individual's emotional stability. Individuals scoring high in this personality trait show poor emotional adjustment in the form of stress, higher levels of anxiety and depression, they are also more self-conscious, impulsive and vulnerable whereas people scoring low in Neuroticism seem to be more self-confident, calm, even tempered and relaxed. Extraverted individuals (scoring high in Extraversion) are 'predisposed to experience positive emotions' (23). They are seen to be energetic, talkative, enthusiastic, cheerful and, at times, even dominant; they generally enjoy large groups and other people's company while seeking excitement and stimulation. In contrast, people scoring low in this personality trait enjoy time on their own or in small groups and are generally quiet and reserved. Openness describes an individual's levels of experimental curiosity. People scoring high in this personality trait are seen to be creative, innovative, imaginative and untraditional. They generally seek new experiences while people scoring low in Openness are more conventional, inflexible and show a narrow interest in exploring new ideas. Agreeableness 'involves getting along with others in pleasant, satisfying relationships' (103). Individuals scoring high in Agreeableness are generally cooperative, trusting, caring, generous and kind. Low scorers are described as manipulative, self-centred, suspicious, and ruthless (141). Conscientiousness, as the last of the five personality traits, describes an individual's ability to work hard (5). Individuals scoring high in this personality trait 'tend to be ordered, dutiful, self-disciplined and achievement orientated' (113) whereas individuals scoring low are less organised and reliable and show a lower level of self-discipline. Scoring high in this category indicates a high degree of persistence and motivation in the pursuit of goal accomplishment, duties and responsibilities.

8.4 The Five Factor Model as a valid measure of personality

The FFM has been researched and validated across cultures and languages. Ostendorf (104), for example, validated the FFM in German, Trull (133) in Chinese and Thompson (131) used the 'Big Five' structure across different cultures using an international English scale. McCrae (91) further assessed the cross-cultural generalisability of the Five Factor Model in German, Portuguese, Hebrew, Chinese, Korean, and Japanese samples. His findings suggested that the FFM of personality traits is indeed universal.

Cross-cultural studies have investigated different personalities in relation to gender (28; 115). They reported that women generally score higher in Neuroticism and Agreeableness, while men score higher in Extraversion and Conscientiousness. Interestingly these differences are only apparent in modern societies where women have more opportunities equal to those of men.

The FFM has also assessed the stability of personality traits over time as well as across different age groups. In a longitudinal study Costa suggested that personality is stable after the age of 30 (26). However, recent research and meta-analysis (121) of previous studies suggest a maturation effect as changes in all five personality traits occur at various points in life. Generally levels of Agreeableness and Conscientiousness increase with time. Extraversion, Neuroticism and Openness show the tendency to decrease. Next to these group effects individuals demonstrate unique patterns of personality change at all stages of life (114).

Despite extensive research on the FFM many researchers have criticised this kind of personality assessment on firstly having too few (10) or too many personality traits (19; 42). For instance, McAdams (85) referred to the FFM of personality as a 'psychology of a stranger' and argued that it did not have the level of detail to explain all of human personality which led Hough (61) to suggest a 9-factor model of personality. Secondly it is also said to be limited because it is data-driven and based on language observations rather than a theory (10; 42; 64; 137). Lastly, the statistical methodology of factor analysis used to identify the personality traits is criticised for not having a universally-

recognised basis (10; 42; 61). Triandis (132) furthermore argued that the generalisability across cultures does not include culture specific traits. Further studies are looking at the cross cultural validity of this assessment (31; 130). In his revised NEO Personality Inventory, published in 2000, Costa (23) suggested possible changes to the wording of the questionnaire in order for it to adapt to a population with low reading skills.

Besides the criticism the FFM has found many supporters allowing it to be used as a valid measure of personality traits (23; 24; 24; 27; 35; 46; 47; 73; 88; 88; 89). It describes the basic factors of a personality and has been generalised across various languages, measures (94), and cultures (26; 90) and it even shows evidence to be stable over time (36). The so-called 'Big Five' (46) describe an individual on an emotional (Neuroticism), interpersonal (Extraversion), experiential (Openness to experience), attitudinal (Agreeableness), and motivational (Conscientiousness) level.

8.5 The Five Factor Model and its applications

Today, the FFM of personality assessment is widely used across different fields. John et al (67) used this assessment to investigate personality in children. He added 'Irritability' and 'Activity' to the traditional five traits suggesting that the personality trait of children might be more differentiated than that of adults. More recently the Five Factor Personality Inventory – Children (95) was published allowing the assessment of children between 9 and 18 years of age.

In an occupational environment several studies have been conducted confirming the popular application of the Five Factor Model in this field (5; 64). The most cited study by Barrick & Mount (5) found that Conscientiousness was related to performance criteria whereas Extraversion was seen as a valid measure for occupations involving social interaction. This personality-occupation relationship was further confirmed by Holland (59) who found that personalities are different across jobs. Hao Zao (141)

further investigated independent business individuals (entrepreneurs) and managers using the FFM. He found that entrepreneurs scored higher in Conscientiousness and Openness and lower in Neuroticism and Agreeableness. In several articles Judge et al (70-72; 74) investigated the relationship of the 'Big Five' in a job environment. He summarised that a) Extraversion, Agreeableness and Openness to experience were correlated to transformational leadership; b) that low Neuroticism, high Extraversion and Conscientiousness were related to job satisfaction; c) that low Neuroticism and high Conscientiousness correlated with performance motivation; d) that Extraversion showed the strongest correlation with leadership followed by Conscientiousness, Openness and Agreeableness; and e) that Conscientiousness predicted intrinsic (job satisfaction) and extrinsic (income and occupational status) career success whereas Neuroticism was seen to negatively predict extrinsic success. Judge's findings are supported by a validation study done by Sinclair and Barrow (119) on job performance in managers. They found high Extraversion and Openness as well as low Neuroticism to be related to job performance.

Another area of research involving personality assessment via the FFM lies within the field of psychiatry. From Costa's (25) and McCrae's (92) clinical use of the Five Factor Model, this personality assessment has been shown to be reliable and valid in this field. Both authors explained that even though the FFM can only assist in diagnosing the patient it provides a useful framework for the client's personality to be organised. It provides a comprehensive picture of the patient's psychological strengths and weaknesses which can then be used to select appropriate treatments. Though Butcher (13) found the FFM to be too superficial for clinical assessments, a recent review by Dinzeo et al (37) concluded that the FFM played an important role in personality assessment and as such presented a useful framework in illness management. McReynolds (96) further suggested that the results of the personality assessment should be discussed with the patient as a useful part of the therapeutic process.

According to Bagby RM (4) the 'consideration of personality features is crucial to the understanding and management of major depression'. Dinzeo investigated the relationship between personality traits assessed by the FFM and mental diseases (37). According to him high Neuroticism and low Extraversion is associated with the risk of developing psychoses, while Neuroticism scores have further been linked to greater severity of positive psychotic symptoms, affective symptoms and substance abuse. Widiger et al (138; 139) further confirmed the use of the FFM in the assessment of personality disorders and provided evidence that excessive Neuroticism seems to be involved in personality disorders. Bienvenu (8) has provided evidence that Neuroticism is strongly correlated to anxiety disorder, even though many questions around the interaction of personality traits and this disorder have not yet been answered. Further findings suggested that Agreeableness and Conscientiousness were related to antisocial personality disorders as well as substance use and violence in schizophrenic patients (37). In contrast low scores in Agreeableness seem to be associated with social isolation whereas low Conscientiousness is linked to increased suicide rates in psychiatry patients (37). Even though the role of Openness in patients has not been fully understood so far it seems to be associated with fewer depressive symptoms and better social functioning.

Further studies looking at Post Traumatic Stress Disorder (PTSD) reveal that high levels of Neuroticism increase the risk of this reaction to a traumatic event (106). However, additional research in this area is suggested as the influence of environmental factors as well as previous experiences need to be considered. Two review studies on smokers and their personality traits reveal that smokers show higher traits of Neuroticism and Psychoticism compared to ex-smokers and non-smokers (116) and that increased Neuroticism as well as Extraversion are associated with the likelihood of being a smoker.

8.6 Personality traits in athletes

The physical and mental aspects of physical activity have been documented in many studies (32; 63; 128). In addition, many studies have addressed the topic of personality types in athletes, most of them confirming that physical activity correlates with higher levels of Extraversion and Conscientiousness and lower scoring of Neuroticism (38; 58; 78; 102; 112; 113; 129; 135). Looking at different levels of elite sport, Kirkaldy (78) investigated differences between Olympic and non-Olympic athletes. His study found that top female athletes scored the highest Extraversion traits and the lowest Neuroticism scores. Applying the framework of the FFM Courneyz (29) investigated correlations between exercise behaviour, exercise motives and exercise barriers. Her results indicated that high Extraversion and Conscientiousness were positively related where-as Neuroticism negatively related to exercise training. High scores in Neuroticism and low scores in Conscientiousness were further related to individuals who had difficulties in overcoming exercise barriers. Potgieter and Venter (109) looked at students and their exercise behaviour and found that those more frequently dropping out of their exercise routine scored higher in Neuroticism than those who managed to adhere to their exercise plans. However, having used the Eysenck PI he found no differences between adherers and non-adherers in the scores of Extraversion.

Using the MBTI Buckworth (12) further investigated the physical activity behaviour of students in order to determine how best to engage students in physical activity. His findings confirm those by previous authors (38) reporting that extraverts are more confident exercising due to the optimistic nature of that trait. More introvert individuals on the contrary are more likely to drop out of an exercise routine due to a low level of self-efficacy. She concluded that understanding the personality of students has implications that can contribute to exercise adherence.

In addition to exercise behaviour and motivation the understanding of an individual's personality has further implications on the role of perceived stress (22). Biondi (9) investigated psycho endocrine response patterns to

stress and identified different influences on stress perception. His review listed gender, age, personality, coping style, and social support as possible influences on perceived stress, but most of all highlighted the subjective perception of a specific situation as a main determinant. With regards to personality high scores in Neuroticism indicated higher levels of anxiety. These individuals often perceive stress differently than those less anxious and more self-confident. In a sporting context Raglin (110) found that most athletes perform best when their anxiety levels are high. However, the difference in performance might be explained by the interpretation of anxiety. Better performers view their anxiety as desirable, whereas unsuccessful athletes associate their anxiety with self-doubts and catastrophic feelings. Dienstbier (34) concluded that the ability of an athlete to deal with stress or arousal defines psychological toughness and corresponds with emotional stability and better performance in complex tasks.

8.7 Personality traits and cognitive performance

Many studies have also been done on the effect of personality traits on cognitive performance. Cognition reflects 'real world' functions (1) and involves processing of information, applying knowledge, and changing preferences on either a conscious or unconscious level. These functions show cognitive strategies that are different between, but constant within individuals (97). The idea that these individual differences can reveal different underlying psychological processes has been proposed by Underwood (134) but only recently has this been incorporated into cognitive neuroscience (79) where studies have found differences in brain activation during cognitive tasks to be associated with personality traits (39; 54; 68; 122; 126).

For example, it was found that attention and executive functions were impaired in depressive individuals (105) and that emotionally more stable personalities with extravert tendencies were able to perform better during mental tasks with noise disturbances (7). Based on Watson's (136) conclusion that Extraversion is associated with a positive emotional stimuli

and Neuroticism with a negative emotional stimuli Canli (14) used MRI technology to measure brain activity. He hypothesised that activity in brain areas associated with positive emotions would be higher in extrovert individuals when confronted with a positive emotional stimuli. A similar hypothesis was made for neurotic individuals when exposed to negative emotional stimuli. Participants completed the FFM personality assessment and where thereafter presented with a number of positive and negative images. Canli's findings confirmed both his hypotheses indicating that personality differences play a role in underlying mechanisms of cognitive functions. However, Canli pointed out that the task was uncontrolled and therefore other mental processes may have taken place during the assessment. Within the same study, Canli also investigated brain processing during emotional face recognitions. Following previous studies Canli was able to verify amygdala activation to fearful faces. Furthermore he found a correlation between the personality trait of Extraversion and the emotion recognition of happy faces. Haas (52) further investigated the relationship between Neuroticism and brain activation and found that individuals with a tendency to be sensitive to negative information and scoring high in Neuroticism had greater activity in the medial prefrontal cortex when presented with sad facial expressions.

Hooker et al (60) looked at motivational factors involved in learning and found Neuroticism to be associated with increased activity in neural mechanism for fear learning. The authors suggested that Neuroticism is associated with an enhanced ability to encode fear associations.

The personality trait of Conscientiousness has been investigated in Posner's (108) study on attention and self-regulation. His investigations revealed that executive function requires awareness of detail as well as control over self-behaviour and mental state, all characteristics of the personality trait of Conscientiousness. His research suggested that several brain areas are involved in executive function allowing the assumption that the above neural network is related to Contentiousness. Furthermore, Bonanno et al (11) investigated cognitive performance on four different groups of individuals: non-defensive and low anxious, high anxious, repressors and defensive and high anxious. He found that repressors, individuals able to control their

behaviours and emotions, made significantly fewer mistakes during their cognitive tasks than the other groups. This indicates that the ability of repressor individuals to control behaviour increases cognitive performance in a similar way as the personality trait of Conscientiousness.

8.8 The Brain Resource Company

The Brain Resource Company, further referred to as BRC, is a service company which provides standardised test batteries to measure brain function and cognition across different applications. As a result of a countless number of different studies on small datasets, isolated theories, and a variety of different methodologies most studies within neurosciences have mutually incomparable data. Thus, there was a need to establish a standardised database (65). The BRC has designed such a database allowing a network of worldwide testing laboratories to contribute to the first controlled and standardised International Database on the human brain. Rather than looking at a few brain functions, the Brain Resource International Database (BRID) focuses on the brain's core cognitive competencies. Data captured through standardised and valid test batteries (48; 107; 140) includes demographics, brain function (Psychophysiology - EEG/ERP), cognition (online/touch screen test battery), brain structure (sMRI/fMRI), and Genomics (cheek swab or blood sample) thus adding to the database of more than 2000 'normative' subjects as well as a growing number of patients with neurological and psychiatric illnesses. Initially, the BRC was used by pharmaceutical companies in order to research the effects of pharmaceutical compounds on the brain. This service has now been expanded to scientists and provides an integrated approach as the outcomes include the effects of age, gender, years of education, and personality type. The main goals of this integrated and centralised database are 'to quantify individual's differences in normative brain function, to compare an individual's performance to their database peers and to provide a robust normative framework for clinical assessment and treatment prediction' (48). The CEO of the BRC, E. Gordon notes that 'the combination of size and multidimensional measures of brain

function captured in this database may provide a normative and evidence-based framework for individually-based assessments in 'personalised medicine'. In order to achieve this, the BRC has overcome difficulties in finding consent on the essence of what needs to be included in a brain data base, has managed to eliminate technical differences in data collection and, opened the opportunity for researchers to share their data.

The tests conducted follow the data profiles as adopted by the BRC. They are computerised and fully automated, yet easy to use while reflecting an individualised cognitive performance profile. The assessments are ideally suited for cognitive profiling during staff recruitment ('WebNeuro Recruit', 'WebNeuro Safety' 'WebNeuro Career'), early detection of cognitive decline ('WebNeuro/IntegNeuro Assurance'), assessments of signs of depression or cognitive effects of sleep deprivation ('WebNeuro Wellness'), general cognitive performance in sports and the effect of concussion ('WebNeuro/IntegNeuro Sport'), identification of gifted or struggling children and quantification of cognitive impairment or disability ('WebNeuro/IntegNeuro Focus'). The assessments can be completed on either a computer or touch screen, with or without EEG measures. Upon completion the participant's data is transmitted via a secure website to the Brain Resource Central Analysis Facility for individual assessment. Individual reports are then provided within 48 hours.

The participants of our study completed the 'WebNeuro Sport' computer assessment which consists of an assessment on basic cognitive functions (memory, attention, sensor-motor, emotion recognition, and executive function) as well as a personality assessment using the FFM.

9. RESEARCH DESIGN AND METHODS

9.1 Participants

A team of 25 male hockey players who competed on an international level were recruited for this study. The athletes were fully informed about the study and they signed an Informed Consent Form prior to participation. This document also included a list of exclusion criteria such as any recent illness, hospitalisation, or surgical procedures as well as the BRC “Exclusion criteria for healthy control participants at recruitment” (see Appendix 1). None of the recruited athletes were excluded because of the above exclusion criteria.

