Reinforcement Sensitivity Theory of Personality Questionnaire: Factor Structure Based on CFA and ESEM, and Associations with ADHD

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Abstract

Revised reinforcement sensitivity theory (r-RST) of personality is a major neuropsychological theory of motivation, emotion and personality. This paper presents the results of a study examining: (1) the factor structure of the Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ) using confirmatory factor analysis (CFA) and exploratory structural equation modeling (ESEM); and (2) the relationships of the r-RST constructs in the RST-PQ with attention deficit hyperactivity disorder (ADHD) symptom groups of inattention (IA) and hyperactivity/impulsivity (HI). A total of 572 (Sample 1) and 309 (Sample 2) adults completed the RST-PQ. Participants in Sample 2 also completed a questionnaire measuring ADHD symptoms. Results revealed more support for the ESEM model with six factors than the CFA model. For both the ESEM and CFA models, both IA and HI symptom groups were associated positively with the RST-PQ constructs of behavioral inhibition system (BIS) and behavioral approach system (BAS) Impulsivity, with IA also associated negatively with the BAS-Goal-Drive Persistence. The theoretical implications of these findings for understanding the factor structure of the RST-PQ, and for ADHD (IA and HI) in terms of r-RST, are discussed.

Keywords: ADHD; revised-Reinforcement Sensitivity Theory; Reinforcement Sensitivity Theory of Personality Questionnaire; CFA; ESEM.

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Researchers increasingly contend that establishing links between psychological disorders and personality and temperament dimensions are important as they can enhance our understanding of diatheses, cause, progression, prognosis and treatment (Markon, Krueger, & Watson, 2005; Nigg et al., 2002; Watson, Clark, & Harkness, 1994; Widiger & Costa Jr, 1994; Widiger & Trull, 1992). In recent years, the revised version of reinforcement sensitivity theory (r-RST) has emerged as a major neuropsychological model of personality (Gray & McNaughton, 2000; McNaughton & Corr, 2004; for a review, see Corr, 2008; and a subsequent update, Corr & McNaughton, 2012). This paper presents the results of a study examining: (1) the factor structure of the Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ) using confirmatory factor analysis (CFA) and exploratory structural equation modeling (ESEM); and (2) the relationships of the r-RST constructs in the RST-PQ with attention deficit hyperactivity disorder (ADHD) symptom groups of inattention (IA) and hyperactivity/impulsivity (HI).

In the original reinforcement sensitivity theory (o-RST), proposed by Gray (1982), personality was viewed in terms of individual differences in two major neurobiological systems: the behavioral inhibition system (BIS), and the behavioral approach system (BAS). The BIS was postulated to be sensitive to conditioned stimuli relating to punishment, frustrative non-reward and novelty, and its activation was associated with anxiety and passive avoidance behavior. The BAS was postulated to be sensitive to conditioned stimuli related to reward and non-punishment, and its activation was associated with positive emotions and approach behaviors.

The o-RST was substantially updated by Gray and McNaughton (2000; see also Corr &

McNaughton, 2012; McNaughton & Corr, 2004; and Corr, 2008). In the revised RST model (r-RST), the BAS is conceptualized as it was in o-RST. It functions to move the individual towards the final (typically biological) reinforcer, with the individual continuously identifying, planning, and executing responses to reduce the temporal and spatial distance from reinforcer. Reward interest, goal planning and drive-persistence are assumed to constitute early stages of approach motivation, with the individual experiencing anticipatory pleasure along the path. Reward responsivity and impulsivity are assumed to constitute later stages of approach behavior, with the individual experiencing high pleasure.

In r-RST, reactions to all types of punishment are postulated to be mediated by the fight-flight-freeze system (FFFS), which in many respects is comparable to the BIS in the o-RST. The r-RST makes a distinction between punishment that can be avoided, and punishment that cannot be avoided and may need to be approached. The former is assigned to the FFFS. Emotionally, FFFS activation results in fear; and behaviorally, depending on situation affordances, it leads to defensive behaviors, such as flight, escape and active avoidance when the punishment can be avoided, or fight and freeze when the punishment is more proximal and less easy to avoid.

The BIS in r-RST is still linked to anxiety, although it is not related to mediating reactions to punishment. Instead, it is related to detecting and resolving goal conflicts, especially ones entailing approach-avoidance (involving the BAS and FFFS activations, respectively). When the BIS is activated, it inhibits prepotent conflicting behaviors, and heightens attention and increases arousal. Conflicts are resolved by increasing the negative valence of stimuli – which serves to input into the FFFS - leading to a resolution that favors either an approach response when it is perceived that the danger has diminished (mediated by the BAS) or an active avoidance or escape response when it is perceived that the danger is present or increased (mediated by the FFFS). Emotionally, BIS activation results in anxiety, worry and rumination about possible danger. Cognitively, it generates obsessional thoughts about the possibility that something unpleasant would happen soon if the danger cannot be avoided, and behaviorally, it leads to disengagement when the danger is considered to be unavoidable.

One of the most often used measures for o-RST is the Carver and White (1994) Behavioral Inhibition System/Behavioral Activation System (BIS/BAS) scales. The BIS/BAS scales, as originally conceptualized, have measures for the BIS and BAS (with subscales for Reward Responsiveness, Fun Seeking, and Drive). Heym, Ferguson, and Lawrence (2008) showed that the seven items in the BIS scale can be empirically separated into subscales measuring Anxiety and Fear. It has been proposed that these Anxiety and Fear scales can be used for measuring the r-RST constructs of the BIS and the FFFS, respectively. However, it is possible that as the fear items were negatively worded, while the other items were positively worded, the FFFS scale may represent a measurement artefact (method factor) unrelated to substantive content Corr (2016), Although several scales for r-RST have recently been developed (Jackson, 2009; Smederevac, Mitrović, Čolović, & Nikolašević, 2014), the Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ; Corr & Cooper, 2016) is closer to the theoretical assumptions and structure of r-RST and, for this reason, has gained more popularity.

