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Impulsive and rigid temperament subtypes and executive functioning: An exploratory study of temperament configurations and neuropsychological performance

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Abstract

The aim of this study was to explore differences between the executive performance profiles in second order temperament trait configurations consisted of levels of harm avoidance (HA) and novelty seeking (NS). These trait configurations yield the impulsive temperament subtype (high NS and low HA) and the rigid temperament subtype (high HA and low NS). Participants were categorised into the two *a priori* defined groups according to their scores on NS and HA. The performance and reaction time scores on the computerised Abstract Reasoning and Executive Functioning battery (PennCNP) of the impulsive temperament subtype (n = 121) and the rigid temperament subtype (n= 131) were compared. The results indicate that the rigid temperament subtype reacted slower to both complex (executive functioning) and less complex tasks (attention and working memory) than the impulsive temperament subtype. However, on the single verbal task, no significant performance or reaction time differences were observed. In a simpler timed task, no overall differences were found, but significant reaction time differences were found in a forced choice complex task. Significant differences were maintained with analyses of intelligence and parental education as covariates. The results are discussed in the context of dynamic interaction of temperament dispositions and effortful self-regulation.

Keywords: Executive functioning, temperament subtypes, harm avoidance, novelty seeking, psychobiological theory.

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Introduction

Temperament has been shown to influence behaviour and recently, this association has been facilitated by developments in the fields of neurophysiology, neuropsychology and neuroimaging. A number of studies have investigated links between inheritable temperament dimensions and specific psychiatric disorders and the relationship between psychiatric disorders and neuropsychological functioning (Aigner et al., 2007; Boeker et al., 2006;

Guillem, Pampoulova, Rinaldi & Stip, 2008). However, few studies have been conducted exploring specific temperament configurations and their accompanying executive functioning correlates.

It has been found that temperament dimensions share a common underlying neural base with several neuropsychological facets of executive functioning (Baum et al., 2010; Bergvall, Nilsson & Hansen, 2003; Spielberg et al., 2012) and that differences in temperament dispositions may be an antecedent for observed differences in executive abilities (Henderson & Wachs, 2007; Rueda, Posner, & Rothbart, 2005). Executive functioning involves the integration of higher order processing, which consists of various motivational, affective, cognitive and behavioural components that are necessary for decision-making, planning and goal-oriented behaviours (Morasch & Bell, 2011; Whitney, Jameson & Hinson, 2004). Thus, executive functioning is a complex neuropsychological construct underlying various levels and processes of neurocognitive attenuation and augmentation.

Investigations of neuropsychological performance and specific temperament traits have yielded some promising results with executive performance been shown to correlate with impulsiveness ratings (Keilp, Sackeim & Mann, 2005), as well as novelty seeking (NS) and harm avoidance (HA) (Cloninger, Przybeck, Svrakic & Wetzel, 1994). Guillem et al. (2008) conducted a study examining the correlation between temperament traits and executive performance. Their findings revealed a direct correlation between executive functioning and both HA and NS, with high HA favouring cognitive flexibility and high NS linked to greater interference sensitivity and poorer manipulation. Cassimjee and Murphy (2010) reported a significant negative correlation between HA and performance accuracy on an attention and working memory task and positive associations between HA and reaction time on abstraction and concept formation tasks with and without working memory.

Cloninger, Svrakic and Przybeck (1993) postulated a psychobiological personality model that includes four basic temperament dimensions or traits of which two of the traits of HA and NS will be the focus of this study. According to Cloninger et al. (1993), temperament is the precedent for our pre-potent responses to commence, sustain and halt behavioural responses. NS is an individual's tendency to engage in particular action behaviours and is associated with a genetic bias toward impulsivity, quick loss of temper and exploratory activities (Cloninger, 1987; Roussos, Giakoumaki & Bitsios, 2009). By contrast, HA is associated with a tendency to inhibit behaviours, and is associated with a fearful, cautious, pessimistic and a shy approach (Cloninger, 1987; Gardini, Cloninger, & Venneri, 2009; Kantojärvi et al., 2008; Lundqvist, 2008). These traits are related to independent yet dynamic neural networks, namely the behavioural inhibition system (BIS) and the behavioural activation system (BAS)

(Henderson & Wachs, 2007; Mardaga & Hansenne, 2007; Ravaja, Keltikangas-Järvinen & Kettunen, 2006). Individual differences in inhibition and activation dispositions and the behavioural correlates are thought to reflect variations in the underlying neural systems. The neurotransmitter systems, particularly dopamine and serotonin, have also been implicated – research suggests that HA is linked to the serotonin system, and NS is linked to the dopamine system (Carver & Miller, 2006; Gardini et al., 2009; Henderson & Wachs, 2007).