The athletes completed the testing during a training camp. The ‘WebNeuro Sport’ is an online assessment and as such a computer and internet connection was set up in a testing room. No music or television was allowed during testing and the outside noise levels were kept to a minimum in order not to disturb the testing process. The athletes were test one after the other. After the athlete was introduced to the testing protocol (website, login and general introduction) he was left alone in the testing room. This allowed for minimal distraction during testing.

9.2 Testing protocol

The participant logged onto the BRC webpage: www.brainresource.com. He then went into the ‘log in’ area of ‘WebNeuro Sport’ to enter his personnel login details provided by BRC. These login details were unique identification numbers in order to ensure anonymity. After reading and agreeing to the BRC terms and conditions the participant entered his personal details. He was then given a general introduction (see explanation below) to the flow of the online testing. This provided the participant with sufficient information on what to expect during the testing.

9.2.1 General introduction to the participant

Each participant was introduced to the test using the following explanation:

‘The assessment will take about 60 minutes to complete. The online test will begin once you have selected the overall START button. You will then be asked to complete a general demographic questionnaire. Once this is completed, the test will move on to the cognition tasks. Prior to each cognition task an explanation of the specific task is giving to you as well as an example demonstrated on the screen. This is to ensure that you fully understand the testing requirements. Once understood and ready to proceed, you can select the ‘continue’ button in order for the specific task to begin. After completing the cognition tasks the test continues with the ‘Carlstedt Subliminal Attention, Reactivity and Coping scale for Athletes’ as well as the personality questionnaire. Once this is completed you will be informed that the test has been concluded successfully.’

9.3 The ‘WebNeuro Sport’ online assessment

The BRC testing battery ‘WebNeuro Sport’ consists of 16 tests which takes approximately 60 minutes to complete. The test consists of three parts, divided as follows:

1. *Web-based demographic questionnaire*
2. *Web-based cognitive tests*

This includes the basic cognitive assessments in the following categories:

- a) Attention / Behavioural
- b) Executive Function
- c) Emotion Recognition
- d) Language
- e) Memory
- f) Sensory-Motor Function

3. *Web-based 'Carlstedt Subliminal Attention, Reactivity and Coping scale for Athletes' (further referred to as CSARC-A) testing and Personality Assessment*

1. *Web-based demographic questionnaire*

The web-based demographic questionnaire is the first of 16 tests and consists of 23 self-reported questions. The questions cover the following : Personal details, vision and/or hearing impairment, mobility in hands, handedness, mobile phone use, learning difficulties, psychiatric and/or neurological history, sleep history of the last month, physical activity habits, eating habits, smoking and alcohol history, drug history, relevant surgery, physical trauma of the head, overall health, emotional well-being and mood status (over the previous week), emotional intelligence, prescription drugs, early life stress, and traumatic experience.

2. *Web-based cognitive tests*

After completing the demographic questionnaire the test moves on to the cognitive function tests. The cognitive tests include test 2 up to test 14 out of the total number of 16 tests during 'WebNeuro Sport'. They are divided into 6 different categories: a) Attention and Behavioural tasks, b) Executive function , c) Emotion Recognition, d) Language tasks, e) Memory capacity and, f) Sensory-Motor function.

The Category of Attention / Behavioural is tested with 'Sustained Attention', 'Switching of attention' and the behavioural tasks of the 'Go no go' test. Executive Function is tested by 'Executive maze', while Emotional Cognition is assessed by 'Processing of facial emotions'. Language skills are tested by 'Spot the real word'. Memory capacity is tested by 'Memory recall and cognition', 'Digit Span', 'Memory recall, and cognition' test – delayed, 'Processing of facial emotions' test – delayed and 'Visual working memory'. Sensory-Motor function is tested by 'Motor tapping' and 'Choice reaction time'. Each test is explained prior to the start of the test and the participant is free to choose when he is ready to begin. A definition of each cognitive test is provided in Table 1.

3. The CSARC-A test and Web-based Personality assessment

The CSARC-A test (15; 15; 20) is test number 15 out of the total of 16 assessments. It consists of 60 questions which are to be answered with YES or NO to assess subliminal attention, subliminal reactivity as well as progressive and subliminal coping. These brain measures are directly linked to key components of peak performance, such as the ability to focus, physiological reactivity, cognitive processing, motor readiness and control, as well as control over emotions during sporting performance.

The personality assessment is the final (16th) test of the 'WebNeuro Sport'. It uses the Five Factor Model of personality assessment which consists of 70 questions. It differentiates between five different personality traits, namely: Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness. The questions are to be answered with 'strongly disagree', 'disagree', 'neutral', 'agree' or 'strongly agree'.

9.4 Statistical analysis

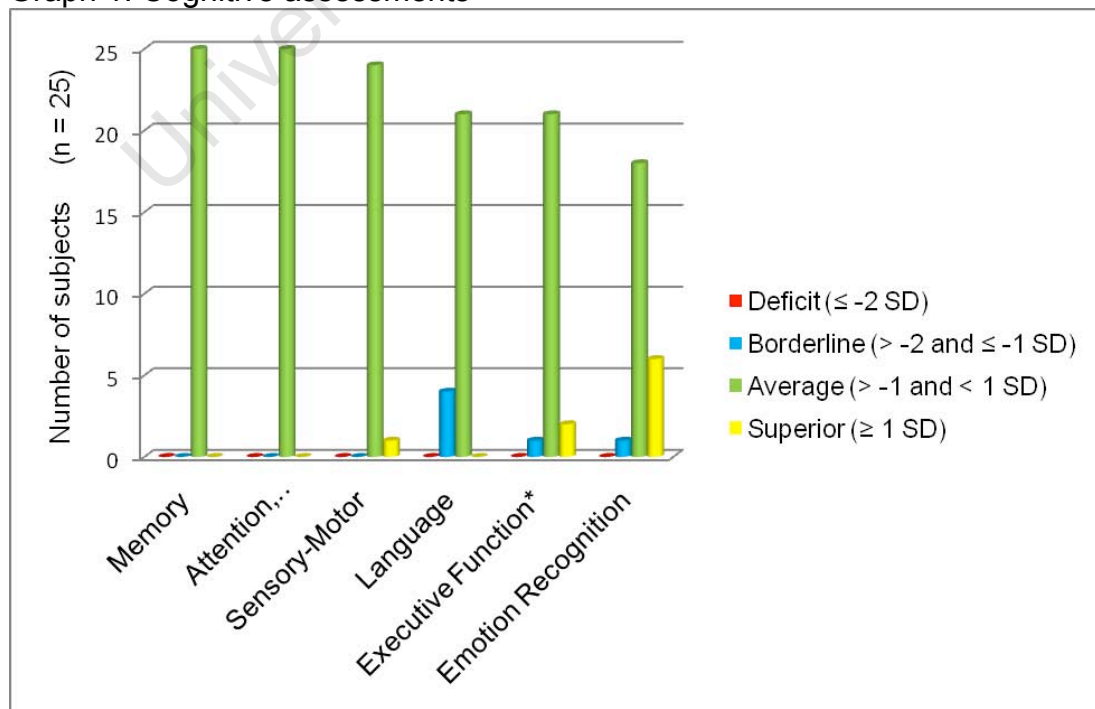
Results were provided by BRC in an excel format. Statistical analyses were done using Prism 3.0 Statistical Software. Since this study focuses on personality traits and cognitive performance data on the CSARC-A test, emotional well-being and mood status, emotional intelligence, early life stress, and traumatic experience was excluded from data analysis. Data on cognition and personality traits was first analysed for normality before each personality trait was then correlated with the results of the cognitive assessment. Parametric data was correlated using two-tailed Pearson correlation, non-parametric data was correlated using two-tailed Spearman correlation equations. Both correlation equations used 95% confidence intervals.

10. RESULTS

10.1 Results on cognitive performance

25 male elite athletes with an average age of 25.0 ± 3.6 were tested in this study. Graph 1 describes the athlete's score in each of the different categories of the cognitive function tests. These scores are based on detailed measurements (e.g. response time, number of correct words, etc) taken during the assessment. The x-axis shows the different cognitive function categories as Memory, Attention, Sensory-Motor, Language, Executive Function, and Emotion Recognition. The number of athletes is shown on the y-axis. The scores are defined as 'standardised scores' indicating that each result is normalised for age and gender within the BRC database (1). The different scores for each different category of cognitive function are labelled and defined as either 'Deficit' (≤ -2 SD), 'Borderline' (> -2 and ≤ -1 SD), 'Average' (> -1 and < 1 SD) or 'Superior' (≥ 1 SD). Positive 'standardised scores' indicate strengths while negative scores indicate possible weaknesses. 'Standardized scores' beyond -2 or 2 are statistically significant.

Graph 1: Cognitive assessments



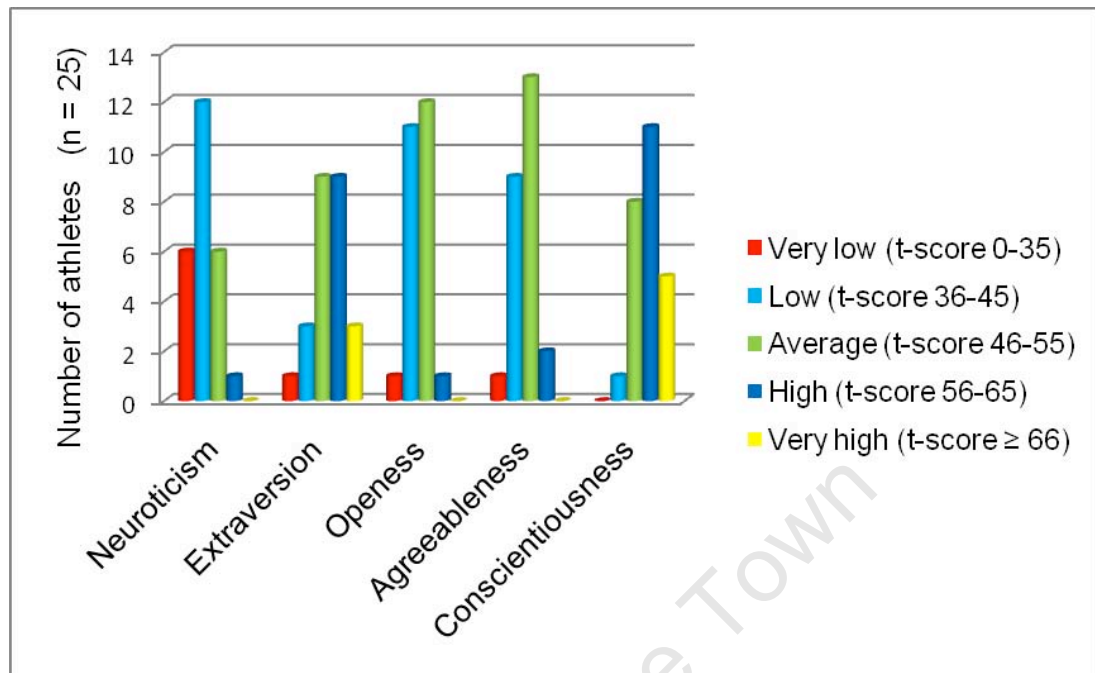
* One test was not completed successfully. Data of one participant is therefore missing in this category.

Overall most athletes scored 'average' within their cognitive assessments. However, the performance in emotion recognition was outstanding for almost a quarter of the athletes where 6 participants scored 'superior' while most of the others (18) scored 'average'. Only 1 participant scored within the 'borderline' category. The cognitive skill of Executive Function showed two athletes scoring 'superior' while 21 scored 'average' and 1 participant fell within the 'borderline' category. In Sensory-Motor skills only 1 athlete scored 'superior' whereas the other 24 athletes fell within the 'average' category. For Memory and Attention all 25 athletes scored 'average'. Language skills were scored 'average' by 21 participants, while 4 scored 'borderline' within this category.

10.2 Results on personality traits

Graph 2 describes the athletes' personality traits as classified by the Five Factor Model. The personality traits Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness are labelled on the x-axis. The number of athletes scoring in a particular personality trait category is shown on the y-axis. The scores of our athletes were compared to their age and gender peers (not limited to athletes) in the BRC database and are therefore labelled as t-scores (1). They are defined as either 'Very low' (t-score between 0 and 35), 'Low' (t-score between 36 and 45), 'Average' (t-scores between 46 and 55), 'high' (t scores between 56 and 65) or 'very high' (t scores ≥ 66).

Graph 2: Personality traits defined by the Five Factor Model



Most athletes scored within the 'low'/'average' or 'average'/'high' category of the five personality traits. The most outstanding personality trait was Conscientiousness where 5 athletes scored 'very high' and 11 scored within the 'high' range. 8 athletes scored 'average' in this trait and only 1 athlete scored low. The second most distinct personality trait was Neuroticism. 6 athletes scored 'very low', 12 scored 'low', and 6 scored 'average' while only 1 athlete scored 'high' category and none 'very high'.

Extraversion, the third most distinct personality trait, showed most athletes scoring 'average' (n = 9), 'high' (n = 9) or 'very high' (n = 3). Only 4 athletes scored 'low' (n = 3) or 'very low' (n = 1) and 1 participant scored 'very low'.

In the personality trait of Openness only 1 subject scored 'very low', 11 scored 'low', 12 scored 'average' and 1 athlete scored 'high'. No athletes scored in the highest category for Openness.

Agreeableness was only scored 'very low' by 1 athlete, 9 scored 'low', 13 scored 'average' and 2 scored 'high' in this trait. No athletes scored in the highest category for Agreeableness.

10.3 Results on correlations between personality traits and cognitive performance

All the cognitive function categories that had significantly correlated with any of the five personality traits as defined by the NEO-Five Factor Model are shown in Table 2. Furthermore, some of the most distinct correlations are displayed in Figure 3.

Most correlations were found for the personality trait of Conscientiousness. Accuracy in recognising sad faces ($r = 0.55$), accuracy in recognising disgust faces ($r = -0.61$), reaction time in recognising disgust faces ($r = -0.46$), as well as performance during the attention task (number of correct responses in recognising the words - $r = 0.41$) all correlated with Conscientiousness. Additionally, Conscientiousness also correlated with variability in reaction time during the motor tapping task ($r = -0.52$) and with working memory (false misses - $r = 0.46$).

Neuroticism had the second most correlations and reached significance within four different cognitive function categories: memory and recognition, emotion recognition, sensory-motor function and attention/behaviour(al). Negative correlations were found for accuracy in recognising sad faces ($r = -0.41$), number of correct responses to a word ($r = -0.48$) and delayed recall trial 4 of a certain set of words ($r = -0.46$). Positive correlations were found with the variability of reaction time during motor tapping ($r = 0.48$) and the number of errors (recognising the wrong words) within this intrusion trial ($r = 0.44$).