The development of the RST-PQ was theoretically motivated to measure the specific components of r-RST (Corr & Cooper, 2016). It has 65 self-rating items. Corresponding to the r-RST, the RST-PQ has scales to measure the constructs of the FFFS, the BIS, and the BAS. The FFFS scale is unidimensional, and includes items covering freeze, flight, and active avoidance/escape. Pointing out that it was difficult to measure fight cleanly by human personality questionnaires, because it has been found to be negatively related to the other BIS components, and positively with the BAS (Reuter, Cooper, Smillie, Markett, & Montag, 2015), Corr and Cooper (2016) did not include defensive fight items as part of the FFFS. Instead, they offered a separate measure for this, called Defensive Fight. In the RST-PQ, the BIS scale is unidimensional, and includes items for motor planning interruption, worry, obsessional thoughts, and behavioral disengagement. The BAS scale is multidimensional, with four subscales: Reward Interest (RI; processes that are related to being open to new experiences and opportunities that might potentially provide a reward); Goal-Drive Persistence (GDP; high motivation and the maintenance of motivation to attain long-term goals); Reward Reactivity (RR; positive emotional responses to an attained reward); and Impulsivity (I; processes that enable an individual quickly and spontaneously to change their behavior to 'grab' a reward).

Structurally, therefore, the proposed model for the RST-PQ is a six-factor oblique model. In the initial RST-PQ development and validation study, the developers reported that CFA of the RST-PQ supported this model (Corr & Cooper, 2016), with salient factor loadings (> .40) for all items on their respective factors. There was also good support for the convergent and discriminant validities, and reliabilities of the factors. However, a careful examination of the CFA findings in the original study show that, based on currently accepted standards for inferring of model fit (Hu & Bentler, 1999), the RMSEA value (0.052) indicated good fit, but the CFI value (0.87) indicated poor fit. The oblique six-factor structure of the RST-PQ has been tested using CFA in other studies (Eriksson, Jansson, & Sundin, 2019; Krupić, Corr, Ručević, Križanić, & Gračanin, 2016; Pugnaghi, Cooper, Ettinger, & Corr, 2018; Wytykowska, Fajkowska, Domaradzka, & Jankowski, 2017). With the exception of the study by Krupić et al. (2016), the findings in the other studies also showed that, like the findings in the Corr and Cooper (2016) study, the RMSEA values indicated good fit, and the CFI values indicated poor fit. Krupić et al. (2016) found good fit in terms of the RSEMA value, but only adequate fit in terms of the CFI value. Despite these findings, the authors in all the studies cited above concluded support for the theorized six-factor oblique model for the RST-PQ.

Besides the mixed support for the theorized six-factor model, there are a number of limitations in terms of inconsistencies between RST-PQ and r-RST. First, in the RST-PQ, both the FFFS and BIS scales are unidimensional, despite the fact that both the FFFS and BIS have been considered in r-RST to be related to multiple distinct processes: the FFFS with fight, freeze, and flight; and the BIS with motor planning interruption, worry, obsessional thoughts, and behavioural disengagement. Notwithstanding this, the relevant distinct processes for the FFFS and the BIS are tapped by items in RST-PQ FFFS and BIS scales. Second, there are limitations in how some of the RST-RQ scales relate with each other. Inconsistent with theoretical expectations, in the initial development and validation study of the RST-PQ (Corr & Cooper, 2016) ,findings showed that both the FFFS and BIS were correlated positively with reward reactivity and impulsivity (r = .16–.21), and that the correlation between reward reactivity and impulsivity was not significant (r = .02). Thus, it could be argued that these relations are inconsistent with r-RST. Third is concern related to defensive fight which is not in the RST-PQ, per sa, but presented as a separate scale. As noted earlier, Corr and Cooper (2016) have pointed out that it may be difficult to distinguish reactive, defensive aggression (controlled by FFFS) from instrumental aggression (controlled by the BAS) as the language in questionnaires may simply fail to differentiate the psychological states of each type – also see Corr (2016).

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Although there appear to be concerns in terms of alignment of the RST-PQ with r-RST, and mixed support for the oblique six-factor RST-PQ model, Corr and Cooper (2016) and others (Krupić et al., 2016; Pugnaghi et al., 2018; Wytykowska et al., 2017) have offered the RST-PQ, with the theorized six-factor oblique factor, as a useful questionnaire for research involving r-RST. However, we feel that this support may have been overstated. In part, this is because, the CFA approach used in all past factor analysis studies involving the RST-PQ has recently been questioned for testing adequately the factor structure of complex questionnaires (Marsh, Morin, Parker, & Kaur, 2014). With six factors and 65 items, the RST-PQ is a complex questionnaire – and the theoretical nature of it adds more complication (e.g., the FFFS and BIS are positively correlated by virtue of the fact that BIS activation inputs to the FFFS, and the reverse can happen too).

The standard CFA approach (independent cluster model of CFA; ICM-CFA) used previously is a model-based approach in which items load only on their target factors, and all the loadings on non-target factors (cross-loadings) are constrained to zero (Jöreskog, 1969; A. Morin, Marsh, & Nagengast, 2013). The restriction on cross-loadings in the ICM-CFA approach is considered highly restrictive as items are rarely pure indicators of their latent factors and, therefore, some degree of construct-relevant association with non-target, but conceptually related factors, is to be expected (Morin, Arens, Tran, & Caci, 2016). Thus the ICM-CFA approach is unlikely to capture the reality of the RST-PQ data set, and could consequently show poor fit for this measure even when this is not the case. Related to this, Marsh et al. (2007; Marsh et al., 2009) argued that it is almost impossible to get acceptable fitting models for good multidimensional (5 to 10 factors) rating scales when examined only with ICM-CFA.

To overcome the limitations of the CFA approach, the ESEM approach has been developed (Asparouhov & Muthén, 2009). ESEM is a synergy of the EFA and CFA approaches, incorporating the advantages of the EFA approach (allowing cross-loadings) and CFA approach (model-based) approaches. Existing findings have demonstrated the superiority of the ESEM approach over the EFA and ICM-CFA approaches (Marsh et al., 2014; Marsh et al., 2009). Thus, for a more comprehensive evaluation of the structure of the RST-PQ there is a need to apply ESEM. Information from such studies will provide a more valid test of the factor structure of the RST-RQ and, therefore, more likely, better research application and contributions.