Individuals have independent threshold stimulus-response characteristics; however, these characteristics are functionally interconnected (Cloninger, 1987). Individual basic responses associated with particular behavioural clusters are a function of integrated responses on two or more trait dimensions. Associated behavioural configurations of HA and NS, for example, constitute the rigid temperament subtype (low NS and high HA) and the impulsive temperament subtype (high NS and low HA). The rigid temperament subtype is characterised by passivity, as well as an inability to tolerate conflict and ambiguity, and the impulsive temperament subtype is characterised by impatience and recklessness.

Williams, Suchy and Rau (2009) also emphasised that temperament traits appear to account for some of the individual differences in executive functioning; however, they caution that no singular temperament trait is associated with specific executive performance profiles. The trend and potency of the link between temperament and executive abilities may vary with the level and interaction of temperament traits. Hence, this exploratory study aims to investigate differences in executive performance as a function of the rigid and impulsive temperament subtypes which reflect HA and NS configurations.

Methods

Participants

The data were collected from a sample of undergraduate psychology students at a residential university in South Africa. Six hundred and thirty students from the 1,124 registered students invited to participate in the study agreed to partake. Participants with a medical and psychiatric history and those with incomplete records were excluded from the analyses. This yielded a final sample of 420. These participants were categorised according to their scores on HA and NS. Mean splits were used to categorise high and low HA and high and low NS. A further categorisation was conducted, where participants were placed in two *a priori* defined groups according to Cloninger's typology (1987). Hundred and sixty eight participants, based on their combined scores on NS and HA, did not fulfil the criteria for categorisation into the two a priori defined groups and were excluded from the final data analyses. The remaining 254 participants were categorised accordingly: Those with high HA and low NS were labelled as belonging to the rigid temperament group (n = 131) and those with low HA and high NS as belonging to the impulsive temperament group (n = 121). The mean age for the rigid temperament subtype was 19.53 and that for the impulsive temperament subtype was 19.97. There were 112 females and 19 males in the rigid temperament group and 102 females and 19 males in the impulsive temperament group.

Measuring instruments

The Temperament and Character Inventory (TCI) is a 238 item forced-choice true-false standardised self-administered questionnaire, derived from the psychobiological personality model. Internal consistency coefficients range from .70 to .89 for the seven factors in a non-clinical sample (Cloninger et al., 1994).

Computerised tasks of the Executive Function and Abstract Reasoning battery (PennCNP) were obtained with permission from the University of Pennsylvania (http://penncnp.med.upenn.edu). The PennCNP consists of five tests of abstract reasoning and executive functioning and one sensorimotor test. The tests include the Penn Abstraction, Inhibition and Working Memory Task (AIM), the Letter-N-Back (LNB2), the Penn Conditional Exclusion Task (PCET), the Penn Short Logical Reasoning Test (SPVRT), and the Short Raven's Progressive Matrices (SRAVEN). Performance indicators were performance accuracy and reaction time. The neuropsychological facets of executive functioning as measured by the tests are as follows: the MPRAXIS is a measure of sensorimotor ability, AIM assesses abstraction and concept formation, both with and without working memory, LNB2 assesses attention and working memory, PCET is a measure of abstraction in executive function, SPVRT is a measure of verbal intellectual ability and SRAVEN is a measure of abstraction and mental flexibility.

Procedure

Ethical approval for the study was obtained from the relevant university authorities. All participants signed informed consent forms and were assured of confidentiality. A web-interface was established between the computer laboratory at the University of Pretoria and the Brain-Behavior Laboratory at the University of Pennsylvania to facilitate the group administration of tests. A maximum of 25 participants attended each group session. Sessions were facilitated by three attending researchers and eight research assistants, each of whom was trained in the administration of the test battery.

Results

Table 1 outlines the results from an independent group t-test, which highlights the significant differences between the subtypes on a number of executive performance outcomes. All the significant differences were for reaction time, not for performance accuracy. The impulsive group proved to be faster on abstraction and concept formation, attention and working memory, sensorimotor ability, abstraction in executive functioning, as well as abstraction and mental flexibility.