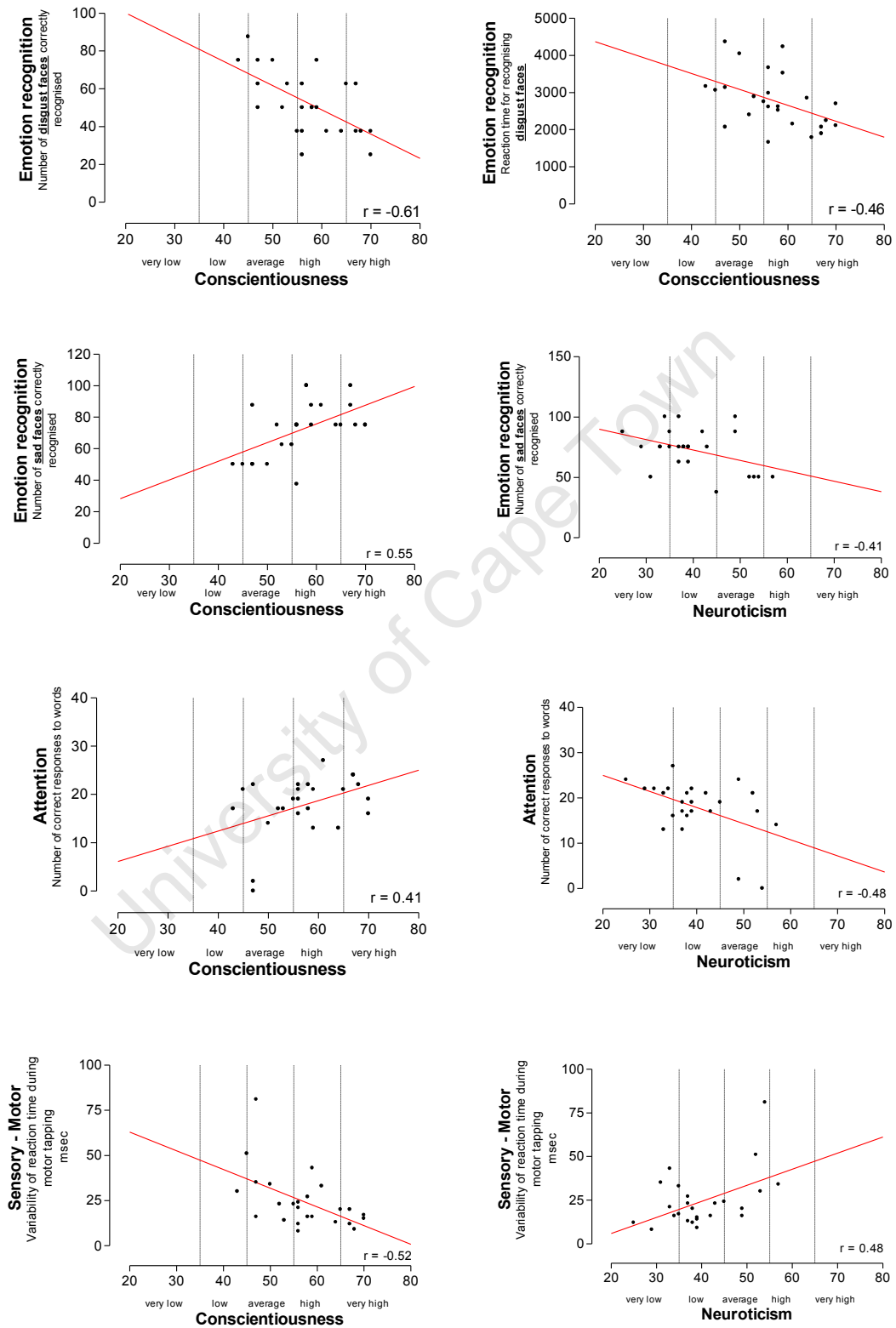
The personality trait of Openness to experience correlated with the accuracy in recognising fear faces ($r = 0.46$), with immediate recall (trial 3) of a certain set of words ($r = -0.41$) and with intrusion trial 3 (number of errors when recognising the wrong words, $r = 0.41$).

Agreeableness was correlated with emotion recognition, with attention, as well as with memory and recognition. Recognition of fear faces ($r = -0.35$), reaction time during the sustained attention task ($r = -0.40$), the total number of correct words during immediate recall trial 1-3 ($r = 0.49$), the number of

errors during the intrusion trial 1 ($r = -0.40$) as well as the total number of errors during the intrusion trials 1-3 ($r = -0.49$) all correlated to Agreeableness.

Extraversion only correlated with the language task of recognising the real word ($r = -0.41$).

Figure 3: Significant correlations between personality traits and cognitive performance



11. DISCUSSION AND CONCLUSION

The most evident findings in our study were the personality trait correlations with a) emotion recognition, b) attention, and c) sensory motor skills. A brief introduction of each specific cognitive function category is given before discussing the relevant results.

11.1 Personality traits and the cognitive task of emotion recognition

The most distinct performance of our subjects was in emotion recognition. Four out of the five personality traits assessed were correlated with facial emotion recognition. The facial emotion recognition test required the participant to look at several pictures of facial expressions, one at a time, and to rate them into categories of fear, happy, sad, neutral, angry, and disgust expressions. Charles Darwin concluded that 'facial expression has been considered a salient component of emotional behaviour' (30). While being subjective and based on individual experiences expressed emotions are a form of non-verbal communication and are associated with feelings, thoughts and behaviour. They furthermore indicate interest and involvement with others and allow us to connect with the world around us. The online Encyclopedia 'Wikipedia' states that 'emotions are related to activity in brain areas that direct our attention, motivate our behaviour and determine the significance of what is going on around us'. Facial expressions therefore show a true reflection of an individual's mental, physiological, and emotional state as they happen subconsciously and are difficult to influence (2).

Russel (117) reviewed differences in facial emotions across different cultures and found that the face reveals emotions in a way that is universally understood. However, the perception and intensity of this emotional understanding might vary across cultures. In his review Mandal et al (82) took this a step further and suggested that the left side of the face expresses more emotions and displays cultural specific norms where as the right side of the face shows more universal signals. Following Mandal findings, Nomuro (100) investigated the response to ambiguous (positive and negative)

expressed facial emotions. He identified several brain areas (anterior cingulate, medial frontal, and bilateral inferior frontal gyrus) involved in processing positively and negatively valenced stimuli. He suggested that the neural network involving these brain areas play a crucial role in social behaviour as this allowed ambiguously expressed faces to be processed correctly. In addition to Mandal's findings, several other studies have identified the brain areas involved in emotion processing (19; 50; 52; 56; 111).

According to Haman et al (55) brain activity associated with emotion processing is influenced by a range of different factors, such as gender, age and personality. Investigating age as an aspect affecting emotion processing Ruffman (55) and Keighley (77) found that younger individuals performed a lot better in processing facial emotions than older adults. However, this seems to be dependent on the facial emotion to be recognised. Guyer (51) investigated these findings further by focussing on fear recognition and brain activation. He found increased amygdala activation to fearful faces in adolescents as compared to adults, which equates to greater subconscious bodily prompting in younger individuals. Guyer suggested that this pointed to an 'increased vulnerability to affective disorders' in adolescent populations. Furthermore, Guyer found stronger connectivity between the amygdala and hippocampus in adults. He concluded that the increased connectivity between these two brain areas could be seen as a 'sign of maturation in learning or habituation to facial expressions'.

A further study on facial expressions in different age groups focussed on disgust recognition (127). The authors found an age-related improvement in recognising disgust faces which he explained mainly by the fact that younger individuals made more mistakes in disgust recognition because they had the tendency to mistake disgust for anger.

Suzuki and co-workers (240) found the opposite effect with disgust recognition. They found an age-related decline in sadness recognition. Since negative emotions are related to sadness recognition they concluded that older individuals experiences less negative emotions and therefore have more difficulty in recognising sadness. This could be explained by a

maturation effect where, with age and life experience, one becomes less sensitive to this facial expression.

In our athletes our strongest correlation was between the emotion recognition of disgust and Conscientiousness. Our group of athletes fell within the same age category as Suzuki's (127) young group above. Since Suzuki's findings suggest that younger individuals have the tendency to mistake anger for disgust our high negative correlation between both disgust recognition and reaction time to disgust recognition and Conscientiousness can be more fully explained by age. In our relatively young athletes, the more conscientious they were, the more they seem to mistake disgust for anger.

Conscientiousness as well as Neuroticism correlated with the recognition of sad faces, although oppositely. We found that those athletes scoring high in Conscientiousness were more accurate in recognising sad facial expressions. Through the eyes of a conscientious individual a sad face could also be read as a 'disappointed' facial expression. Conscientious individuals care about what they do and aim to perform at their best. They might therefore be highly sensitive to sad expressions, read as 'disappointment', as disappointing others is something the achievement orientated personality trait would try to avoid through self-discipline and hard work.

Interestingly, we found a negative correlation between Neuroticism and sadness recognition, although the scope of our athletes was quite limited in this personality trait (Table 3). The majority of athletes scored in the lower categories of Neuroticism, with only one scoring high (at the lower end of the 'high' category) and none scoring in the very high category. As a result, the correlation was relatively weak, with $r = 0.41$. Most previous studies reported positive correlations between Neuroticism and experiencing sadness (33; 123). On the other hand, Mandal (83) suggested that neurotic individuals have a tendency to reject sad faces. Our results are in keeping with Mandal's findings where higher scores in Neuroticism show relatively weaker performances in sad facial recognition, which may be due to a tendency to reject this facial expression.

Openness showed a positive and Agreeableness a negative correlation with recognising fearful faces. Individuals scoring high in Openness, also known as 'Openness to experience', are seen to be more curious and sensitive to inner feelings. Reflecting more on one's own inner feelings and being open to new experiences will generally make these individuals more sensitive to their surroundings. Fearful faces are a non verbal expression of danger and emergency. Since open individuals are able to recognise this facial expression better than others, they are more able to prepare and adapt to such situations. In an elite team environment this can be seen as a psychological strength. Reading either the team colleagues' or the opponents' level of fear allows reading the game 'between the lines' and being able to do so respond accordingly.

In contrast Agreeableness, was negatively correlated with recognising fearful faces. This could be explained by the nature of this 'nice guy' personality. High scorers' in Agreeableness prefer social harmony, cooperation, friendliness and consideration for others. A fearful facial expression simply does not fit into the world of an agreeable person and is therefore difficult to recognise for individuals scoring high in Agreeableness.

11.2 Personality traits and the cognitive task of attention

The second most important finding is the correlation of two personality traits with Attention: Conscientiousness correlated positively whereas Neuroticism correlated negatively with this specific task. Attention is defined as either selective or divided. 'Selective attention implies conscious awareness of, and concentration upon, a particular source of stimulation or information' (49). Divided attention by contrast is more typical of real world tasks as it covers attention that is divided over a range of different input and their processing. Smith (120) defined attention as one of the 'fundamental executive processes'.

During our specific task of verbal interference (125), as a measure of selective attention, the athlete was required to name the ink colour that a

word was written in rather than the actual word. The number of correct responses was recorded. This task measures the ability of an individual to control inappropriate, well-learned, impulsive, and automated responses (1). Several studies concurred (7; 34) that emotional stability, one of the characteristics of low Neuroticism, has been found to be associated with better performance in attention tasks. This was confirmed in our study where low and very low scores in Neuroticism, hence emotionally stable individuals had better performances with more correctly recognised words.

The other personality trait that was also correlated with Attention was Conscientiousness. In his recent study MacDonald (81) distinguished between two different types of cognitive processing: a) implicit (automatic, effortless, fast, and parallel processing of information) and b) explicit (conscious, effortful, step by step processing of information, analytical, planning, and cognition control). He analysed explicit cognitive behaviour, also described as effortful control of automated responses, and its relation to social and emotional behaviour. He found that (effortful) control of behaviour was not only related to controlling automatic impulses and long term planning but also to the personality trait of Conscientiousness.

Our results are in line with the above findings. We found a positive relationship between behaviour control during an attention task and Conscientiousness. One needs to bear in mind that this assessment focuses on selective attention and, to a high degree, does not reflect the real world. Divided attention especially important in a team sport environment where the athletes are required to focus and process several parts of the game at the same time, e.g. moving the ball forward but also pay attention to where the team mates are located on the field or how fast the opponent is running. However there are times when selective attention becomes important in situations such as penalty shooting, ignoring spectators and other distractions.

11.3 Personality traits and the cognitive task of sensory-motor skills

Neuroticism and Conscientiousness are again correlated oppositely, this time with motor tapping (variability of reaction time). This test required the subject to tap the 'space' button on the keyboard as many times as possible for 30 seconds. The total number of taps as well as the variability in time between taps is measured giving an indication of basic hand-eye coordination. Hand-eye coordination refers to the control of eye movement and the processing of visual input to guide body movement (66). It is crucial for daily activities such as writing as well as usage of tools and computers and it is an essential basis for the development of further advanced movement skills in sporting performance.

The positive correlation we found indicates that athletes who scored low in Neuroticism showed less variability in their motor tapping performance. Neuroticism, as described before, is defined as the personality trait of emotional stability and describes an individual's ability to deal with stress. Low scores in Neuroticism are seen to be more emotionally stable and being able to deal with higher stress levels than people scoring high in this personality trait. Therefore, athletes higher in Neuroticism seem to be less able to deal with the stress of completing a specific task which then results in greater variability in their sensory motor function. While at first sight their performance might not differ from those scoring low in this traits, it is the variability in performance that brings out the inconsistency in the outcome of this specific cognitive task. Therefore it is the individual's self-confidence – one of the major aspects of Neuroticism – which is most likely to impact on any performance task. High Neuroticism scores indicate low self-confidence which means weak confidence in one's own abilities, and such individuals will perform with greater variation and a possibly less successful outcome.

Looking next at the negative correlation between motor tapping and Conscientiousness we did expect athletes with high scores in this personality trait to have less variability in their motor tapping. Several studies have linked this personality trait to performance (5; 11; 73; 113). The level of self-

discipline and achievement orientation of Conscientiousness indicates that this personality trait would have a positive impact on the consistency of their performance in this task.

University of Cape Town

11.4 Limitations to the study

Limitations in our study lie in the fact that we were not able to control for all assessments to be completed before a training session in order to avoid physical as well as mental fatigue. Another limitation is the fact that some athletes were set up to complete the assessment on a laptop while others completed the assessment on a normal computer. Since the assessment requires many tasks to be completed using the mouse, differences in technology might have had an impact on our results. Furthermore, due to the fact that the assessments were done during a training camp we were not able to control the time of day.

We also did not control for caffeine and alcohol intake before the online assessment was done. According to the BRC Methodology Document (1) these 2 factors may potentially have an effect on the outcome of the assessment. Lastly, we were only able to complete our assessments on team athletes. Future studies could look at personalities and cognitive function categories in elite individual athletes, non-athletes, as well as other team sports.

11.5 Conclusions and answer to research question

This study looked at the Five Factor Model of personality and its correlation with cognitive function tests in elite athletes. Our research question at the beginning of this study was as follows:

Are there any correlations between different personality traits and cognitive performance in a team of elite hockey players?

This question can be answered in the affirmative.

In summary we are able to conclude that differences in individual personalities resulted in differences in cognitive performance in our sample of elite hockey players.. These findings have practical implications for coaches and athletes: when looking at performance an ideal personality trait combination for athletes would be high scoring in Conscientiousness and low scoring in Neuroticism. Almost a quarter of the team scored in the 'superior' category in facial emotion recognition, suggesting that this is an important attribute in elite environments. Together with the information on existing physical fitness these results can be used as an integrative 'brain-body' approach to improve individual as well as team performance.

Our study did not aim to establish whether our findings are specific to elite athletes, a hockey team or a team environment in general. Future studies will have to address the possible correlation between personality traits and cognitive abilities in other elite team sports, elite individual sports, as well as amateur sports on an individual or team basis.

12. REFERENCES

1. Brain Resource International Database Methodology Document. *BRID Methodology* 2005.
2. Wikipedia, Entry as at 11.01.2009 [Online]. 2009.
3. **Allport GW and Odbert HS.** *Trait names: A psycholexical study.* Psychological Monographs, 1936.
4. **Bagby RM, Psych C, Quilty LC and Ryder AC.** Personality and depression. *Canadian Journal of Psychiatry* 53: 14-25, 2008.
5. **Barrick MR and Mount MK.** The Big Five personality dimensions and job performance: A meta-analysis. *Personnel Psychology* (44), 1-26. 1991.
6. **Bates JE.** Concepts and measures of temperament. In: *Temperament in Childhood*, edited by Kohnstamm GA, Bates JE and Rothbart MK. New York: John Wiley, 1989, p. 3-26.
7. **Belojevic G, Jakovljevic B and Slepcevic V.** Noise and mental performance: personality attributes and noise sensitivity. *Noise & Health* 6: 77-89, 2003.
8. **Bienvenu OJ and Stein MB.** Personality and anxiety disorders: a review. *Journal of personality disorders* 17: 139-51, 2003.
9. **Biondi M and Picardi A.** Psychological stress and neuroendocrine function in humans: the last two decades of research. *Psychotherapy and psychosomatics* 68: 114-50, 1999.

10. **Block J.** A contrarian view of the five-factor approach to personality description. *Psychological Bulletin* 117: 187-215, 1995.
11. **Bonanno GA and Singer JL.** Repressive Personality Style. In: Repression and dissociations, edited by Singer JL (Ed). Chicago: The University of Chicago Press, 1986.
12. **Buckworth J, Granello D and Belmore J.** Incorporating personality assessment into counseling to help college students adopt and maintain exercise behaviors. *Journal of college counseling* 5: 15-25, 2002.
13. **Butcher NJ and Rouse SV.** Personality: individual differences and clinical assessment. *Annual Review of Psychology* 47: 87-111, 1996.
14. **Canli T.** Functional brain mapping of extraversion and neuroticism: learning from individual differences in emotion processing. *Journal of personality* 72: 1105-32, 2004.
15. **Carlstedt RA.** Integrative Evidence-Based Athlete Assessment and Intervention: A Field-Test and Validated Protocol. *The Journal of the American Board of Sport Psychology* 1: 2007.
16. **Caroll RT.** Myers-Briggs Type Indicator-The Skeptic's Dictionary [Online]. 2004.
17. **Caspi A and Silva PA.** Temperamental qualities at age three predict personality traits in young adulthood: longitudinal evidence from a birth cohort. *Childhood development* 66: 486-98, 1995.
18. **Cattell, R. B.** Personality and motivation: Structure and measurement. 19(1), 53-67. 1957. New York: Harcourt, Brace & World, *Journal of Personality Disorders*.