The support for any model is enhanced if external validities for the factors in the model can be demonstrated. To date, several studies have examined the relevance of o-RST and r-RST in explaining various psychopathologies (Bijttebier, Beck, Claes, & Vandereycken, 2009). In this respect, an underactive BIS or low punishment sensitivity has been linked theoretically to Attention Deficit Hyperactivity Disorder (ADHD; Quay, 1988). ADHD is a neurodevelopmental disorder that is typically diagnosed during childhood (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; *American Psychiatric Association* [APA], 2013). However ADHD is now recognized as an adult disorder as well (APA, 2013). In DSM-5, ADHD is characterized by behavioral patterns of inattention, and hyperactivity-impulsivity. For the diagnosis of ADHD, the DSM-5 (and also DSM-IV [APA, 1994] and DSM-IV TR [APA, 2000]) list the same 18 symptoms under two separate symptom groups, namely inattention (IA) and hyperactivity/impulsivity (HI), with nine symptoms for each group. According to Deloitte Access Economics (2019), the prevalence of ADHD in Australia is around 4.25 for children, and 4% for adults, with a male to female ratio of 2 to 3:1. This equates to approximately 14,500 Australians. The estimate cost for ADHD in 2019 was $20.42 billion, and an additional cost of $10.19 billion for productivity losses due to ADHD.

Theoretically, single pathway models of ADHD have linked ADHD to a response inhibition deficit or impulsivity (Barkley, 1997), dysfunctional responses to rewards (for a review, see Luman, Oosterlann, & Sergeant, 2005), underactive BIS or low punishment sensitivities (as proposed in the o-RST; Quay, 1988), and insensitivity to delayed rewards (Sagvolden, Aase, Zeiner, & Berger, 1998). In contrast, dual pathways models of ADHD have implicated different processes for the IA and HI symptom groups. Sonuga-Barke (2003) proposed that deficits in executive functioning underlie the IA symptoms, while deficits in reward response underlie the HI symptoms. Martel and Nigg (2006) linked problems with cognitive control processes to the IA symptoms, and problems with motivational control processes to HI symptoms. As will be noted, these models implicate problems associated with reward and/or punishment sensitivities and/or control processes. As the core feature of RST is reward sensitivity, punishment sensitivity, and control process, it follows that RST (in particular r-RST) should have special relevance for understanding ADHD.

At a more general level, it has been argued that ADHD and personality dimensions are the same constructs viewed through different theoretical lenses (Miller, Miller, Newcorn, & Halperin, 2008). Two recent meta-analyses demonstrated the relevance of personality and temperament dimensions for understanding ADHD (Gomez & Corr, 2014; Gomez, Van Doorn, Watson, Gomez, & Stavropoulos, 2017). In the Gomez and Corr (2014) study, the meta-analysis examined the relationships of the personality dimensions in the Five-Factor Model (FFM) with IA and HI. The major findings were that IA and HI were both associated with low conscientiousness, low agreeableness; and high negative emotionality; conscientiousness was more strongly related to IA than HI; and agreeableness was more strongly related to HI than IA. In the other meta-analysis study (Gomez et al., 2017) examined the relationships of Cloninger's personality dimensions with ADHD. Major findings were that all personality dimensions, except Self-Transcendence, were significantly associated with ADHD; the associations were especially strong for Novelty-Seeking and

Self-Directedness, being positive for Novelty-Seeking and negative for Self-Directedness.

It will be noticed that both the meta-analysis studies mentioned above did not include RST constructs. However, to date, data from at least two studies do provide some hints as to how r-RST constructs may be related to ADHD. In relation to Cloninger's temperament and character dimensions (Cloninger, Svrakic, & Przybeck, 1993), Gomez, Woodworth, Waugh, & Corr (2012) reported that IA was predicted positively by Harm Avoidance and negatively by Self-Directedness; and HI was predicted positively by Persistence. Based on the conceptual overlaps of Cloninger's temperament and character dimensions with r-RST constructs, these authors interpreted their findings in terms of r-RST. More specifically, they argued that their findings supported the view that IA is related to BIS and FFFS (low Self-Directedness and high Harm Avoidance) and HI is related to BAS (high Persistence). Gomez and Corr (2010) examined directly how the traits of r-RST are related to ADHD. Their study used the r-RST constructs, as proposed for the modified BIS/BAS scales (Heym et al., 2008). The findings indicated that IA was correlated positively with BIS, and HI was correlated positively with BAS-Drive. Also, HI was correlated positively with BAS-Fun-Seeking. However, for the same data, a multiple regression analysis, which controlled for age, sex and Oppositional Defiant Disorder symptoms, showed no unique associations for all the r-RST constructs with IA, with HI showing unique association with only BAS-fun seeking. Given the argument made before that the FFFS measure derived from the BIS/BAS scales may represent a measurement artefact unrelated to substantive content (Corr, 2016), these findings need to be treated with caution. In contrast, RST-PQ has sound conceptual, theoretical and psychometric qualities for measuring the r-RST constructs; and it is conceivable that the RST-PQ could provide a clearer and more meaningful understanding of the relationships of the r-RST constructs with ADHD, as explained next.

As noted earlier, Sonuga-Barke (2003) proposed the dual pathways ADHD model. This model proposes that ADHD is associated with deficits in both motivation (related to delayed aversion) and executive (related to response inhibition) functions, with these deficits contributing independently to ADHD. Martel, Nigg, and von Eye (2009; see also Nigg, 2010) have referred to the executive control processes and motivational processes as “top-down” and “bottom-up”, respectively. Top-down control behaviors are goal-directed, resource-demanding and planful, whereas bottom-up control behaviors, which include affective responses, are strongly influenced by immediate incentives. Also, deficits in motivation are linked to HI, whereas deficits in executive functions are linked to IA (Sonuga-Barke 2003; see also Martel, Nikolas, Jernigan, Friderici, & Nigg, 2010). According to Martel et al. (2010), personality traits related to low effortful control, conscientiousness and resiliency reflect top-down control processes, whereas personality traits related to high reactive control, negative emotionality, neuroticism, extraversion, and low agreeableness reflect bottom-up control processes.

