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BIS and BAS Sensitivities at Different Levels of Personality Description: A Latent-Variable Approach with Self- and Informant-Ratings

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ABSTRACT

We examine the structural overlap of the Behavioral Inhibition System (BIS) and the Behavioral Approach System (BAS) with Stability and Plasticity, the two higher-order factors encompassing the Big Five. Carver and White's BIS/BAS and the Big Five Inventory were administered to a sample of 330 adults, serving both as targets and informants. Self- and other-ratings were modeled by using the Correlated Trait-Correlated Method model. BIS and BAS correlated highly with metatraits, after method variance and measurement error were partialled out: BIS was positively related to Stability, while BAS was positively related to Plasticity and negatively related to Stability. After the higher-order factors were controlled, the BIS was highly and positively related to Emotional stability, whereas the BAS had a small but significant relationship with Extraversion. Findings are discussed with regard to the most appropriate level of generality/specificity at which the personality correlates of BIS and BAS can be investigated.

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Introduction

The Behavioral Inhibition System (BIS) and the Behavioral Approach System (BAS) represent two broad neuropsychological systems that underlie behavioral and emotional reactions to classes of attractor and repulsor stimuli (Corr, 2008; Corr & McNaughton, 2008). Individual differences in functioning and sensitivities of these systems have been thoroughly described within the general framework of the Reinforcement Sensitivity Theory (RST), one of the most established neuropsychological models of personality (Gray, 1972).

According to recent revisions of the RST (Corr & McNaughton, 2012; McNaughton & Corr, 2004), the BIS is activated by conflicting stimuli, which elicit an approach response but contain potential threats (Gray & McNaughton, 2000). It is responsible for passive avoidance, namely cautious approach to a dangerous or unpleasant situation (Corr, 2013). Its activity is accompanied by feelings of anxiety, which entail increased vigilance toward danger (defensive approach).

The BAS, by contrast, is thought to be activated by cues for reward, non-punishment or escape from punishment, and it elicits approach behavior. Different components of BAS can be identified: *Drive*, *Fun-Seeking*, and *Reward Responsiveness* (Carver & White, 1994). *Drive* concerns the persistence in the pursuit of desired goals; *Fun-Seeking* refers to the desire for new rewards and the willingness to approach them on the spur of the moment; *Reward Responsiveness* reflects a positive response to the occurrence of reward.[1]

Research has shown that sensitivity to these neuropsychological systems accounts for some portion of the individual differences seen in personality (Corr et al., 2013). Among the Big Five factors (McCrae & Costa, 1999), Extraversion and Neuroticism (the opposite of Emotional stability) are the two traits mostly related to BIS and BAS systems: Extraversion is the primary manifestation of BAS sensitivity, whereas Neuroticism bests reflect the sensitivity to BIS (Depue & Collins, 1999; DeYoung, 2010; for a recent review, see Corr, 2016). Although relevant motivational components can be identified also for the other Big Five traits (i.e., agreeableness, conscientiousness, and openness to experience), their correlations with BIS and BAS are less well characterized (Corr et al., 2013).

Understanding how BIS and BAS relate to the Big Five may provide interesting insights regarding their nature. The Big Five Model is one of the most comprehensive and widely-researched taxonomies of personality traits (John & Naumann, 2010). The mapping of basic motivational systems into this framework may, therefore, help characterize the individual's sensitivity to BIS and BAS in terms of relatively consistent patterns of behavior. However, one may ask whether the Big Five represents the most appropriate level

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[1]A third system has been identified in the Fight-Flight-Freeze System (FFFS), which is activated by frustrating, punishing, and threatening stimuli that require immediate action. The FFFS is responsible for simple active avoidance (e.g., escape), and is accompanied by fear and panic (defensive avoidance) (Corr, 2013; Gray & McNaughton, 2000). A preliminary version of the manuscript included the FFFS, as measured by three items of Carver and White's (1994) BIS/BAS Scales (see, for example, Poythress et al., 2008). However, due to the poor psychometric properties of the FFFS measure, and considering its marginal importance for the research questions, we decided to focus the study on BIS and BAS.

of analysis. In this study, we suggest to consider Stability and Plasticity, the two higher-order traits encompassing the Big Five, as an alternative framework for investigating the personality correlates of RST constructs. We also propose an empirical approach to the assessment of Stability and Plasticity and their relationships with external variables, which makes use of multiple informant data.

Higher-order factors of the Big Five: Current status and methodological caveats

Although the Big Five factors of personality have originally been conceived as relatively independent dimensions (Goldberg, 1993), empirical findings have revealed a consistent pattern of correlations among them. This might suggest the existence of broader factors, or metatraits, which occupy superordinate positions in the hierarchical structure of personality.