19. **Cattell, R. B and Stice, G. F.** Handbook for the Sixteen Personality Factor Questionnaire. 1957. Institute of Personality and Ability Testing, Champaign, IL.
20. **Chadwick R.** Critical moment performance and "Athletes's Profile" assessment in high school soccer players: An investigation of the theory of critical moments. 2005. American Board of Sports Psychology. Technical Report from ABSP Certification final project.
21. Clack, Gillian and Judy Allen. Response to Paul Matthews' criticism. 2008
22. **Cohen JI.** Stress and mental health: a biobehavioral perspective. *Issues in Mental Health Nursing* 21: 185-202, 2000.
23. **Costa PT and McCrae RR.** *Revised NEO personality inventory (NEO-PI-R) and NEO five factor inventory (NEO-FFI) professional manual.* Odessa, FL: Psychological Assessment Resources, 1992.
24. **Costa PT and McCrae RR.** *The NEO personality inventory manual.* Odessa, FL: Psychological Assessment Resources, 2009.
25. **Costa PT, Jr.** Clinical use of the five-factor model: an introduction. *Journal of personality assessment* 57: 393-8, 1991.
26. **Costa PT, Jr. and McCrae RR.** Personality in adulthood: a six-year longitudinal study of self-reports and spouse ratings on the NEO Personality Inventory. *Journal of personality and social psychology* 54: 853-63, 1988.
27. **Costa PT, Jr. and McCrae RR.** Stability and change in personality assessment: the revised NEO Personality Inventory in the year 2000. *Journal of personality assessment* 68: 86-94, 1997.

28. **Costa PT, Jr., Terracciano A and McCrae RR.** Gender differences in personality traits across cultures: robust and surprising findings. *Journal of personality and social psychology* 81: 322-31, 2001.
29. **Courneya, K. S. and Hellsten LA.** Personality correlates of exercise behavior, motives, barriers and preferences: an application of the five-factor model. 24, 625-33. 1998. *Personality and Individual Differences*.
30. **Darwin C.** *The expressions of emotions in Man and Animals*. New York: Philosophical Library, 1872.
31. **De Fruyt F, McCrae RR, Szirmak Z and Nagy J.** The Five-factor Personality Inventory as a measure of the Five-factor Model: Belgian, American, and Hungarian comparisons with the NEO-PI-R. *Assessment* 11: 207-15, 2004.
32. **Dempsey JA and Johnson BD.** Demand vs. capacity in the healthy pulmonary system. *Schweiz Z Sportmed* 40: 55-64, 1992.
33. **Derryberry D and Reed MA.** Temperament and attention: orienting toward and away from positive and negative signals. *Journal of personality and social psychology* 66: 1128-39, 1994.
34. **Dienstbier RA.** Arousal and physiological toughness: implications for mental and physical health. *Psychological Review* 96: 84-100, 1989.
35. **Digman JM.** Personality structure: emergence of the five-factor model. *Annual Review of Clinical Psychology* 41: 417-440, 1990.
36. **Digman JM.** Five robust trait dimensions: development, stability, and utility. *Journal of personality* 57: 195-214, 1989.

37. **Dinzeo TJ and Docherty NM.** Normal personality characteristics in schizophrenia: a review of the literature involving the FFM. *The Journal of Nervous and Mental disease* 195: 421-9, 2007.
38. **Eagleton JR, McKelvie SJ and de Man A.** Extraversion and neuroticism in team sport participants, individual sport participants, and nonparticipants. *Perception and Motor Skills* 105: 265-75, 2007.
39. **Ebmeier KP, Deary IJ, O'Carroll RE, Prentice N, Moffoort APR and Goodwin GM.** Personality associations with the uptake of the cerebral blood flow marker Tc-exametazime estimated with single photon emission tomography. *Personality and Individuals differences* 5: 587-595, 1994.
40. **Eysenck HJ.** *Dimensions of personality.* 1947.
41. **Eysenck HJ.** *The structure of human personality.* 1952.
42. **Eysenck HJ.** Four ways five factors are not basic. *Personality & Individual Differences* 667-673, 1992.
43. **Eysenck HJ and Eysenck SBG.** *Psychoticism as a Dimension of Personality.* London: Hodder and Stoughton, 1976.
44. **Funder DC.** Personality. *Annual Review of Psychology* 52: 197-221, 2001.
45. **Goldberg, L. R.** Language and individual differences: The search for universals in personality lexicons. In Wheeler (Ed.). 141-165. 1981. Beverly Hills, CA: Sage, *Review of Personality and social psychology*, Vol. 1.

46. **Goldberg LR.** An alternative "description of personality": the big-five factor structure. *Journal of personality and social psychology* 59: 1216-29, 1990.
47. **Goldberg LR and Saucier G.** So what do you propose we use instead? A reply to Block. *Psychological Bulletin* 117: 226-5, 1995.
48. **Gorden E, Cooper N, Rennie C, Hermens D and Williams LM.** Integrative Neuroscience: The Role of a Standardized Database. *Clinical EEG and Neuroscience* 36: 64-75, 2005.
49. **Groome D.** *An Introduction to Cognitive Psychology.* Hove and New York: Psychology Press Taylor & Francis Group, 2000.
50. **Gur RC, Schroeder L, Turner T, McGrath C, Chan RM, Turetsky BI, Alsop D, Maldjian J and Gur RE.** Brain activation during facial emotion processing. *Neuroimage* 16: 651-62, 2002.
51. **Guyer AE, Monk CS, McClure-Tone EB, Nelson EE, Roberson-Nay R, Adler AD, Fromm SJ, Leibenluft E, Pine DS and Ernst M.** A developmental examination of amygdala response to facial expressions. *Journal of cognitive Neuroscience* 20: 1565-82, 2008.
52. **Haas BW, Constable RT and Canli T.** Stop the sadness: Neuroticism is associated with sustained medial prefrontal cortex response to emotional facial expressions. *Neuroimage* 42: 385-92, 2008.
53. **Hackney AC.** Exercise as a stressor to the human neuroendocrine system. *Medicina (Kaunas)* 42: 788-797, 2006.

54. **Haier RJ, Sokolski K, Katz M and Buchsbaum MS.** The study of personality with positron emission tomography. In: Personality dimensions and arousal, edited by Strelau J and Eysenck HJ. New York: Plenum Publishing Corporation, 1987, p. 251-267.
55. **Hamann S and Harenski CL.** Exploring the brain's interface between personality, mood, and emotion: theoretical comment on Canli et al. (2004). *Behavioural Neuroscience* 118: 1134-6, 2004.
56. **Hamann SB, Stefanacci L, Squire LR, Adolphs R, Tranel D, Damasio H and Damasio A.** Recognizing facial emotion. *Nature* 379: 497, 1996.
57. **Hathaway, S. R and McKinley, J. C.** A multiphasic personality schedule (Minnesota): I. Construction of the schedule. 10, 249-254. 1940. *Journal of Psychology*.
58. **Hogan J.** Personality correlates of physical fitness. *Journal of personality and social psychology* 56: 284-8, 1989.
59. **Holland JL.** *Making vocational choices: A theory of vocational personalities and work environments.* Englewood Cliffs, NJ: Prentice Hall, 1985.
60. **Hooker CI, Verosky SC, Miyakawa A, Knight RT and D'Esposito M.** The influence of personality on neural mechanisms of observational fear and reward learning. *Neuropsychologia* 46: 2709-24, 2008.
61. **Hough, L. M.** The "Big Five" personality variables--construct confusion: Description versus prediction. (5), 139-155. 1992. *Human Performance*.

62. **Hunsley J, Lee CM and Wood JM.** Controversial and questionable assessment techniques. edited by Lilienfeld SO, Lohr JM and LSe. Guilford: Science and Pseudoscience in Clinical Psychology, 2004, p. 65.
63. **Huonker M, Halle M and Keul J.** Structural and functional adaptations of the cardiovascular system by training. *Int J Sports Med* 17 Suppl 3: S164-S172, 1996.
64. **Hurtz GM and Donovan JJ.** Personality and job performance: the Big Five revisited. *The Journal of applied psychology* 85: 869-79, 2000.
65. **Insel TR, Volkow ND, Landis SC, Li TK, Battey JF and Sieving P.** Limits to growth: why neuroscience needs large-scale science. *Nature Neuroscience* 7: 426-427, 2004.
66. **Johansson RS, Westling G, Backstrom A and Flanagan JR.** Eye-hand coordination in object manipulation. *The Journal of Neuroscience: the official journal of the Society of Neuroscience* 21: 6917-32, 2001.
67. **John, O. P and Srivastava, S.** The Big-Five trait taxonomy: History, measurement, and theoretical perspectives. L.A.Pervin & O.P.John (Eds.). 2, 102-138. 1999. New York: Guilford Press., Handbook of personality: Theory and research.
68. **Johnson DL, Wiebe JS, Gold SM, Andreasen NC, Hichwa RD, Watkins GL and Boles Ponto LL.** Cerebral blood flow and personality: a positron emission tomography study. *American Journal of Psychiatry* 156: 252-7, 1999.
69. **Jokela M and Hanin YL.** Does the individual zones of optimal functioning model discriminate between successful and less successful athletes? A meta-analysis. *J Sports Sci* 17: 873-887, 1999.

70. **Judge TA and Bono JE.** Relationship of core self-evaluations traits--self-esteem, generalized self-efficacy, locus of control, and emotional stability--with job satisfaction and job performance: a meta-analysis. *Journal of applied psychology* 86: 80-92, 2001.
71. **Judge TA, Bono JE, Ilies R and Gerhardt MW.** Personality and leadership: a qualitative and quantitative review. *Journal of applied psychology* 87: 765-80, 2002.
72. **Judge TA, Heller D and Mount MK.** Five-factor model of personality and job satisfaction: a meta-analysis. *Journal of applied psychology* 87: 530-41, 2002.
73. **Judge, T. A., Higgins C, Thoresen CJ, and Barrick MR.** The Big Five personality traits, general mental ability, and career success across the life span. 52, 621-652. 1999. *Personnel Psychology*.
74. **Judge TA and Ilies R.** Relationship of personality to performance motivation: a meta-analytic review. *Journal of applied psychology* 87: 797-807, 2002.
75. **Jung CG.** *Psychological Types*. Princeton University Press, 1971.
76. **Kagan J, Snidman N and Arcus D.** Childhood derivatives of high and low reactivity in infancy. *Childhood development* 69: 1483-93, 1998.
77. **Keightley ML, Winocur G, Burianova H, Hongwanishkul D and Grady CL.** Age effects on social cognition: faces tell a different story. *Psychology and aging* 21: 558-72, 2006.
78. **Kirkcaldy B.** Personality profiles at various levels of athletic participation. *Personality and Individual Differences* 3: 321-6, 1982.

79. **Kosslyn SM, Cacioppo JT, Davidson RJ, Hugdahl K, Lovallo WR, Spiegel D and Rose R.** Bridging psychology and biology. The analysis of individuals in groups. *American Psychologist* 57: 341-51, 2002.
80. **Lawrence G and Charles Martin.** CAPT (Center for Applications of Psychological Type) retrieved 20. April 2008 [Online]. 2008.
81. **MacDonald KB.** Effortful control, explicit processing, and the regulation of human evolved predispositions. *Psychological Review* 115: 1012-31, 2008.
82. **Mandal MK and Ambady N.** Laterality of facial expressions of emotion: Universal and culture-specific influences. *Behavioural Neurology* 15: 23-34, 2004.
83. **Mandal MK and Rai A.** Responses to facial emotion and psychopathology. *Psychiatry Research* 20: 317-23, 1987.
84. **Matthews P.** The MBTI is a flawed measure of personality [Online]. 2004.
85. **McAdams DP.** The five-factor model in personality: a critical appraisal. *Journal of personality* 60: 329-61, 1992.
86. **McCrae RR and Costa PT.** Reinterpreting the Myers-Briggs Type Indicator From the Perspective of the Five-Factor Model of Personality. *Journal of personality* 57: 1467-6494, 1989.
87. **McCrae RR and Costa PT.** Trait explanations in personality psychology. *European Journal of Personality* 9: 231-252, 1995.

88. **McCrae RR, Costa PT, Paul TJ, Gregorio H, Rolland JP and Parker WD.** Cross-cultural assessment of the five-factor model: The Revised NEO Personality Inventory. *Journal of Cross-Cultural Psychology* 29: 171-188, 1998.
89. **McCrae RR and Costa PT Jr.** Validation of the five-factor model of personality across instruments and observers. *J Pers Soc Psychol* 52: 81-90, 1987.
90. **McCrae RR and Costa PT Jr.** Adding Liebe und Arbeit: The full five-factor model and well-being. *Personality and Social Psychology Bulletin* 17: 227-232, 1991.
91. **McCrae RR and Costa PT Jr.** Personality trait structure as a human universal. *Am Psychol* 52: 509-516, 1997.
92. **McCrae RR.** The five-factor model and its assessment in clinical settings. *Journal of personality assessment* 57: 399-14, 1991.
93. **McCrae RR, Costa PT, Jr., Ostendorf F, Angleitner A, Hrebickova M, Avia MD, Sanz J, Sanchez-Bernardos ML, Kusdil ME, Woodfield R, Saunders PR and Smith PB.** - Nature over nurture: temperament, personality, and life span development. *Journal of personality and social psychology* 78: 173-86, 2000.
94. **McCrae RR and John OP.** An introduction to the five-factor model and its applications. *Journal of personality* 60: 175-215, 1992.
95. **McGhee, R. M, Ehrler, D. J, and Buckhalt, J.** Five Factor Personality Inventory - Children (FFPI-C). 2007. Austin, TX: Pro-Ed.
96. **McReynolds P.** Psychological assessment and clinical practice: Problems and prospects. In: *Advances in personality assessment*, edited by Butcher NJ and Spielberger CD. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, 1985.

97. **Miller MB, Van Horn JD, Wolford GL, Handy TC, Valsangkar-Smyth M, Inati S, Grafton S and Gazzaniga MS.** Extensive individual differences in brain activations associated with episodic retrieval are reliable over time. *Journal cognitive Neuroscience* 14: 1200-14, 2002.
98. **Myers IB and McCaulley MH.** *Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator (2nd ed.)*. Palo Alto, CA: Consulting Psychologists Press, 1985.
99. **Noakes TD.** Training the mind. In: *Lore of Running*, Cape Town: Oxford University Press Southern Africa, 2001, p. 679-739.
100. **Nomura M, Iidaka T, Kakehi K, Tsukiura T, Hasegawa T, Maeda Y and Matsue Y.** Frontal lobe networks for effective processing of ambiguously expressed emotions in humans. *Neuroscience Letters* 348: 113-6, 2003.
101. **Norman, W. T.** Toward an adequate taxonomy of personality attributes: Replicated factor structure in peer nomination personality ratings. 66, 574-583. 1963. *Journal of Abnormal and Social Psychology*.
102. **O'Sullivan DM and Zuckerman M.** Personality characteristics of male and female participants in team sports. *Personality and Individual Differences* 25: 119-128, 1998.
103. **Organ, D. W and Lingl, A.** Personality, satisfaction, and organizational citizenship behaviour. (135), 339-350. 1995. *Journal of Social Psychology*.
104. **Ostendorf, F.** Sprache und Persönlichkeitsstruktur: Zur Validität des Fünf-Faktoren-Modells der Persönlichkeit. 1990. Regensburg, Germany, S. Roderer Verlag.