Table 1: Significant group differences on executive performance outcomes

Executive Domain	Temperament Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Mean	Error p value
Abstraction and Concept Formation						
Reaction Time incorrect [Block 2]	Rigid	96	2787.94	1235.05	126.05	0.046
	Impulsive	89	2445.07	1068.99	113.31	
Attention and Working Memory						
Reaction Time	Rigid	131	439.59	111.45	9.73	0.025
	Impulsive	120	412.25	76.18	6.95	
Reaction Time [Block 1]	Rigid	131	456.54	127.82	11.16	0.008
	Impulsive	120	416.83	103.05	9.40	
Sensorimotor Ability						
Reaction Time [Trial 1]	Rigid	131	830.79	319.62	27.92	0.016
	Impulsive	121	744.64	235.60	21.41	
Reaction Time [Trial 2]	Rigid	131	612.18	107.63	9.40	0.003
	Impulsive	121	575.44	88.10	8.00	
Abstraction in Executive Functioning						
Reaction Time	Rigid	131	1994.36	518.91	45.33	0.049
	Impulsive	120	1870.77	466.27	42.56	
Abstraction and Mental Flexibility						
Reaction Time	Rigid	130	18968.42	8906.19	781.12	0.005
	Impulsive	119	15946.11	7672.59	703.34	

In order to determine whether intelligence (SRAVEN scores) and parental education influenced reaction times on performance outcomes, a number of analyses of covariance (ANCOVAs) were conducted on the executive functioning variables outlined in Table 1.

Tables 2 and 3 outline the unadjusted and adjusted scores for the various performance outcomes. The rank orderings of the group means were not changed by adjustment for either covariate; however, after adjustment, the means were slightly higher/lower for each group. All the adjusted scores were statistically significant.

Table 2: Adjusted and unadjusted scores for executive performance outcomes and intelligence

Executive Domain	Temperament Group Statistics				
	Group	*N*	**Unadjusted scores**	**Adjusted scores**	**Intelligence mean score *(sd)***
Abstraction and Concept Formation					
Reaction Time incorrect [Block2]	Rigid	96	2787.94 ms	2788.55 ms	43.73 *(9.34)*
	Impulsive	89	2445.07 ms	2425.98 ms	43.94 *(8.91)*
Abstraction in Executive Functioning					
Reaction Time	Rigid	131	1994.36 ms	1993.43 ms	43.73 *(9.34)*
	Impulsive	120	1870.77 ms	1859.66 ms	43.94 *(8.91)*
Abstraction and Mental Flexibility					
Reaction Time	Rigid	130	18968.42 ms	18963.34 ms	43.73 *(9.34)*
	Impulsive	119	15946.11 ms	15951.66 ms	43.94 *(8.91)*

Table 3: Adjusted and unadjusted scores for executive performance outcomes and parental education

Executive Domain	Temperament Group Statistics				
	Group	*N*	**Unadjusted scores**	**Adjusted scores**	***t* value and *p* value**
Abstraction and Concept Formation (controlling for the father's education)					
Reaction Time incorrect [Block 2]	Rigid	96	2787.94	2785.06	$t = 1.998$
	Impulsive	89	2445.07	2448.18	$p = 0.047$
Abstraction and Concept Formation (controlling for the mother's education)					
Reaction Time incorrect [Block 2]	Rigid	96	2787.94	2786.52	$t = 1.98$
	Impulsive	89	2445.07	2446.61	$p = 0.049$
Attention and Working Memory (controlling for the father's education)					
Reaction Time	Rigid	131	439.59	439.68	$t = 2.25$
	Impulsive	120	412.25	412.15	$p = 0.025$
Attention and Working Memory (controlling for the mother's education)					
Reaction Time	Rigid	131	439.59	439.30	$t = 2.19$
	Impulsive	120	412.25	412.56	$p = 0.029$
Attention and Working Memory (controlling for the father's education)					
Reaction Time (Trial 1)	Rigid	131	456.54	456.58	$t = 2.69$
	Impulsive	120	416.83	416.78	$p = 0.008$
Attention and Working Memory (controlling for the mother's education)					
Reaction Time (Trial 1)	Rigid	131	456.54	455.95	$t = 2.6$
	Impulsive	120	416.83	417.47	$p = 0.01$
Sensorimotor Ability (controlling for the father's education)					
Reaction Time [Trial 1]	Rigid	131	830.79	829.85	$t = 2.36$
	Impulsive	121	744.64	745.66	$p = 0.019$
Reaction Time [Trial 2]	Rigid	131	612.18	612.11	$t = 2.93$
	Impulsive	121	575.44	575.51	$p = 0.004$
Abstraction and Mental Flexibility (controlling for the father's education)					
Reaction Time	Rigid	130	18968.42	18968.42	$t = 2.84$
	Impulsive	119	15946.11	15946.11	$p = 0.005$
Abstraction and Mental Flexibility (controlling for the mother's education)					
Reaction Time	Rigid	130	18968.42	19012.70	$t = 2.93$
	Impulsive	119	15946.11	15897.73	$p = 0.004$

Discussion

This study set out to explore differences in performance accuracy and reaction time between subtypes of temperament on computerised measures of abstract reasoning and executive functioning. The use of a computerised test battery enables efficacious recording of both speed and accuracy information (Gur et al., 2010). These advantages allow for additional information on intergroup differences, which traditional neuropsychological measures of executive function cannot yield.