As top-down and bottom-up control processes are differentially related to IA and HI, respectively, it follows that low effortful control, conscientiousness and resiliency should be associated with IA, whereas high reactive control, negative emotionality, neuroticism, extraversion, and low agreeableness should be associated with HI symptoms (Martel et al., 2010). Overall, therefore, there are good theoretical grounds to assume that a comprehensive understanding of how personality dimensions are related to ADHD would improve our understanding of ADHD, especially relating to behavioral criteria, heterogeneity and development of ADHD (De Pauw & Mervielde, 2010), and simpler biologically-linked markers (endophenotypes) of ADHD (Nigg, 2010). In this respect, as the BIS and FFFS relate to top-down processes, and the BAS to bottom-up control processes, and keeping in mind the neuropsychological processes implicated for the FFFS, BIS and BAS, it can be argued that examining the relationships of the r-RST constructs with ADHD constructs could provide additional insights in terms of the neuropsychological processes involved in IA and HI, and thus ADHD, which in turn will indicate the cognitive and motivational processes that could be treatment targets for ADHD. Related to this, and despite the limitations identified for the RST-PQ, the use of the r-RST can be expected to provide the most useful relations of r-RST and ADHD.

One major aim in the current study was to use CFA and ESEM models to examine the six-factor RST-PQ model. Another major aim was to examine how the RST-RQ constructs were uniquely related to ADHD IA and HI symptom groups. As studies have shown that ADHD behaviors decline with age, and they are relatively higher among males than females (Biederman, Mick, & Faraone, 2000), the potential confounding effects of age and sex were controlled in our analysis. Given past findings for the performance of CFA and ESEM models in general (Marsh et al., 2014), we hypothesized better support for the ESEM model. Additionally, it was hypothesized that HI would be predicted positively by one or more of the BAS constructs. In this regard, we expected a unique association for HI with BAS-Impulsivity as this construct is comparable to BAS-Fun Seeking in the BIS/BAS scales (Smillie, Jackson, & Dalgleish, 2006). Given that at the theoretical level, the BIS is associated with cognitive processes, such as information processing and attention processing (Corr, 2008), and as ADHD (both IA and HI symptoms) has been linked to deficits in executive control processes, such as response inhibition, planning, working memory, attention shifting, and problem solving (Barkley, 1997; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), we expected unique associations for IA and HI with the BIS.

Method

Participants

All data were collected from participants residing in Australia. We used two groups of samples (Sample 1 and Sample 2). Sample 1 (N = 571) was used to examine the six-factor structure of the RST-PQ. This sample comprised 422 females (73.8%) and 151 males (26.2%). Age ranged from 18 to 79 years (M = 23.983, SD = 8.21). The mean (SD) age for males and females were 23.33 (7.30) years and 24.22 (8.52) years, respectively. Females and males did not differ significantly on age, t (570) = 1.14, p = 0.11. The majority of participants (56%) were first year undergraduate psychology students recruited from the psychology participant pool in exchange for course credit points. Other participants were members of the general community. For this sample the mean (SD) and range scores for IA were 15.28 (6.31) and 1 to 36. For HI, they were 13.43 (6.01) and 1 to 36, The ASRS has six items that are used as screeners, with a total scores for the six symptoms ranging from 0 to 24. For these scores, Kessler et al. (2005) have proposed a cut-off score of $\geq$ 14 (sensitivity = 64.9%, specificity = 94.0%) for a general population to screen for those with and without ADHD. Based on this criteria, the percentages of individuals with ADHD in this sample was 24.5% (N = 140). In terms of highest educational level, 43.3% completed secondary school, 9.6% completed trade/technical school, 35.3% completed or were completing an undergraduate university degree, 10.5% completed or were completing a postgraduate university degree, and 1.4% did not provide this information. For the sample, 39.5.% identified themselves as being in a relationship or married, 57.4% as being single, and 1.6% as divorced, separated, or widowed, and 1.6% did not provide this information. Regarding employment status, 53.4% were working, 7.9% were unemployed, 0.7% was retired, 35.1% were students, and 1.9% did not provide this information.

Sample 2 was also used to examine support for the six-factor structure of the RST-PQ, and also to examine how the RST-RQ constructs were related to ADHD IA and HI symptom groups. This sample had 309 (71 males, 233 female, five did not state their gender) participants, with ages ranging from 18 to 82 years. They were recruited from the general population through paid advertisements posted on social media (Facebook). These adverts were targeted for both males and females aged 18 years or older who were based in Australia. Participants who completed the survey could enter a prize draw for a $50 AUD shopping voucher. The mean age (*SD*) of all participants was 47.66 years (16.85). The mean age (*SD*) of males and females were 47.59 (19.73) and 48.21 (15.66), respectively. There was no significant difference for age between male and female participants, t (302) = 0.27, *ns*. For this sample the mean (*SD*) and range scores for IA were 15.88 (6.61) and 1 to 36. For HI, they were 14.60 (6.11) and 2 to 36, Using the cut-off scores proposed by Kessler et al. (2005) for the six screening items, the percentages of individuals with ADHD in this sample was 39.7 % (N = 95). In terms of employment status, the majority were working (49%). The rest were engaged as student (19%), retired (9%), home duties (7%) or unemployed (7%). Education levels were reported as primary or secondary at 34.4%, and tertiary was 65.6%. This study used the Adult ADHD Self-Report Scale (ASRS: Kessler et al., 2005) Symptom Checklist (described below) for measuring ADHD IA and ADHD HI symptoms groups.

It may be worth noting that Samples 1 and 2 were not combined in any way for any of the analyses conducted in the current study. Notwithstanding this, there was no difference between the samples for the mean score for IA, t (879) = 1.32, p = 0.19; gender ratio, $\chi 2$ (1) = 0.27, p = 0.60; and percentages of those working and not working, χ^2 (1) = 1.55, p = 0.21. The samples differed for age, t (879) = 28.02, p = 0.001; HI, t (879) = 2.74, p = 0.01; percentages of individuals meeting the ADHD diagnosis, based on the six ADHD screening items, χ^2 (1) = 22.12, p = 0.001; and percentages of those having attended secondary and beyond secondry education, χ^2 (1) = 6.60, p = 0.05. The effect size for the difference in age was large (Cohen's d = 1.98). For HI, it was small (Cohen's d = 0.19), and it was also small for education (phi = .08), and the percentages of individuals meeting the ADHD diagnosis (phi = .16). Thus although the groups differed noticeably for age, they can be considered comparable for mean scores for IA, HI, education and employment status, and number of individuals who could be positive for ADHD.