105. **Paelecke-Habermann Y, Pohl J and Leplow B.** Attention and executive functions in remitted major depression patients. *Journal of affective disorders* 89: 125-35, 2005.
106. **Paris J.** Predispositions, personality traits, and posttraumatic stress disorder. *Harvard Review of Psychiatry* 8: 175-83, 2000.
107. **Paul RH, Lawrence J, Williams LM, Clark CR, Cooper N and Gorden E.** Preliminary Validity of "Integneuro": A New Computerized Battery of Neurocognitive Tests. *Inter J Neuroscience* 115: 1549-1567, 2005.
108. **Posner MI and Rothbart MK.** Attention, self-regulation and consciousness. *Philosophical transactions of the Royal Society of London Series B, Biological sciences* 353: 1915-27, 1998.
109. **Potgieter JR and Venter RE.** Relationship between adherence to exercise and scores on extraversion and neuroticism. *Perception and Motor Skills* 81: 520-2, 1995.
110. **Raglin JS.** Anxiety and sport performance. *Exercise and Sport Sciences Reviews* 20: 243-74, 1992.
111. **Reuter-Lorenz P and Davidson RJ.** Differential contributions of the two cerebral hemispheres to the perception of happy and sad faces. *Neuropsychologia* 19: 609-13, 1981.
112. **Rhodes RE, Courneya KS and Bobick TM.** Personality and exercise participation across the breast cancer experience. *Psychooncology* 10: 380-8, 2001.

113. **Rhodes RE and Smith NE.** Personality correlates of physical activity: a review and meta-analysis. *British Journal of Sports Medicine* 40: 958-65, 2006.
114. **Roberts, B. W. and Mroczek D.** Personality trait change in adulthood. (17), 31-35. 2008. *Current Directions in Psychological Science*.
115. **Roberts BW, Walton KE and Viechtbauer W.** - Personality traits change in adulthood: reply to Costa and McCrae (2006). -32.
116. **Rondina RC, Gorayeb R and Botelho C.** Psychological characteristics associated with tobacco smoking behavior. *J Bras Pneumol* 33: 592-601, 2007.
117. **Russell JA.** Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. *Psychological Bulletin* 115: 102-41, 1994.
118. **Ryckman, R.** Theories of Personality. 2004. Belmont, CA, Thomson/Wadsworth.
119. **Sinclair P and Barrow S.** Identifying Personality Traits predictive of Performance. *The BPS's Journal of Occupational Testing - Selection & Development Review* 8: 1992.
120. **Smith EE and Jonides J.** Storage and executive processes in the frontal lobes. *Science* 12: 1657-61, 1999.
121. **Srivastava, S, John, O. P, Gosling, S. D, and Potter, J.** Development of personality in early and middle adulthood: Set like plaster or persistent change? (84), 1041-1053. 2003. *Journal of Personality and Social Psychology*.

122. **Stenberg G, Risberg J, Warkentin S and Rosen L.** Regional patterns of cortical blood flow distinguish extraverts from introverts. *Personality and Individual Differences* 11: 663-673, 1990.
123. **Steward ME, Ebmeier KP and Deary IJ.** Personality correlates of happiness and sadness: EPQ-R and TPQ compared. *Personality and Individual Differences* 38: 1085-1096, 2009.
124. **Stricker LJ and Ross J.** An Assessment of Some Structural Properties of the Jungian Personality Typology. *Journal of Abnormal and Social Psychology* 68: 62-71, 1964.
125. **Stroop J.** Studies of interference in serial verbal reactions. *Journal of Experimental Psychology* 18: 643-662, 1935.
126. **Sugiura M, Kawashima R, Nakagawa M, Okada K, Sato T, Goto R, Sato K, Ono S, Schormann T, Zilles K and Fukuda H.** Correlation between human personality and neural activity in cerebral cortex. *Neuroimage* 11: 541-6, 2000.
127. **Suzuki A, Hoshino T, Shigemasu K and Kawamura M.** Decline or improvement? Age-related differences in facial expression recognition. *Biological Psychology* 74: 75-84, 2007.
128. **Swynghedauw B.** Developmental and functional adaptation of contractile proteins in cardiac and skeletal muscles. *Physiol Rev* 66: 710-771, 1986.
129. **Szabo A.** Habitual participation in exercise and personality. *Perception and Motor Skills* 74: 978, 1992.

130. **Szirmak Z and De Raad B.** Taxonomy and structure of Hungarian personality traits. *European Journal of Personality* 95-117, 1994.
131. Thompson, E. R. Development and validation of an international English big-five mini-markers. (45(6), 542-548. 2008. *Personality and Individual Differences*.
132. **Triandis HC and Suh EM.** - Cultural influences on personality. *Annual Review of Psychology* 53: 113-60, 2002.
133. **Tupes, E. C and Christal, R. E.** Recurrent personality factors based on trait ratings. 61-97. 1961. Lackland Airforce Base, TX: U. S. Air Force, USAF ASD Tech. Rep. No.
134. **Underwood BJ.** Individual differences as a crucible in theory construction. *American Psychologist* 30: 128-134, 1975.
135. **Watson AE and Pulford BD.** Personality differences in high risk sports amateurs and instructors. *Perception and Motor Skills* 99: 83-94, 2004.
136. **Watson D, Clark LA and Tellegen A.** Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology* 54: 1063-70, 1988.
137. **West S and Finch JF.** Personality measurements: reliability and validity issues. In: Handbook of personality psychology, edited by Hogan R, Johnson J and Briggs S. San Diego: Academic Press, 1996, p. 143-164.
138. **Widiger TA and Costa PT, Jr.** Personality and personality disorders. *Journal of abnormal Psychology* 103: 78-91, 1994.

139. **Widiger TA and Lowe JR.** Five-factor model assessment of personality disorder. *Journal of personality assessment* 89: 16-29, 2007.
140. **Williams LM, Simms E, Clark CR, Paul RH, Rowe D and Gorden E.** The Test-Retest Reliability of a Standardised Neurocognitive and Neurophysiological Test Battery: 'Neuromarker'. *International Journal of Neuroscience* 115: 1549-1567, 2005.
141. **Zhao H. and Seibert SE.** The big five personality dimensions and entrepreneurial status: a meta-analytical review. *Journal of applied psychology* 91: 259-71, 2006.

APPENDIX I

Exclusion Criteria according to the Brain Research Company for healthy control Subjects at Recruitment

- not having English as primary language
- A personal history of mental illness not related to physical brain injury
- A personal history of physical brain injury
- A personal history of having received a blow to the head that resulted in unconsciousness (within the last 5 years only)
- A personal or family history (mother, father, brother, sister, child) of Axis-I disorders (Attention Deficit Hyperactivity Disorder (ADHD), Schizophrenia, Bipolar Disorder or other psychological and/or psychiatric disorder)
- A personal history of stroke or neurological disorder such as Parkinson's Disease, Epilepsy, Alzheimer's or Multiple Sclerosis
- A personal history of serious medical conditions related to your Thyroid or Heart, or a history of cancer
- A blood borne illness (HIV, Hepatitis B, Hepatitis C).
- A severe impediment to vision, hearing, or hand movement.
- A personal history of addiction to drugs such as Heroin, Cocaine or Amphetamines
- A personal history of heavy consumption of Marijuana or alcohol
- A personal or family history of genetic disorders

APPENDIX II

SUBJECT INFORMATION

Personality Traits and Cognitive Performance in Athletes

This research project aims to advance our understanding of the relationship between different personalities and their cognitive performance abilities. You are invited to participate in this study and complete the test battery provided by the Brain Resource Company. The anticipated time required to complete these tests is approximately 60 minutes. All tests will be done online and include the assessment of cognitive abilities such as basic motor function, memory capacity, decision making, attention, impulsivity and personality traits etc. Testing is not invasive and will not expose you to any risk.

These results may contribute to the participants' having a better understanding of their psychological profile which may manifest as an improvement in sporting performance.

APPENDIX III

Subject Informed Consent Declaration

UCT / MRC Research Unit for Exercise Science and Sports Medicine,

Department of Human Biology

Personality Traits and Cognitive Performance in Athletes

This research project aims to understand the correlation between different personalities and their cognitive performance abilities. You are invited to participate in this study and complete the test battery provided by the Brain Resource Company. The anticipated time required to complete these tests is approximately 60 minutes. Testing is not invasive and will not expose you to any risk.

Participation in this study is completely voluntary, and you are free to choose not to complete the questionnaire, or *opt out* of the research at any stage. However you are kindly requested to participate as the study stands to enhance the understanding of different personality types and cognitive performance abilities in sports. Your answers and individual identity will be kept strictly confidential.

CONSENT

Date _____

Name _____

I hereby consent to participate in this research study with full knowledge and understanding of the nature of the research project and what is expected of me.

Signature _____

APPENDIX IV

Subject Informed Consent Declaration

Netcare Brain Resource Centre

By signing this document in the spaces below, the client attest to having read and understood the document. The client had the assessment process fully explained to his / her satisfaction and authorizes the Netcare Brain Resource Centre to collect the following data:

Test	Yes	No
WebNeuro Sport		

Please tick off with an x in the applicable column.

I hereby agree that the above information I provide may be used for purposes of my personal assessment.

I hereby agree that all information provided by me will belong to the Brain Resource Company Limited and will form part of an international database.

I understand and agree that scientists internationally may have access to this information at any time in the future and that the information maybe used for scientific, clinical or commercial purposes.

I understand and agree that no personal identification information (i.e. name, address, contact details) will be transmitted to the central international database.

CONSENT

Date _____

Name _____

I hereby consent to participate in this research study with full knowledge and understanding of the nature of the research project and what is expected of me.

Signature _____

APPENDIX V

Table 1

Overview	
Category of cognitive function	Tests completed
Memory	Memory recall and recognition
	Digit Span
	Memory recall and recognition - delayed
	Processing of facial emotions - delayed
	Visual working memory
Attention / Behavioural	Sustained Attention
	Switching of attention
	'Go no go' test
Sensory Motor function	Motor taping
	Choice reaction time
Language	Spot the real word
Executive Function	Executive Maze
Emotion recognition	Processing of facial emotions

University of Cape Town

Overview of cognitive tests completed during the 'WebNeuro Sport' assessment

Explanation of test and outcome measures

Participant has to recall a set of words after several time intervals and later recognise them in a list mixed with other words. This test indicates memory capacity.

Participant has to repeat a presented sequence of numbers which is an indicator of memory capacity.

This test is a repetition of the first test 'Memory recall and cognition' in order to identify participant's ability to memorise the words for a longer period of time.

This test is a repetition of the test 'Processing of facial emotions' in order to identify participant's ability to memorise facial expressions for a longer period of time.

Series of letters appear on the screen. Participant is asked to only press respond button when the same letter comes up twice in a row. This test indicates short term memory capacity.

Participant is asked to name the colour the word is written in and not read the actual word. Indicates participant's ability to keep attention.

Numbers and letters need to be connected in various sequences. Indicates participant's ability to keep attention.

Participant is asked to press a respond button when they see the word "press" written in green but not when it is written in red. This test is a measure for behavioural tasks

Participant is asked to press a respond button as many times as possible in 1 minute. This test measures Sensory-Motor function.

One of four circles lights up. Participant has to press the lit circle as quick as possible. This test measures Sensory-Motor function.

Participant is asked to select the real word which is presented next to a nonsense word. This test is marker for language skills

By trial and error the Participant needs to find a path through a dot-based maze and remember it. This test indicates executive function.

Facial expressions with five different emotions are presented: Neutral, happy, sad, fear, disgust. Participant needs to process and rate them. This test is a measure of emotional recognition.

APPENDIX VI

Table 2

Correlations between personality traits and cognitive functions						
Neuroticism						
Cognitive function	Memory		Emotion recognition		Sensor-Motor Function	
Function measured	Memory recall and cognition		Processing of facial emotions		Motor tapping	
Test	Delayed Recall Trial 4 (correct number of words)	Intrusion errors trial 4 (number of errors)	Accuracy (in recognising sad faces)		Variability of reaction time	
r-value	-0.46	0.44	-0.41*		0.48*	
95% confidence Interval	-0.72 to 0.03	0.03 to 0.72	-0.69 to -0.20		0.11 to 0.74	
Openess						
Cognitive function	Memory			Emotion recognition		
Function measured	Memory recall and cognition		Working Memory		Processing of facial emotions	
Test	Immediate recall trial 3 (number of correct words)	Intrusion errors trial 3 (number of errors)	False alarms (responded when shouldn't)		Accuracy (in recognising fear faces)	
r-value	-0.41	0.41	-0.46		0.46*	
95% confidence Interval	-0.70 to 0.01	0.01 to 0.70	-0.73 to 0.07		0.08 to 0.72	
Agreeableness						
Cognitive function	Memory			Emotion Recognition		Attention
Function measured	Memory recall and cognition			Processing of facial emotions		Sustained
Test	Immediate recall Total of trials 1-3 (total number of correct words)	Intrusion errors Trial 1 (number of errors)	Intrusion errors Total of trials 1-3 (total number of errors)	Accuracy (in recognising fear faces)		Reaction time (Go) (r
r-value	0.49*	-0.40*	-0.49*	-0.35		-0.70
95% confidence Interval	0.11 to 0.74	-0.69 to 0.01	-0.74 to 0.11	-0.65 to 0.05		-0.70 to 0.02
Conscientiousness						
Cognitive function	Memory	Emotion recognition			Sensor-Motor Function	Attention
Function measured	Working memory	Processing of facial emotions			Motor tapping	Verbal intelligence 'Stroop'
Test	False misses (did not respond when should)	Accuracy (in recognising disgust faces)	Reaction time (in recognising disgust faces)	Accuracy (in recognising sad faces)	Variability of reaction time	Accuracy (number or correct r
r-value	0.46	-0.61*	-0.46*	0.55*	-0.52*	0.4
95% confidence Interval	0.07 to 0.73	-0.81 to -0.28	-0.72 to -0.08	0.20 to 0.78	-0.76 to 0.16	0.02 to 0.78

* = Pearson correlation coefficient

Attention
Verbal Interference 'Stroop test'
Accuracy word (number or correct responses to words)
-0.48*
-0.73 to 0.10
Extraversion
Language tasks
Spot the real word
Accuracy (number of words correctly recognised)
-0.41*
-0.69 to -0.02
ntion
f Attention
ected when should)
40
o 0.00
ntion
erference p test'
cy word esponses to words)
‡1*
o 0.69

orrelation, parametric data

University of Cape Town



WebNeuro Sport

CSARCS-A, Cognition, DASS, EI, Personality.

Client: WS-Sample-04 (birth date withheld; age 21 years; male)

Test	Level	Function Measured	Functional Significance
Carlstedt Subliminal Attention, Reactivity and Coping Scale-Athlete Version (CSARCS-A)			
	High Low Medium	Subliminal Attention Subliminal Reactivity Subliminal Coping	Ability to attain peak performance during critical moments
General Cognition			
Memory	Average	Working memory recall and recognition	Ability to attend to, learn, remember, store, retrieve and manipulate new information. It includes long and short term memory
Attention, Behavioral	Average	Sustained attention Focussed attention Impulsivity Cognitive flexibility	Ability to selectively concentrate during cognitive tasks, detect and respond to change in the environment, sustain attention over time and control impulses
Sensory-Motor/Spatial	Average	Hand/eye coordination Accuracy of selecting an appropriate response	Ability to perform motor skills and respond to information in a timely fashion. It includes reaction time
Language	Average	Word comprehension Verbal fluency Verbal memory	Ability to recognize words, access words and remember what has been heard
Executive Function	Average	Planning Abstraction Error correction	Ability to plan, strategize, execute complex tasks, abstract thinking, rule acquisition, inhibiting inappropriate actions and ignoring irrelevant sensory information
Emotion Recognition	Superior	Emotional expressions	Ability to recognize interpersonal emotions through facial expression
Depression Anxiety Stress Scales (DASS)			
	Normal Normal Normal	Depression Stress Anxiety	Screening for Depression and Anxiety

Deficit	≤-2 standard deviation	Average	>-1 and <1 standard deviation
Borderline	>-2 and ≤-1 standard deviation	Superior	≥1 standard deviation

Important Information and Disclaimer

Reference: BRC-Sample12-04 Test Date: Feb 2007 Report Date: 26 Apr 2007

This report provides indications of brain function and cognition as compared to a normative database. Its only purpose is to provide evidence based data to assist the decision making process of a competent relevant professional. It must not be used as a basis for action without consideration by a competent relevant professional.

This report is not intended to diagnose or treat any health condition and it must never be used on its own to make any diagnostic or treatment decisions.

This report does not establish any physician-patient relationship or supplant any in-person medical consultation or examination. Appropriate medical attention should always be sought for any ailments. Do not disregard professional medical advice or delay seeking medical treatment as a result of this report.