This study found significant differences in the overall median reaction time on the executive domains of attention and working memory (LNB2), abstraction in executive functioning (PCET), abstraction and mental flexibility (SRAVEN) and sensorimotor processing (MPRAXIS). Interestingly, no differences were found in the accuracy or speed on the measure of verbal analogical reasoning. Other researchers have reported the influence of a general factor such as intelligence and parental education levels on executive abilities (Gur et al., 2010). Based on these reported findings, an ANCOVA was conducted using the SRAVEN (a measure of intelligence) and maternal and paternal education scores as covariates.

Even when considering these potential moderating factors on reaction time on executive tasks, significant differences between the groups were still observed. The results of this study showed that the rigid temperament subtype consistently performed slower than the impulsive temperament subtype in tasks that required conflict resolution strategies and cognitive control (complex abilities), and in tasks of attention and working memory (simpler abilities) that required no conflict resolution. Moreover, the faster reaction times of the Impulsive subtype were also evidenced across the complexity levels within tasks, for example, in the LNB2-0-back (the easiest trial condition, which does not involve memory per se); the 1-back (which includes a memory load) and the 2-back (which involves a greater information load and a longer delay between stimulus presentation and response).

Based on the variations in task demands, effortful control, when it is considered a facet of executive functioning, may allude to processes of response inhibition, and when it is considered as a facet of temperament may allude to self-regulation processes underlying voluntary inhibition. Cloninger (1987) contended that HA (avoidance system) inhibits NS (approach system) and that this mechanism is consistently seen in the slower reaction times exhibited by the rigid temperament subtype across task demands and the subcomponents of executive measures.

Significant differences in reaction time were observed for tasks that incorporated a feedback message (“correct/incorrect”) and no explanation of the rules on the one hand, and for tasks that provided no feedback to participants on the other hand. Yang et al. (2009) postulated that a personality more consistent with the attribution of errors to an internal source (correlated with higher HA) implicitly processes aversive feedback as more emotionally negative and evocative and this would be associated with greater activation of the subgenual anterior cingulate cortex, a neural structure that exerts inhibitory mechanisms on decision-making and processing speed. Similarly, Farmer, Whitehead and Woolcock (2007) argued that individual variation in behavioural inhibition, activation dispositions and concomitant behavioural correlates such as attention allocation to negative feedback may result in inhibitory response behaviours after negative feedback. The results suggest a significant difference in reaction time for incorrect responses on the abstraction and concept formation tasks.

Based on Suchy's (2009) nomenclature of components of executive functioning, it is worth noting that significant differences were observed in the overall reaction time for correct responses on the measure of abstraction and problem solving (PCET), but not on the overall reaction time for correct responses on the measure of abstraction and concept formation (AIM). In the AIM task, the executive demands would be on set formation and set maintenance, with the complex cognitive skills being planning, reasoning and organisation, and the elemental neurocognitive processes being response selection, inhibition, initiation and attentional vigilance. The PCET task includes these mechanisms in addition to set shifting and its correlates of problem-solving (a complex cognitive skill) and discrepancy detection, cognitive flexibility and attentional shifting (elemental neurocognitive processes). According to the general model of disinhibition (Hirsh, Galinsky & Zhong, 2011), the depletion of cognitive resources imposed by tasks with increased cognitive load appears to attenuate response conflict and BIS activation, which is likely to result in fast prepotent responses.

Conclusion

The contribution of this exploratory study is based on the findings that firstly, reaction time differences are significant when considering the executive functioning profiles of temperament subtypes and secondly, that the reaction time differences across task complexity and structure hint at the multidimensional and multidetermined nature of constructs such as impulsivity and inhibition. The rationale underpinning this investigation was derived from Cloninger's (1987) contention that as second order basic stimulus-response configurations, the impulsive temperament subtype underlies histrionic and antisocial personalities and the rigid temperament subtype underlies the passive-dependent and obsessional personalities and executive functioning differences in these subclinical groups may hint at putative risk factors for these disorders. Studies on antisocial and obsessional personalities have found profiles of executive performance deficits in these cohorts (Markarian et al., 2010; Moritz et al., 2002; Valerius, Lumpp, Kuelz, Freyer & Voderholzer, 2008). Based on the limitations of this study, future studies should include a more diverse sample and non-executive neuropsychological measures to determine whether information processing differences between temperament subtypes are specific to particular neuropsychological domains.

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