Materials

Adult ADHD Self-Report Scale Symptom Checklist (ASRS: Kessler et al., 2005). ADHD ratings were obtained using the ASRS Symptom Checklist. This measure contains the DSM-IV symptoms of ADHD (9 IA items, and 9 HI items). For all items, participants indicated how often they have experienced each symptom over the past 6 months on a scale with options of 0 (*never*), 1 (*rarely*), 2 (*sometimes*), 3 (*often*), and 4 (*very often*). The ASRS has high convergent validity (Kim, Lee, & Joung, 2013) with other adult ADHD questionnaire measures, such as the the Conners Adult ADHD Rating Scale (Conners et al., 1999). In the current study the Cronbach's alpha values for the IA, and HI symptom groups were .86, and .82, respectively.

*Reinforcement Sensitivity Theory - Personality Questionnaire (*RST-PQ; Corr & Cooper, 2016). The RST-PQ was described in the introduction. In brief, it has subscales for FFFS (10 items; e.g., "I would run fast if I knew someone was following me late at night"; and "I am an avoidant sort of person"); BIS (23 items; e.g., "My behavior is easily interrupted"; and "My mind is dominated by recurring thoughts"), BAS-Reward Interest (RI; 7 items; e,g., "I am always finding new and interesting things to do"; and "I regularly try new activities just to see if I enjoy them"), BAS-Goal-Drive Persistent (GDP; 7 items; e.g., "I put in a big effort to accomplish important goals in my life'; and "I am motivated to be successful in my personal life"), BAS-Reward Reactivity (RR; 10 items; e.g., "I am especially sensitive to reward"; and "Good news makes me feel over-joyed") and BAS-Impulsivity (I; 8 items; e.g., "I sometimes cannot stop myself talking when I know I should keep my mouth closed", and "I often do risky things without thinking of the consequences"). Each item is rated on a four-point scale (in relation to the general instruction "How accurately does each statement describe you?"), ranging from 1 (*not at all*) to 4 (*highly*). In the initial development and validation study, Cronbach's alpha values were FFFS =.78, BIS = .93, RI =.75, GDP = 86, RR = .78, I = .74. For the current study, these values were FFFS =.79, BIS = .91, RI =.74, GDP = 87, RR = .75, I = .75.

Procedure

Ethics approval for the recruitment of participants for Sample 1 was obtained from the Human Research Ethics Committee of Federation University Australia. Ethics approval for the recruitment of participants for Sample 2 was obtained from the Cairnmillar Institute Human Research Ethics Committee. All participants were recruited by advertisements and on-line (via Survey Monkey). Pursuant to ethics approval, participants were provided with an information statement prior to their involvement informing them that completing and returning questionnaires indicated that they understood the nature of the research and that they freely consented to participate. The survey contained demographic questions (age, gender, education and employment status), the RST-PQ (for Samples 1 and 2), and ASRS (for Sample 2). All questionnaires were completed anonymously. None of the participants were compensated for their participation, with the exception of the prize draw opportunity for Sample 2 participants.

Statistical Analysis

All statistical analyses were conducted using M*plus* Version 7.3 (Muthén & Muthén, 2012). Weighted least square mean and variance adjusted chi-square (WLSMV) estimator was used for all models. WLSMV can corrected for non-normality in the data set and is suited for responses with four or less response categories (DiStefano, 2002; Lubke & Muthén, 2004; Muthén & Muthén, 2012) as is the case with the items listed in the RST-PQ.

To establish if the CFA or the ESEM mode was better, we followed three steps. In the first step, we examined and compared the global fit of the CFA and ESEM models tested. In the second step, we compared the correlations of the same factors in the CFA and ESEM models. In general, when the correlations for the factors are lower in the ESEM model than the CFA model, it means that the ESEM model captures better the distribution of the variances in the measure than the CFA model (Marsh et al., 2009; A. Morin et al., 2013). In the third step, we examined the factor loadings to ascertain how well the factors were defined. Tabachnick, Fidell, & Ullman (2007) have suggested the following guideline for establishing the saliency of factor loadings when the items have different frequency distributions (as is these case in our RST-PQ data set): 0.32 (*poor*), 0.45 (*fair*), 0.55 (*good*), 0.63 (*very good*), and 0.71 (*excellent*). For the purpose of the current study we used a cut-off score of .45 to infer salience. Thus item loadings of .45 and above were considered salient.

Using our preferred model, we tested the relationships of the RST-PQ factors with ADHD IA and HI: IA and HI total scales scores were regressed on the relevant factors in the model. To control for possible confounding effects of age and gender, both these variables were entered as covariates in the analyses.

As χ^2 values, including the WLSMVχ^2, are inflated by large sample sizes, the fit for all models in the study was also evaluated by three approximate or practical fit indexes. The indexes used were the root mean squared error of approximation (RMSEA), the comparative fit index (CFI), the Tucker Lewis Index (TLI), and the weighted root mean square residual (WRMR). The guidelines suggested by Hu and Bentler (1999) are that RMSEA values close to 0.06, or below be taken as good fit, 0.07 to 0.08 as moderate fit, 0.08 to .10 as marginal fit, and >.10 as poor fit. For the CFI and TLI, values close to .95 or above are to be taken as good fit, values close to .90 and .95 be taken as acceptable fit, and values less than .90 be taken as poor fit. For the WRMR, scores of 1 or less is considered adequate (DiStenfano, Liu, Jiang,

& Shi, 2017). As the CFA and ESEM RST-PQ models were nested, the chi-square difference test ($\Delta\chi^2$) could be used to compare the difference in fit of the models (Marsh, et al., 2014). However, as the $\Delta\chi^2$ test is also highly sensitive to large sample sizes, for this study, models were compared using change in the RMSEA and CFI values, Generally, differences in CFI values of 0.010 or more and/or RMSEA values of 0.015 or more are interpreted as difference for the models being compared (Chen, 2007; Cheung & Rensvold, 2002). As there were eight predictors in each analysis, the *p* value for inferring significance was adjusted to control for Type 1 error. The adjustment involved Bonferroni correction (Perrett, Schaffer, Piccone, & Roozeboom, 2006), and this value was $p < .0062$ (i.e., .05/8).