In so far as permitted by law BRC expressly disclaims any and all responsibility for any liability, loss, injury, damage, expense or risk which may be or is incurred as a consequence, directly or indirectly, of any use or application of this report.



WebNeuro Sport

Test	Level	Function Measured	Functional Significance
Emotional Intelligence (EI)			
	Average	Empathy/intuition	Control of emotions in self and in dealing with others
	Average	Social relationships	
	Average	Self esteem	
Personality			
	Very Low	Neuroticism	Used to understand basic emotional, interpersonal, experiential, attitudinal and motivational style
	High	Extraversion	
	Very High	Openness	
	Low	Agreeableness	
	High	Conscientiousness	

Deficit	≤-2 standard deviation	Average	>-1 and <1 standard deviation
Borderline	>-2 and ≤-1 standard deviation	Superior	≥1 standard deviation

University of Cape Town



CSARCS-A

Carlstedt Subliminal Attention, Reactivity and Coping Scale

Client: WS-Sample-04

The Carlstedt Subliminal Attention, Reactivity and Coping Scale-Athlete Version (CSARCS-A) contains measures that reflect the following neuropsychophysiological processes (Mind-Body processes):

- I. **Subliminal Attention (SA):** this measure reflects an athlete's subliminal or unconscious focusing or concentration tendencies. It can be viewed as the "Zone" facilitator in athletes who score high on this dimension (23-35). They possess an enhanced ability to focus intensely on task-relevant activities (sport-specific action/movement, etc). Paradoxically, low SA can also be performance facilitating.
- II. **Subliminal Reactivity (SR):** this measure reflects an athletes subliminal autonomic nervous system or "fight" or "flight" tendencies. It can be viewed as the "Great Disrupter" of peak performance in athletes who are high on this dimension (16-25). They are likely to exhibit increased psychophysiological reactivity (nervousness; muscle tension) that is mediated by catastrophic and negative intrusive thoughts, especially during critical moments of competition.
- III. **Subliminal Coping (SC):** this measure reflects an athletes subliminal or unconscious ability to fend off negative intrusive thoughts associated with high Subliminal Reactivity. It can be viewed as the "Great Facilitator" of "Zone" states and peak performance in athletes who are high in this measure (22-34).

Measure	Client Score	Range
Subliminal Attention	28	High
Subliminal Reactivity	4	Low
Subliminal Coping	18	Medium

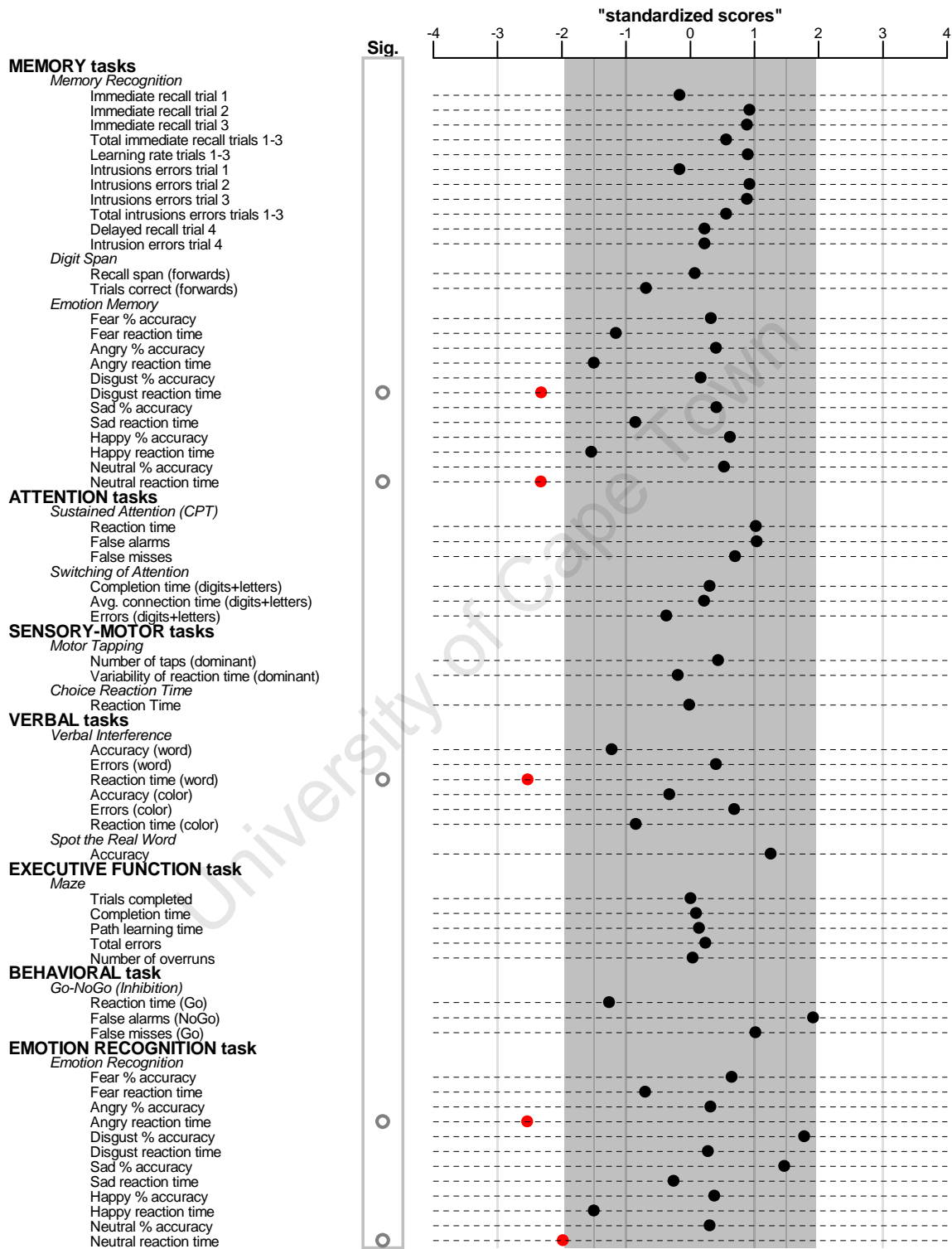
This client has a "**Positive Tendencies**" profile as measured by the CSARCS-A.

It should be noted that the above measures interact to affect performance as a function of the criticality of a competitive moment. In other words the more critical the moment as established by the Carlstedt Critical Moment Analysis System (CCMAS) the greater the probability that an athlete's combination of the above measures will influence performance either positively or negatively. In isolation and outside the context of critical moments or competitive stress singular measures are expected to exert their positive effects. Their negative influences will remain relatively dormant until actual or perceived critical moments or competitive stress are encountered (see Critical Moments During Competition: A Mind-Body Model of Sport Performance When it Counts the Most; Carlstedt [2004] Psychology Press for a complete analysis of the dynamics of the above constructs).

Follow-up Report Service: It is recommended that athletes, coaches and practitioners who use this test battery consult with Dr. Roland A. Carlstedt to further inform the interpretation and implementation. Contact: RCarlstedt@americanboardofsportpsychology.org or DrRCarlstedt@aol.com. See the website: www.americanboardofsportpsychology.org



Client: WS-Sample-04



For convenience, the tasks are organized by broad cognitive groupings. The circles on the left indicate statistically significant differences compared with the normal control. The "standardized scores" on the right are normalized for age and gender, which means differences from zero reflect differences from 'average peer' (also known as z-scores). Positive "standardized scores" indicate strengths, negative "standardized scores" indicate potential deficits (Avg = average). "Standardized scores" beyond -2 to +2 are statistically significant. False alarms (respond when should not) = false positive; errors of commission. False misses (not respond when should) = false negatives; errors of omission. Intrusion = words not on the list. Specialist interpretation is required.



Depression Anxiety Stress Scales

Client: WS-Sample-04

Unresolved anxiety and stress are closely coupled with the cycle of decline in depression.

Depression Anxiety Stress Scales provide a screening for Depression and Anxiety.

Measure	Client Score	Severity Rating
<i>Depression</i>	2	Normal
<i>Stress</i>	6	Normal
<i>Anxiety</i>	4	Normal

University of Cape Town



Emotional Intelligence

Client: WS-Sample-04

Trait	Client Score	Standardized Score	Range
Empathy/intuition	22	0.46	Average
Social relationships	16	0.92	Average
Self esteem	13	0.07	Average
Total	51	0.79	Average

The "standardized scores" on the right are normalized for age and gender, which means differences from zero reflect differences from 'average peer' (also known as z-scores).

Empathy/intuition:

Client WS-Sample-04 is rated as having a good capacity to perceive and understand the emotions in others. He is viewed as having a good ability to use the understanding of those emotions when relating to others.

Social relationships:

Client WS-Sample-04 is perceived to have a good capacity to initiate and maintain positive relationships with others. He is seen to have a highly developed level of confidence in a social environment.

Self esteem:

Client WS-Sample-04 illustrates a good ability to modify self presentation based on understanding the emotions of others. He indicates a good capacity to experience positive emotions when confronted by challenges.

NEO Five-Factor InventoryTM

Interpretive Report

Developed By

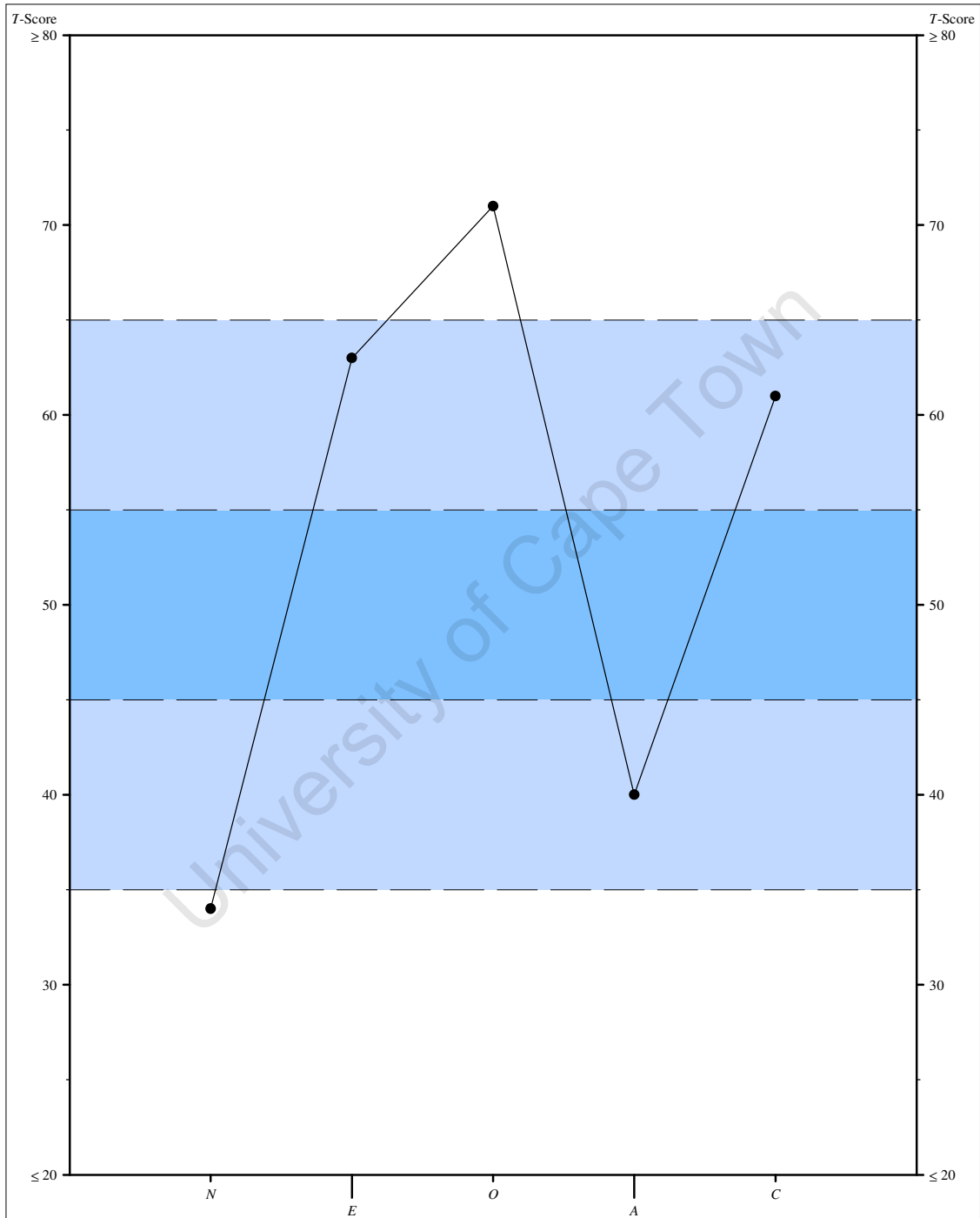
**Paul T. Costa, Jr., PhD,
Robert R. McCrae, PhD,
and PAR Staff**

Client Information

Results For : WS-Sample-04
Client ID : WS-Sample-04
Age : 21
Gender : Male
Test Form : S (NEO-FFI)
Test Date : Feb 2007

The following report is based on research using normal adult samples and is intended to provide information on the basic dimensions of personality. The interpretive information contained in this report should be viewed as only one source of hypotheses about the individual being evaluated. No decisions should be based solely on the information contained in this report. This material should be integrated with all other sources of information in reaching professional decisions about this individual. This report is confidential and intended for use by qualified professionals only; it should not be released to the individual being evaluated. "Your NEO FFI Summary" provides a report in lay terms that may be appropriate for feedback to the client.

NEO-FFI T-Score Profile



NEO-FFI Data Table

	Scale	Raw Score	T Score	Range
(N)	Neuroticism	12	34	Very Low
(E)	Extraversion	38	63	High
(O)	Openness	40	71	Very High
(A)	Agreeableness	25	40	Low
(C)	Conscientiousness	38	61	High

Validity Indices

Validity indices (i.e., B and C questions, and total number of items missing) are within normal limits.

Basis of Interpretation

This report compares the respondent to other college age men and women. It is based on self-reports of the respondent.

This report is based on a short version of the Revised NEO Personality Inventory™. It provides information on the five basic personality factors. More precise estimation of the factors and more detailed information about specific traits that define them can be obtained by administering the NEO PI-R™.

Global Description of Personality: The Five Factors

The most distinctive feature of this individual's personality is his standing on the factor of Openness. Very high scorers like him have a strong interest in experience for its own sake. They seek out novelty and variety, and have a marked preference for complexity. They have a heightened awareness of their own feelings and are perceptive in recognizing the emotions of others. They are very responsive to beauty in art and nature. Their attraction to new ideas and alternative value systems may make them especially tolerant of others, and may lead them to adopt unconventional attitudes. Peers rate such people as imaginative, daring, independent, and creative.

This person is very low in Neuroticism. Individuals scoring in this range are typically very well-adjusted emotionally, rarely experiencing psychological distress. They are not sensitive or moody, and have very few complaints about life. They feel quite secure and have a high level of self-esteem. Friends and neighbors of such individuals might characterize them as relaxed, even-tempered, comfortable, and hardy in comparison with the average person.

Next, consider the individual's level of Extraversion. Such people enjoy the company of others and the stimulation of social interaction. They like parties and may be group leaders. They have a fairly high level of energy and tend to be cheerful and optimistic. Those who know such people would describe them as active and sociable.

This person is high in Conscientiousness. Men who score in this range work toward their goals in a deliberate manner. They have a relatively high need for achievement. They are well organized and reliable and carry through on their commitments. They have good self-discipline and take their obligations seriously. Raters describe such people as careful and hardworking.

Finally, the individual scores in the low range in Agreeableness. People who score in this range are relatively low in concern for others. They can often be brusque or thoughtless in their interactions. They tend to view other people and ideas from a critical standpoint. Their attitudes tend to be tough-minded in most situations. They are competitive and quite able to express hostile feelings directly. People might describe them as relatively stubborn or selfish. (Although antagonistic people such as these are generally not well-liked by others, they are often respected for their critical independence. Their emotional toughness and competitiveness can be assets in many social and business roles.)

Personality Correlates: Some Possible Implications

Research has shown that the scales of the NEO FFI™ are related to a wide variety of psychosocial variables. These correlates suggest possible implications of the personality profile, because individuals who score high on a trait are also likely to score high on measures of the trait's correlates.

The following information is intended to give a sense of how this individual might function in a number of areas. It is not, however, a substitute for direct measurement. If, for example, there is a primary interest in medical complaints, an inventory of medical complaints should be administered in addition to the NEO FFI™.