Results

Step 1: Comparison of Global Fit

Table 1 shows the global fit values for all the RST-PQ models tested. For both samples, based on the guidelines suggested by Hu and Bentler (1998), CFI values for the CFA models indicated poor fit, and the RMSEA values can be taken as good fit. For the ESEM model, for Sample 1 the CFI value indicated adequate fit, and the RMSEA indicated good fit. For Sample 2, both the CFI and RMSEA values indicated good fit. In addition, for both samples, the CFA and ESEM models differed from each other (as the ΔCFI and ΔRMSEA values between all model pairs were > 0.01, and 0.015, respectively), with the ESEM model indicating better fit. Overall, therefore, at the global fit level, the findings showed good and better support for the ESEM model than the CFA model. Both the CFI and TLI are incremental fit indices, which is analogous to R^2 (Kenny, 2020). As increase in R^2 is generally used to infer incremental validity, the higher CFI values in the ESEM model compared to the CFA model can be interpreted as demonstrating support for the incremental validity of the ESEM model over the CFA model.

Step 2: Comparison of Correlations in the CFA and ESEM Models

Table 2 shows the correlations of the factors in the CFA and ESEM models. As shown in the table, for the *p* values set for inferring statistical significance (< .0062), for the same factors in these models, the values were lower in the ESEM model than the CFA model, thereby indicating that the ESEM model was a better model than the CFA model.

Step 3: Factor Loadings in the CFA and ESEM Models

Supplementary Table 1 shows the factor loadings for the CFA and ESEM models for Sample 1, and Supplementary Table 2 shows the factor loadings for the CFA and ESEM models for Sample 2. For Sample 1, for the CFA model, the followings items did not load saliently: FFFS items 19, 46 and 59; GDP item 54; RR item 4; and I item 40. All the BIS and RI items loaded saliently on their respective factors. For the ESEM model, the followings items did not load saliently: FFFS items 19 and 46; BIS item 49; RI items 13, 15 and 26; RR items 8 and 23; and I items 27 and 51. All the GDP items loaded on the GDP factor. Additionally, none of the items cross-loaded saliently. For Sample 2, for the CFA model, the followings items did not load saliently: FFFS items 19, 45, 46, 58 and 59; RI items 15 and 26; GDP item 54; RR item 3 and 36; and I items 38, 44 and 51. All the BIS items loaded saliently on the BIS factor. For the ESEM model, the followings items did not load saliently: BIS item 49; RI items 26 and 35; GDP item 54; RR items 3 and 23; and I items 22, 27 and 49. All the FFFS items loaded saliently on the FFFS factor. Additionally, there was no salient cross-loading. Across both samples, the CFA indicated non-salient loadings for FFFS items 19, 46 and 59; and GDP item 54. Also across both samples, the ESEM model indicated non-salient loadings for FFFS item 49; RR item 23; and I item 27.

Overall, despite some non-salient loadings on the targeted factors, for both models in both samples, the factors were reasonably well defined. Notwithstanding this finding, the factors were somewhat better defined in the ESEM model than the CFA model in the case of Sample 2. Given these findings and also that ESEM model showed better global fit than the

CFA model, and lower correlations between like latent factors, we deemed that the ESEM as the better model for the RST-PQ. We used this model to examine the relations of r-RST constructs with ADHD IA and HI symptom groups.

Relationships of the RST-PQ Factors in the ESEM and CFA Models with IA and HI

Table 3 shows the standardized path coefficients for the predictions of IA and HI symptom groups by gender, age, FFFS, BIS, RI, GDP, RR and I. We conducted this for both the ESEM and CFA models. The latter was done to ascertain if the improvement in fit of the ESEM ADHD model contributed differently (compared to the CFA ADHD model) to the relationships between ADHD and r-RST constructs, and therefore research on r-RST and ADHD. For both the ESEM and CFA analyses, both IA and HI were predicted significantly and positively by BIS and I. Additionally, IA was predicted significantly and negatively by GDP for both analyses. Thus there was no difference in how the RST-PQ constructs were associated with ADHD constructs in the ESEM and CFA models. The differences between the variables with significant beta values were compared using the formula recommended by Paternoster, Brame, Mazerolle, & Piquero (1998). Although details are not provided, there was no differences in the beta values predicting IA and HI by BIS, IA and HI by I. and IA by Goal-Drive Persistence across the ESEM and CFA models.

Discussion

One major aim of the current study was to use CFA and ESEM approaches to examine the six-factor RST-PQ model. These analyses were conducted using two independent samples. Although the CFA for both samples indicated good fit for this model in terms of their RMSEA values, their CFI values indicated poor fit. In contrast, for the ESEM mode, the RMSEA indicated good fit for both samples, and CFI values indicated good fit for one sample and adequate fit for the other sample. Also, for both samples, the ESEM model showed better fit than the CFA model. For both samples, the correlations between the same factors were lower in the ESEM model than the CFA model, thereby indicating that the ESEM model was a better model than the CFA model. Also in the two samples, the pattern of factor loadings for both the CFA and ESEM models revealed a few non-salient targeted loadings, with no salient cross-loadings in the ESEM model. Despite the few non-salient loadings, the factors were reasonably well defined, with this being somewhat better in the ESEM model than the CFA model in the case of Sample 2. Given our findings, we deemed the ESEM was the better model for the RST-PQ. Overall, therefore, our findings provided support for the theorized six factors in the RST-PQ. Our findings indicating mixed support for the CFA model is consistent with existing findings (Corr & Cooper, 2016; Eriksson et al., 2019; Krupić et al., 2016; Pugnaghi et al., 2018; Wytykowska et al., 2017). However, as we also used the ESEM approach to examine the structure of the RST-PQ (not done previously), our findings extend existing findings in this area, and are new.

Another major aim of the current study was to examine the relevance of r-RST constructs, as measured by the RST-PQ, for ADHD. For this we regressed the IA and HI symptom group scores on the RST-PQ factors of the ESEM model. As expected, our findings indicted that both IA and HI symptom groups were uniquely and positively associated with the BIS and BAS-Impulsivity. Similar findings were found for the analyses involving the ESEM and CFM model, thereby indicating that despite being a better fitting model, the ESEM model did not influence research on the r-RST and ADHD. As there is now ample data supporting a bifactor model for ADHD, with a strong general factor (e.g., Gomez et al. 2018; Martel et al., 2012; Morin et al 2016; see Arias Ponce, Martínez-Molina, Arias, & Núñez, 2016 for a review) , it can be taken that there is a considerable shared variances across the IA and HI symptoms. As the regression analysis did not separate the shared variances from the specific group variances in the symptoms, it is conceivable that the shared variance in the IA and HI symptoms may explain why IA and HI showed comparable relations with the BIS and Impulsivity. Interestingly, our findings showed that Goal-Drive Persistence was associated with IA, but not with HI. Given the shared variances across the IA and HI symptom groups, what this means is that Goal-Drive Persistence is most likely to be associated with the specific factors in the IA symptoms. Expressed differently, IA is associated uniquely with Goal-Drive Persistence.

On the whole, our findings are somewhat consistent with the interpretations made by Gomez et al. (2012). On the basis of findings involving Cloninger's temperament and character dimensions (Cloninger et al., 1993), Gomez et al. argued that IA is related to high BIS and FFFS and HI is related to high BAS. The findings for HI in our study concur with existing r-RST data showing that for the Heym et al.'s (2008) modified BIS/BAS scales, BAS-fun seeking (that is comparable to BAS-Impulsivity) has a unique association with HI. However, the findings for IA (and HI) differ from existing r-RST data showing that Heym et al.'s (2008) BIS scale had no association with IA (or HI; Gomez & Corr, 2010). The finding that IA had unique negatively association with BAS-Goal-Drive Persistence is new.

Given our findings for the BIS, and the theoretical and conceptual characteristics of the BIS, it follows that high IA and HI will be associated with resolving reward-punishment conflicts. In general, such conflicts will result in an approach response when it is perceived that the conflict experienced has relatively low punishment. In contrast, it will result in active avoidance or escape response when it is perceived that the conflict experienced has relatively high punishment (Corr & Cooper, 2016). However, properly to evaluate the relative potential for reward and punishment in a conflict, the individual needs to exert effortful executive processing (Corr & Cooper, 2016). Given that ADHD is associated with deficits in executive functioning (Barkley, 1997; Willcutt et al., 2005), it can be speculated that high levels of ADHD symptoms will reduce one's ability to deal with the conflicts effectively and appropriately in a timely manner. Given that ADHD is associated with heightened BAS-

Impulsivity sensitivity, it is conceivable that in real time this would result in the approach response dominating the avoidance response in view of heightened BAS-Impulsivity sensitivity.

Other findings and implications in the study worthy of note are as follows. First, across both samples, the CFA indicated non-salient loadings for FFFS items 19 ("I would be frozen to the spot by the sight of a snake or spider"), 46 ("I would leave the park if I saw a group of dogs running around barking at people") and 59 ("Looking down from a great height makes me freeze"); and GDP item 54 ("I think it is necessary to make plans in order to get what you want in life"). Also across both samples, the ESEM model indicated non-salient loadings for FFFS item 49 ("My behaviour is easily interrupted"); RR item 23 ("I often feel that I am on an emotional 'high'"); and I item 27 ("I sometimes cannot stop myself talking when I know I should keep my mouth closed"). Thus, it may be speculated that the relevance of these items for measuring the related r-RST constructs is questionable. It may be worth reviewing the relevance of these items in any future revision of the RST-PQ. Second, given that we found that ADHD (both IA and HI) was associated with heightened BAS-Impulsivity sensitivity, it means that ADHD is associated with deficits in processes that enable an individual to quickly and spontaneously change their behavior to get a reward. For example, because of poor inhibitory control process, a child with ADHD will experience difficulties in changing their on-going behaviors even when they suddenly notice that rewards will be available for alternative behaviors. Third, as IA, but not HI, was found to be negatively associated with BAS-Goal-Drive Persistence, and as this factor is associated with processes to move the individual towards the reinforcer, HI more than IA will be associated with bias for an approach response over an avoidance response when dealing with conflicts involving reward and punishment. For example, when both reward and punishment are present, children with ADHD with excessive levels of the hyperactivity/impulsivity symptoms, will be more inclined to engage in approach responses, whereas those with excessive levels of the inattention symptom will be more inclined to engage in avoidance responses. Fourth, viewed from the r-RST perspective, our findings indicate that treatment of ADHD needs to focus on improving executive functioning processes and poor inhibitory control processes related to resolving approach-avoidance conflict behaviours. Indeed, such treatment procedures have been applied in the past for treatment of ADHD with reasonable level of success (for a review, see Rutledge, van den Bos, McClure, & Schweitzer, 2012) . Fifth, it is worth noting that unlike the current study, previous studies have so far not used the RST-PQ which, as argued here, can be expected to provide a better and more meaningful understanding of the relationships of the r-RST constructs with ADHD. In this respect, because the RST-PQ was developed on a detailed theoretical analysis of the specific components processes of r-RST (see Corr, 2008; 2013) , it can be argued that the findings and interpretations made in the current study allowed for a more in-depth analyses of the r-RST personality variables and processes involved in ADHD. Sixth, as our findings showed that CFAs of the RST-PQ result in inflated factor correlations, it follows that there would be biased estimates of the correlations of these factors with other (external) variables when included in the CFA model (Marsh et al., 2014). This also means that the findings in past studies that have provided such data may be misleading. Related to this, as we examine the relationship of the RST-PQ factors in the ESEM model (that provides an unbiased estimate of the factor correlations in the RSR-PQ), the findings involving how the RST-PQ factors are related to IA and HI can be interpreted as providing reasonable support of the external validity of the RST-PQ factors.

The findings in this study can also be interpreted in terms of the Research Domain criteria (RDoC) framework that has been developed by the National Institute of Mental Health (Insel et al., 2010). RDoC has been offered as an alternate to the traditional diagnostic classification system (e.g., DSM-5). The aim of RDoC is to re-categorize psychiatric disorders in terms of measurable behavioral dimensions and underlying mechanisms (Insel et al., 2010). It has five domains, reflecting different aspects of emotional, cognitive, motivational and social behavior. Two of these domains are relevant to r-RST and RST-PQ. There are negative valence systems (responsible for responses to aversive situations, such as fear and anxiety; and positive valence systems (responsible for responses to positive motivational situations, such as responses to rewards, impulsive responses and consummatory behavior) (Musser & Raiker, 2019). Thus, the negative valence systems and the positive valence systems can be mapped on to the BIS/FFFS and the BAS, respectively. Given our findings for the relations between the r-RST constructs in the RST-PQ with IA and HI, it can be speculated that both IA and HI are related positively with negative valance (more specifically, anxiety and punishment insensitivity) and positive valence related to impulsivity (more specifically, processes that enable an individual to quickly and spontaneously change their behaviors to 'grab' a reward). Also, IA, but not HI, is associated negatively with positive valence related to goal-drive persistence (more specifically, high motivation and the maintenance of motivation to attain long-term goals). Expressed differently, our findings indicate that from a RDoC framework, IA and HI are related to difficulties in not being able to change one's behaviour when faced with changing reward conditions, with a tendency to respond more to immediate rewards than delayed rewards. Both IA and HI are also associated with more anxiety responses and and problems in resolving reward-punishment conflicts. Additionally, IA, but not HI, is associated with lower long term motivation for rewards. Thus although, from a RDoC framework, there is considerable overlap in the behavioral responses and underlying processes (poor response inhibition, dysfunctional responses to reward, problems in resolving reward-punishment conflicts, and high anxiety) for IA and HI, IA and HI can still be considered distinct as our finding suggest that while IA is associated with lower long term motivation for rewards, HI is not.