Coping and Defenses

In coping with the stresses of everyday life, this individual is unlikely to react with ineffective responses, such as hostile reactions toward others, self-blame, or escapist fantasies. He is more likely than most adults to use humor and less likely to use faith in responding to threats, losses, and challenges. In addition, he is somewhat more likely to use positive thinking and direct action in dealing with problems. His general defensive style can be characterized as adaptive and flexible. He is more likely to present a defensive facade of superiority than to be self-sacrificing. He may use such defense mechanisms as acting out and projection.

Somatic Complaints

This person may be prone to discount physical problems and minimize the severity of somatic symptoms and medical complaints. In health care situations, it may be important to check for problems even when he reports no difficulties.

Psychological Well-being

Although his mood and satisfaction with various aspects of his life will vary with the circumstances, in the long run this individual is likely to relish positive experiences, minimize problems, and generally be happy. Because he is open to experience, his moods may be more intense and varied than those of the average man. Because he is high in Conscientiousness, his accomplishments and achievements may give him greater satisfaction with life.

Cognitive Processes

This individual is likely to be more complex and differentiated in his thoughts, values, and moral judgments than others of his level of intelligence and education. He would also probably score higher on measures of ego development. Because he is open to experience, this individual is likely to perform better than average on tests of divergent thinking ability; that is, he can

generate fluent, flexible, and original solutions to many problems. He may be considered creative in his work or hobbies.

Interpersonal Characteristics

Many theories propose a circular arrangement of interpersonal traits around the axes of Love and Status. Within such systems, this person would likely be described as arrogant, calculating, gregarious, sociable, and especially dominant and assured. His traits are associated with high standing on the interpersonal dimension of Status.

Stability of Profile

Given the individual's age, some changes in personality are possible over the next few years. However, this profile is likely to be useful as a rough guide to the individual's personality throughout adulthood.

University of Cape Town

NEO FFI Item Responses

Item Rsp.	Item Rsp.	Item Rsp.	Item Rsp.	Item Rsp.
1. A	13. SA	25. A	37. A	49. SA
2. N	14. N	26. D	38. D	50. A
3. D	15. D	27. N	39. N	51. D
4. SA	16. A	28. SA	40. A	52. SA
5. N	17. SA	29. N	41. D	53. SA
6. D	18. SD	30. SD	42. N	54. N
7. SA	19. D	31. SA	43. SA	55. D
8. A	20. A	32. A	44. A	56. N
9. A	21. D	33. D	45. D	57. D
10. A	22. SA	34. A	46. A	58. A
11. D	23. SD	35. SA	47. SA	59. A
12. D	24. N	36. D	48. D	60. SA

Validity Items

A. Yes B. Yes C. Yes

Summary of Responses

SD: 5.00% D: 28.33% N: 16.67% A: 26.67% SA: 23.33% ?: 0.00%

Personality Style Graphs

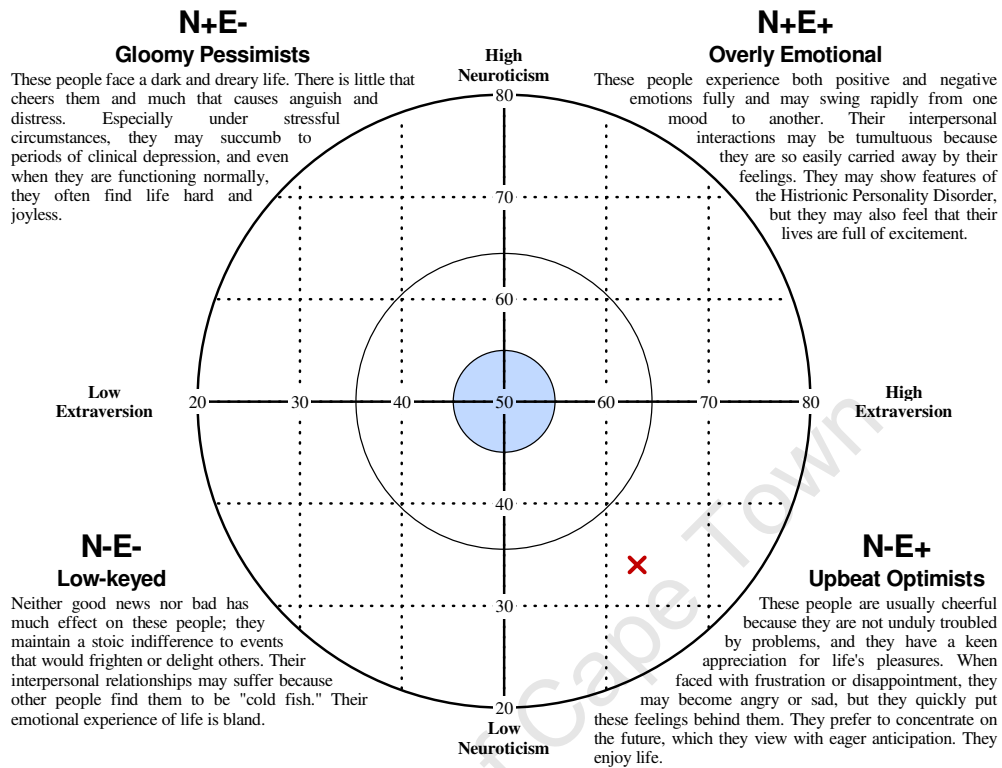
Broad personality factors are pervasive influences on thoughts, feelings, and actions, and combinations of factors provide insight into major aspects of people's lives, defining what can be called *personality styles*. For example, for many years psychologists have known that interpersonal interactions can be conceptualized in terms of a circular ordering or circumplex, defined by the two axes of Dominance and Love, or by the alternative axes of Extraversion and Agreeableness. These two factors define a *Style of Interactions*.

The nine other pairs of factors also define styles, and all ten are represented in NEO Style Graphs. An "X" is placed on each graph to indicate where the respondent falls; the description of that quadrant applies to the respondent. Descriptions are likely to be most accurate if (1) the "X" is far from the center; (2) the "X" is near the diagonal passing through the center of the quadrant; and (3) all the facets in each domain show similar levels. If the "X" is placed in the central circle, then none of the descriptions is especially relevant. If the "X" is located near the horizontal or vertical axis, then both quadrants on that side of the circle may be descriptive. If there is marked scatter among the facets in a domain, then interpretation should focus on these facets rather than the domain and its combinations in Style Graphs.

NEO Style Graphs

Style of Well-Being

Vertical Axis: Neuroticism (= 34 T)
 Horizontal Axis: Extraversion (= 63 T)

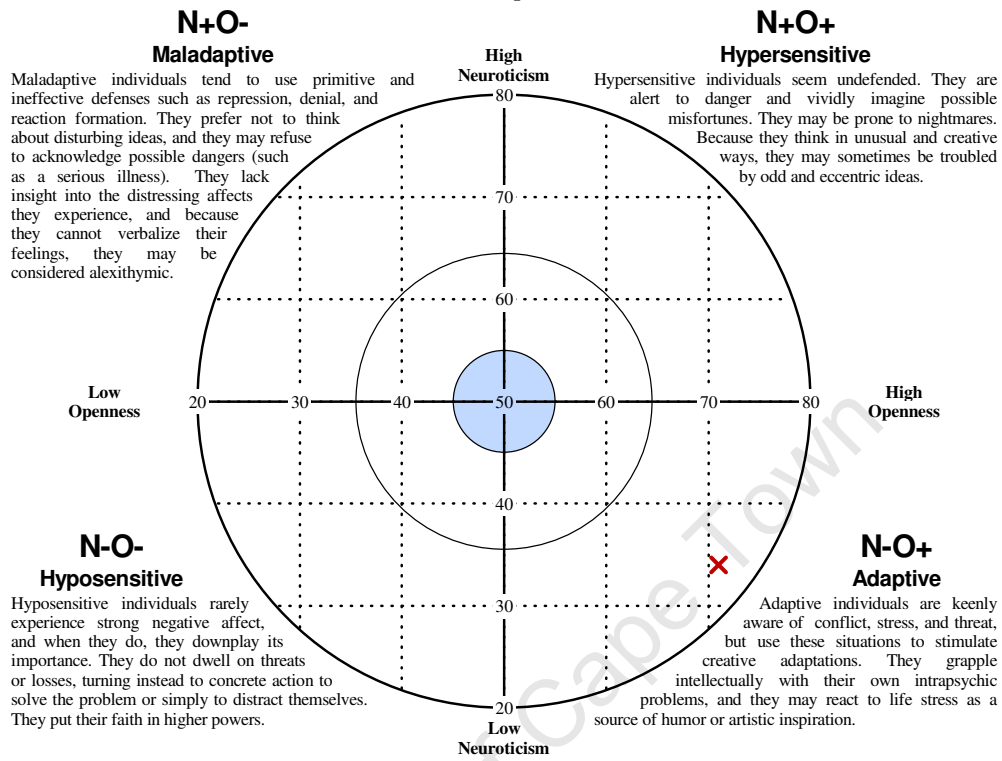


University of Cape Town

NEO Style Graphs

Style of Defense

Vertical Axis: Neuroticism (= 34 T)
 Horizontal Axis: Openness (= 71 T)

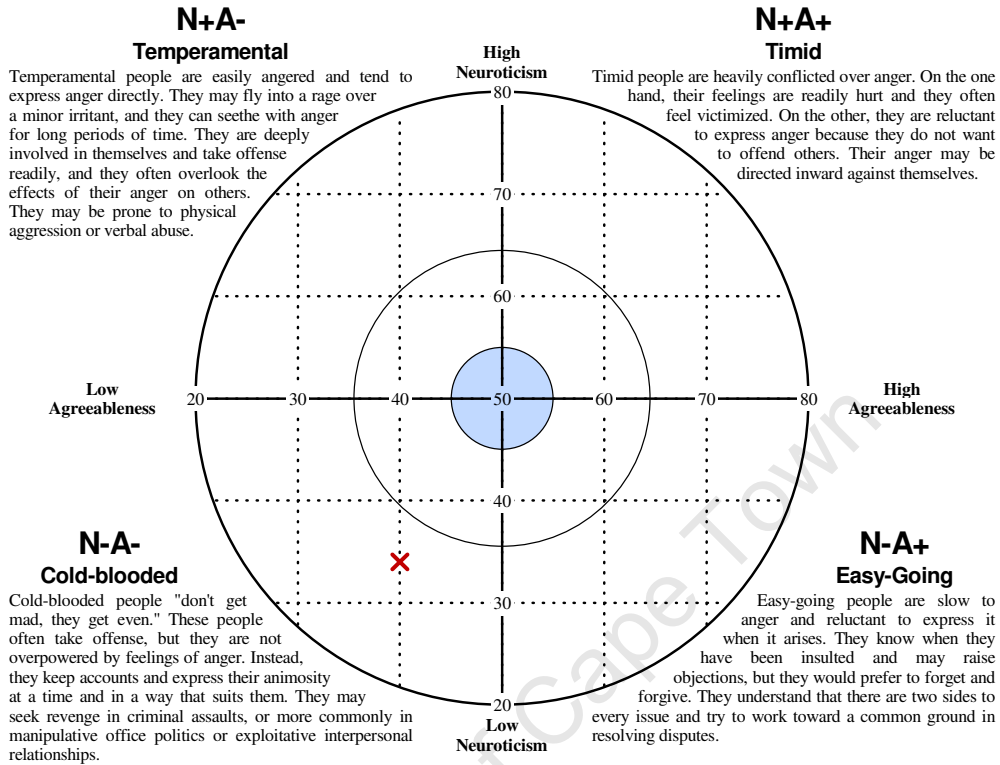


University of Cape Town

NEO Style Graphs

Style of Anger Control

Vertical Axis: Neuroticism (= 34 T)
Horizontal Axis: Agreeableness (= 40 T)

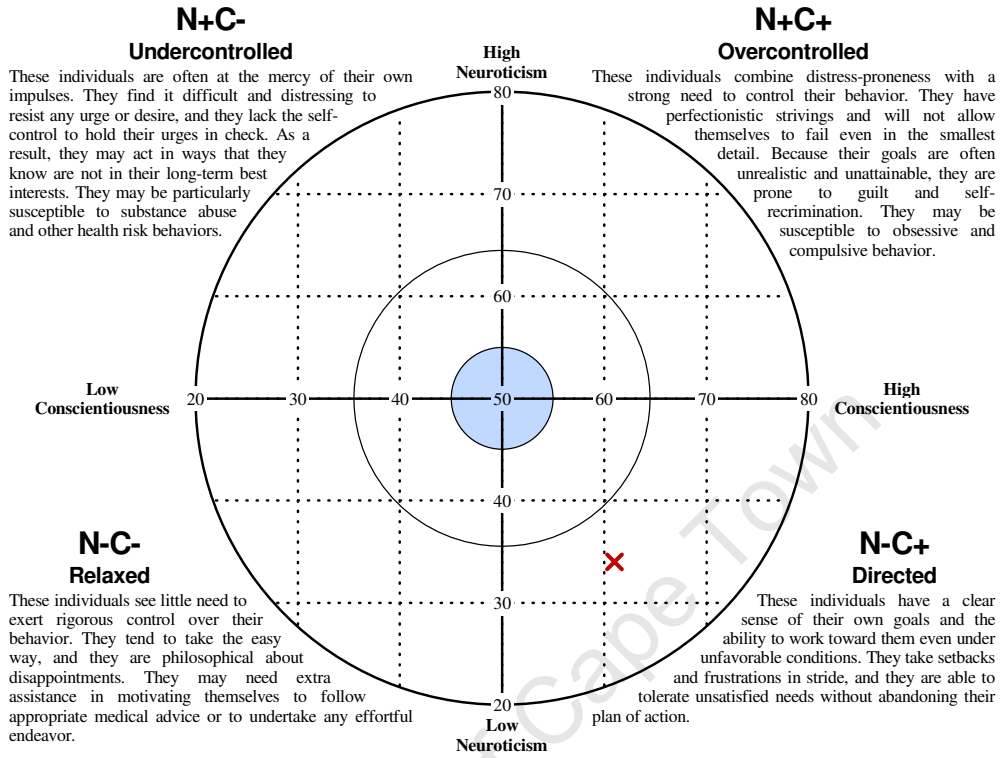


University of Cape Town

NEO Style Graphs

Style of Impulse Control

Vertical Axis: Neuroticism (= 34 T)
Horizontal Axis: Conscientiousness (= 61 T)

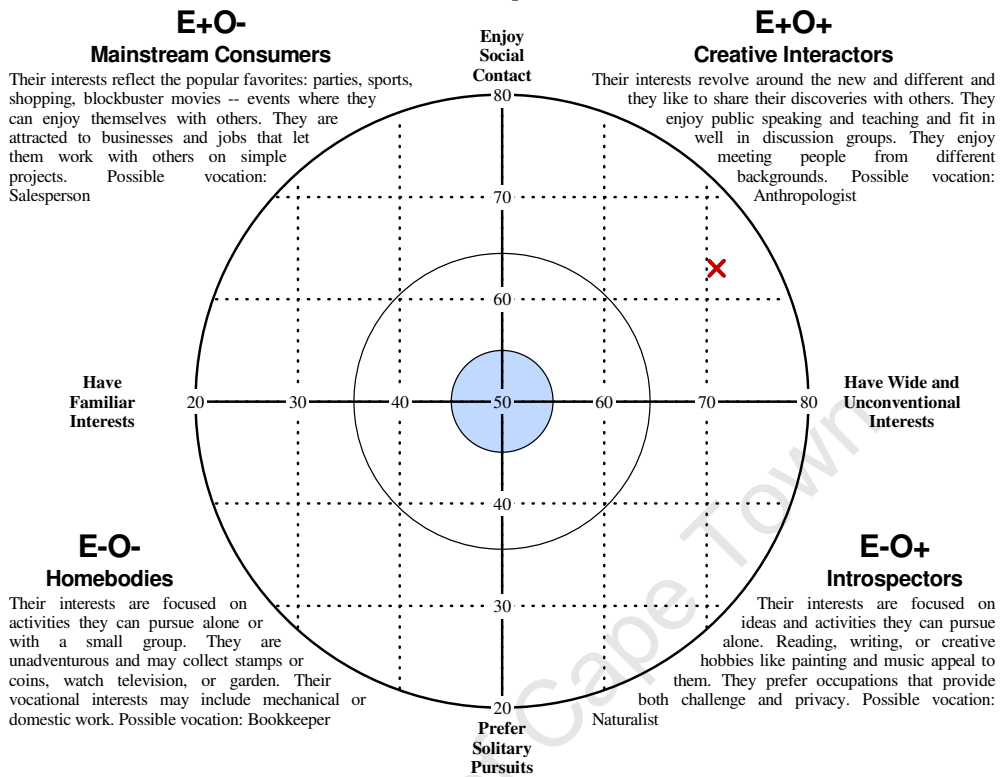


University of Cape Town

NEO Style Graphs

Style of Interests

Vertical Axis: Extraversion (= 63 T)
 Horizontal Axis: Openness (= 71 T)