The findings and interpretation made in the current study need to be viewed with several limitations in mind. Firstly, as all measures involved self-ratings, it is possible that the findings were confounded by common method variance. Secondly, as this was a cross-sectional study, the findings show only associations and not causal relations. Thirdly, as many of the participants were university psychology undergraduates, especially in sample one, the results should be generalized to the broader population with caution. Fourthly, as the FFFS in the RST-PQ was unidimensional, it was not possible to clearly establish what FFFS component(s) (fight, fear of freeze) was/were associated with ADHD.

In summary, the findings in the current study provided important new information. First, as noted in the introduction, previous CFA studies of the RST-PQ have claimed support for the six-factor oblique model, although the fit values reported in these studies were not consistent with this view. In general, in these studies, the RMSEA value indicated good fit, whereas the CFI values have indicated poor fit. As this study examined the factor structure of the RST-PQ using the more advanced ESEM with targeted rotation, we were able to demonstrate more clear support for the six-factor oblique model, with both the CFI and RMSEA values indicating adequate or good fit. Indeed, our findings demonstrated support for the incremental validity of the ESEM factor model over the CFA factor model. Second, like previous studies that have examined the associations of RST constructs and ADHD in terms of o-RST, the current study, examined this association in terms of r-RST. As a consequence, we were able to report new findings, as reported above, that are more aligned with up-to-date models of RST. Consequent our findings have relevance for theories and treatment of ADHD. Overall, they indicated/confirm that ADHD is associated with reward-punishment conflicts, and difficulties in changing one’s behaviour when faced with changing reward conditions, and sustaining long-term motivation for rewards. Thus, despite these limitations, the findings in the current studies do provide a strong basis for future studies in this area, controlling for the limitations raised here. In this regard, we propose future research should consider modeling the RST-PQ in terms of the ESEM model with the six theorized factors. As demonstated in the current study, because of this, we have been able to provide new information that has theoretical and clinical implications for the RST-PQ, and the association between r-RST and ADHD.

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Table 1

Fit of the CFA and ESEM Oblique 6-Factor Models Tested in the Study

Models	χ^2 (*df*)	CFI	TLI	RMSEA (90% CI)	WRMR	ΔCFI	ΔRMSEA
				Sample 1			
CFA	5932.46 (2000)	.844	.828	0.059 (0.057 - 0.060)	2.082	-0.095	0.019
ESEM	3247.93 (1705)	.939	.925	0.040 (0.038 - 0.042)	.958		
				Sample 2			
CFA	4345.34 (2000)	.846	.840	0.062 (0.059 - 0.064)	1.829	-0.107	0.025
ESEM	2425.59 (1705)	.953	.942	0.037 (0.034 - 0.040)	.809		

Note. CI = confidence interval; χ^2 = chi-square; *df* = degrees of freedom; CFA = confirmatory factor analysis; ESEM = exploratory structural equation modelling; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker Lewis Index; WRMR = Weighted Root Mean Square Residual.

Table 2

Inter-Correlations of the Factors in the RST-PQ for the CFA and ESEM Models

	2	3	4	5	6
			Sample 1		
FFFS (1)	.56***(.34***)	.25** (.09**)	.00 (.00)	.17*** (.15***)	.05 (-.07*)
BIS (2)		-.28*** (-.24***)	-.22*** (-.14***)	.03 (.05)	.05 (.00)
RI (3)			.64*** (.22***)	.49*** (.28***)	.36*** (.12***)
GDP (4)				.39*** (.22***)	.05 (.03)
RR (5)					.55*** (.23***)
I (6)					-
			Sample 2		
FFFS (1)	,49*** (.34***)	-12* (.04)	-.10 (-.07)	.27*** (.18***)	.40*** (.00)
BIS (2)		-.27*** (-.19***)	-.23*** (-.18***)	.22*** (.18***)	.51*** (.10)
RI (3)			.65*** (.20***)	.14*** (.29***)	.21** (.03)
GDP (4)				.34*** (.22***)	-.12 (-.04)
RR (5)					.55*** (.13***)
I (6)					-

Note: FFFS = Fight–Flight–Freeze System; BIS = Behavioral Inhibition System; RI = Reward Interest; GDP =Goal-Drive Persistence; Reward Reactivity, I = Impulsivity.

In each cell values to the left are for the CFA model, and values in the right (in parenthesis) are for the ESEM model.

***$p < .001$; **$p < .01$; *$p < .05$.

Table 3

Standard Beta Values for the Predications of Inattention, and Hyperactivity/Impulsivity Symptom Groups by Age, Gender and the Constructs in the RST-PQ ESEM and CFA Models

	ESEM		CFA	
Variable	IA	HI	IA	HI
Age	-.32*	-.21*	-.33* (.13)	-.21* (.08)
Gender	-.05	.06	-.05 (.82)	.06 (.81)
FFFS	-.03	-.03	-.13 (.92)	-.08 (2.93)
BIS	.57*	.60*	.53*(.64)	.43* (.58)
BAS				
Reward Interest	.08	.13	.10 (.92)	.03 (.82)
Goal-Drive Persistence	-.20*	.07	-.19* (.72)	.13 (.69)
Reward Reactivity	.02	.03	-.05 (.93)	-.15 (3.54)
Impulsivity	.22*	.28*	.28* (.83)	.31*(.89)

Note: FFFS = Fight–Flight–Freeze System; BIS = Behavioral Inhibition System; BAS = Behavioral Approach System. For gender, male = 1, female = 2.

* are predictors with *p* values below the level set ($p < .0062$) for inferring statistical significance to control for Type 1 error.