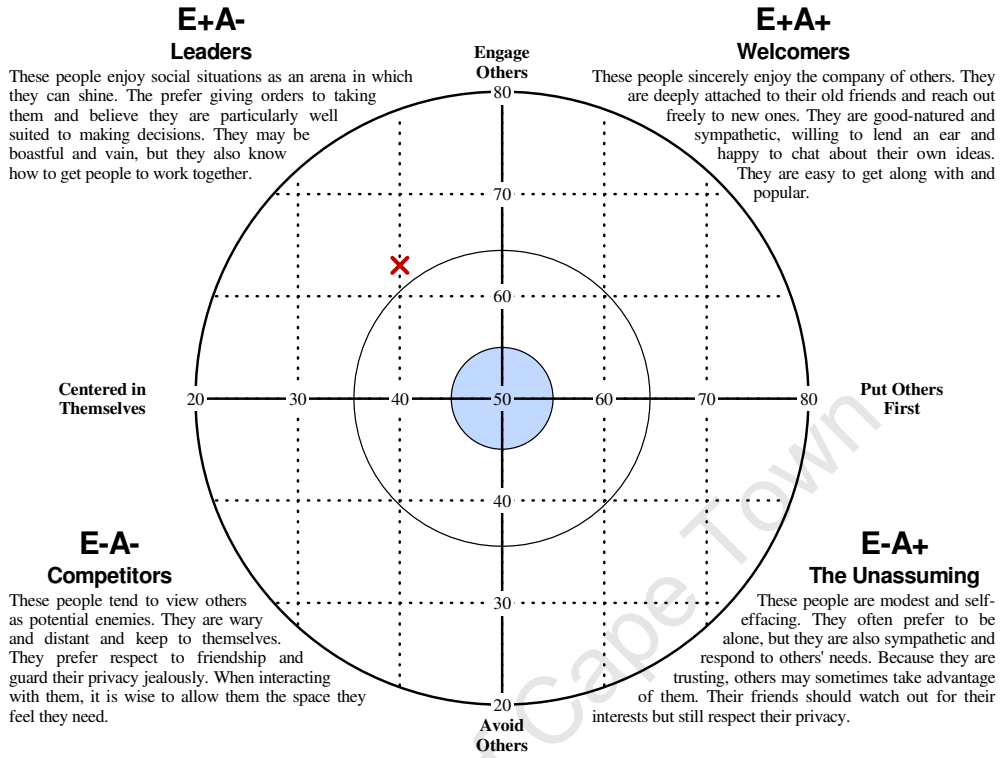


University of Cape Town

NEO Style Graphs

Style of Interactions

Vertical Axis: Extraversion (= 63 T)
 Horizontal Axis: Agreeableness (= 40 T)

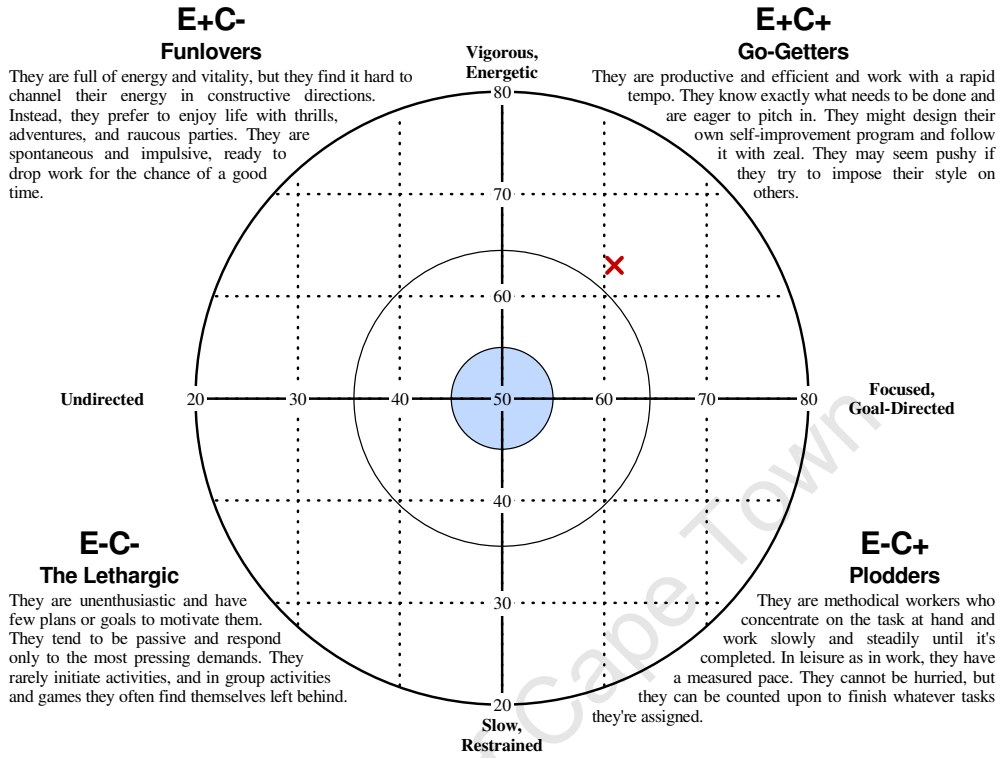


University of Cape Town

NEO Style Graphs

Style of Activity

Vertical Axis: Extraversion (= 63 T)
 Horizontal Axis: Conscientiousness (= 61 T)



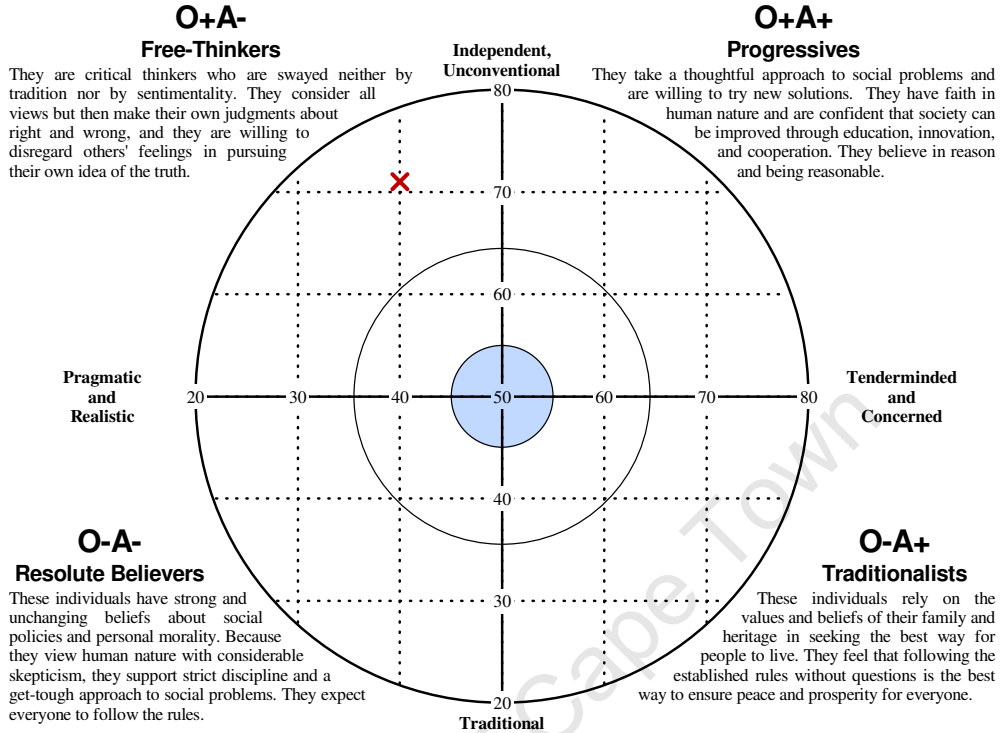
University of Cape Town

NEO Style Graphs

Style of Attitudes

Vertical Axis: Openness (= 71 T)

Horizontal Axis: Agreeableness (= 40 T)



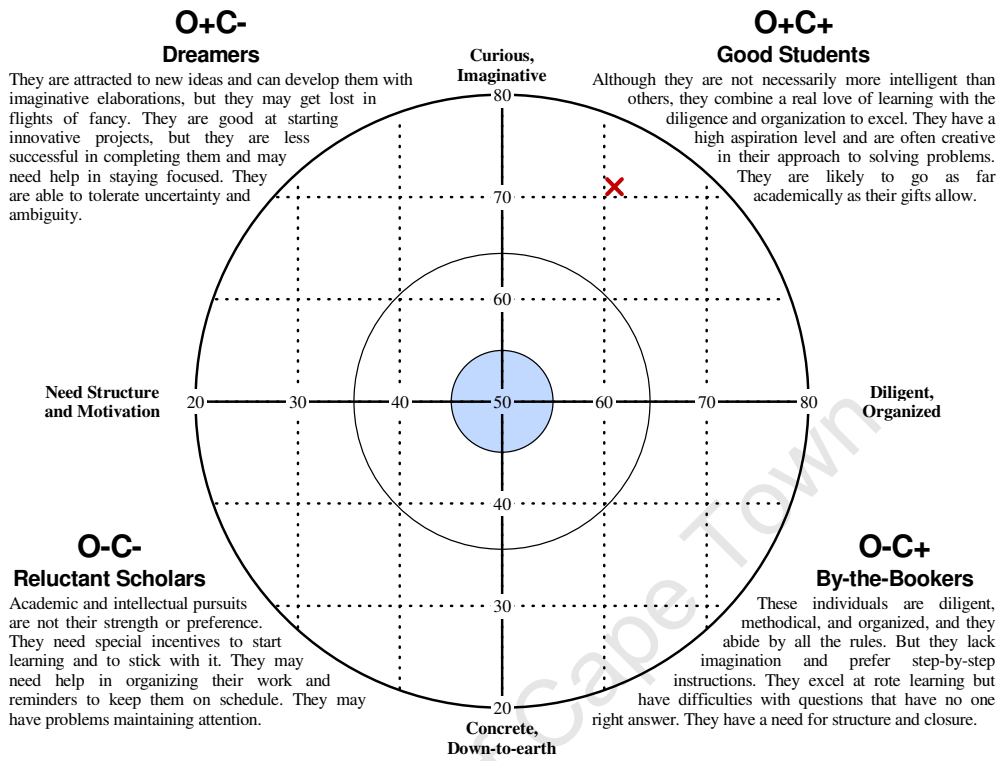
University of Cape Town

NEO Style Graphs

Style of Learning

Vertical Axis: Openness (= 71 T)

Horizontal Axis: Conscientiousness (= 61 T)



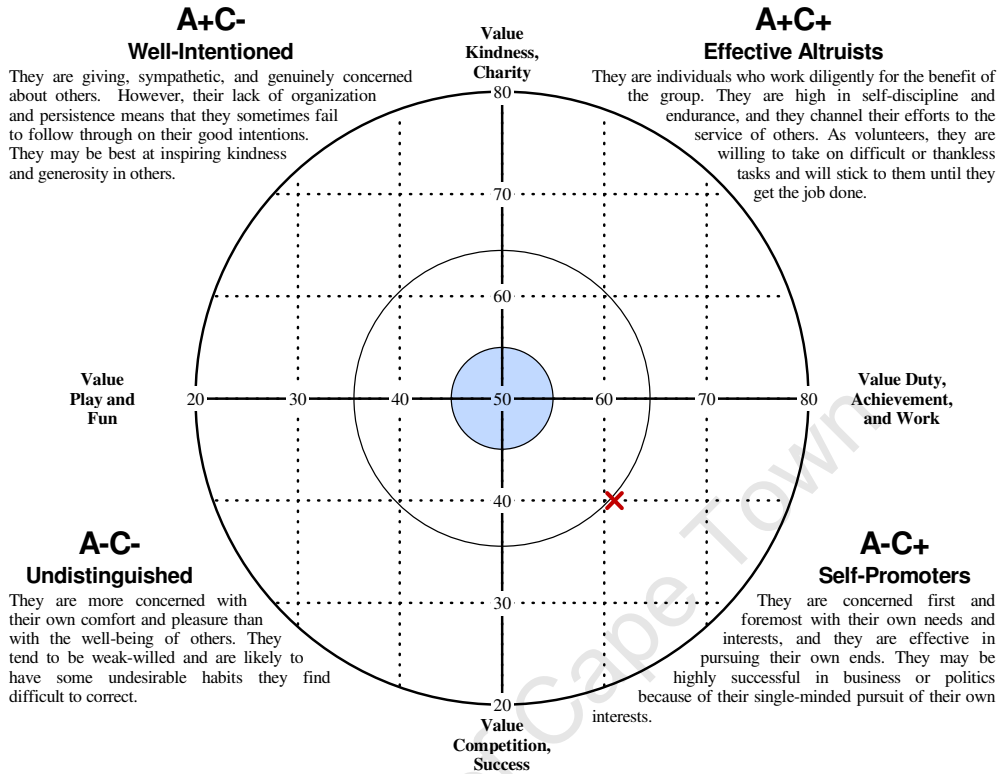
University of Cape Town

NEO Style Graphs

Style of Character

Vertical Axis: Agreeableness (= 40 T)

Horizontal Axis: Conscientiousness (= 61 T)



University of Cape Town

APPENDIX 8

Table 3: Descriptive data of participants (age and cognitive functions correlating to personality traits)

		Memory & Recognition							
Subject details		Memory recall and recognition							Working
	Age	Delayed Recall (correct number of words)	Delayed Intrusion trial (number of errors)	Immediate recall (number of correct words)	Immediate Intrusion trial (number of errors)	Immediate recall (total number of correct words)	Intrusion Trial (number of errors)	Intrusion trials (total number of errors)	False misses
Min	19,9	16	0	16	0	53	0	0	0
Max	32,6	20	4	20	4	60	3	7	1
Mean	25 ± 3.61	19.16 ± 1.14	0.84 ± 1.14	19.2 ± 1.12	0.8 ± 1.12	57.36 ± 2.22	1.36 ± 1.15	2.64 ± 2.22	0.12 ± 0.33

		Emotion recognition				Sensor-Motor function	Verbal Tasks	Attention	Language	Carls
		Processing of facial emotions				Motor tapping	Stroop test	Sustained Attention	Spot the real word	Questionn
	Accuracy in recognising sad faces (%)	Accuracy in recognising fear faces (%)	Accuracy in recognising disgust faces (%)	Reaction time in recognising disgust faces (msec)	Variability of reaction time (msec)	Number of correct responses in recognising the word	Reaction time (msec)	Number of words correctly recognised	Sublimina	
Min	37,5	50	25	1661,75	8	0	90,85	42,64	1	
Max	100	100	87,5	4362,75	81	27	303,57	3,8	3	
Mean	72.5 ± 17.31	78 ± 17.03	52.5 ± 16.93	2777.91 ± 747.1	24.52 ± 15.86	17.84 ± 6.17	239.22 ± 63.88	51 ± 36	21.52	

Table 2: Descriptive data of participants (scoring in NEO FFM personality assessment)

		NEO Five Factor Model Personality Assessment								
		Neuroticism		Extraversion		Openness		Agreeableness		Conscient
	Questionnaire score	t-score*	Questionnaire score	t-score*	Questionnaire score	t-score*	Questionnaire score	t-score*	Questionnaire score	
Min	5	25	25	41	14	26	17	26	26	
Max	30	57	43	71	36	64	37	63	44	
Mean	16.8 ± 6.55	40.12 ± 8.28	34.52 ± 4.89	57 ± 8.28	24.64 ± 4.36	44.56 ± 7.54	29.24 ± 4.29	48.24 ± 7.93	35.6 ± 5.32	

memory
False Alarms
0
314
24.04 ± 75.88

stedt
naire Score
al Coping
.1
2
± 5.3

tiousness
t-score*
43
70
57.16 ± 8.00

University of Cape Town