The first attempt to explain the correlations among the Big Five in terms of higher order constructs was provided by Digman (1997). Using factor-analytic procedures, the author identified two higher-order traits, labeled as *Alpha* and *Beta*. Alpha reflects the shared variance of emotional stability, agreeableness, and conscientiousness. Beta reflects the shared variance of extraversion and openness. Digman (1997) interpreted these broad personality factors as the product of socialization and personal growth, respectively.

Since the seminal work by Digman (1997), the higher-order factors of the Big Five (also known as the Big Two), have been the subject of considerable research attention. Several scholars have provided different interpretations for them (Becker, 1999; Blackburn et al., 2004; Carroll, 2002; DeYoung et al., 2002). One of the most influential views has been provided by DeYoung and colleagues, who refer to Alpha and Beta as *Stability* and *Plasticity*, respectively. Stability is assumed to reflect a general tendency to maintain behavioral and motivational stability, by restraining from disruptive impulses. Plasticity is assumed to reflect a general tendency toward cognitive and behavioral exploration (DeYoung, 2006; DeYoung et al., 2002).

A number of studies has shown the robustness and generalizability of the higher-order factors across several languages and Big Five personality measures (e.g., DeYoung, 2006; Jang et al., 2006; Şimşek et al., 2012). Moreover, empirical research has provided support for the criterion validity of metatraits with respect to relevant outcomes (e.g., Alessandri & Vecchione, 2012; Dermody et al., 2016; DeYoung et al., 2008; Hirsh et al., 2009; Liu & Campbell, 2017; Şimşek, 2014; Vecchione et al., 2011; Wilmot et al., 2016).

The debate on the nature of the two higher-order factors, however, is far from being settled. Some authors have questioned the existence of these factors, which have been viewed as reflecting measurement artifacts. For example, Ashton et al. (2009) argued that the correlations among Big Five ratings is due to the presence of indicators that represent same-signed blends of two or more factors. Others have suggested that the correlations among the Big Five can be inflated by a number of response distortions that stem from the use of a single rater, such as socially desirable responding, common method variance, and halo effect (e.g., Chang et al., 2012). This may confound method with substantive variance, introducing systematic sources of bias in the assessment of metatraits. The issue of method variance is, indeed, particularly germane to the assessment of constructs located at superordinate levels, which reflect, by definition, the variance shared by two or more lower-order dimensions – the Five Factors of personality in this case.

Studies that combined multiple sources of information with the aim to unravel the nature of higher-order factors have shown that these factors reflect both substantive personality characteristics and artifactual variance due to evaluative biases (e.g., Anusic et al., 2009; DeYoung, 2006; McCrae et al., 2008; Şimşek, 2014; Şimşek et al., 2012; Vecchione & Alessandri, 2013; but see Biesanz & West, 2004). These results underline the need to control for response biases in the assessment of Stability and Plasticity, collecting data from multiple informants.

We may also want to consider that the Big Two may not represent the highest level of the personality structure. As several authors have argued (e.g., Rushton et al., 2009), the correlation between Stability and Plasticity can be explained by a General Factor of Personality (GFP), which lies at the top of the hierarchy (for arguments for and against GFP, see Rushton et al., 2008, and Hopwood et al., 2011).

Plasticity and stability and BIS/BAS systems: Theoretical and empirical relations

The level of generality/specificity at which Stability and Plasticity have been conceptualized seems particularly appropriate for studying the personality correlates of BIS and BAS, which represents similarly broad dispositions. Whereas Stability and Plasticity can be thought of as general patterns of behavior and experience (DeYoung, 2006), BIS and BAS represent two fundamental motivational systems for behavioral regulation (Carver & White, 1994). Accordingly, correlations with BIS/BAS might be more pronounced for the metatraits than for the Big Five.

Parallelisms and differences between Gray's BIS/BAS dimensions and the two higher-order factors of personality have already been pointed out. With respect to the BAS, for example, Hirsh et al. (2009) argued that it is "reasonably similar to the process of activation that appears to characterize Plasticity" (p. 1096). With respect to the BIS, DeYoung (2013, p. 48) wrote that stability "appears to depend primarily on inhibition, but this is *not* identical to the sort of inhibition usually associated with the BIS and passive avoidance […]. Rather, it resembles what has been called non-affective constraint (Depue & Lenzenweger, 2005), namely the inhibition of emotional and motivational impulses that would disrupt goal-pursuit, regardless of whether those impulses are threat- or reward-related (cf. Carver et al., 2008)".

Interestingly, the neurobiological foundations attributed to Stability/Plasticity and BIS/BAS have striking similarities. At a neurophysiological level, the BAS involves the dopaminergic neurotransmitter system (Depue & Collins, 1999), while the

BIS has been related to the serotonergic network (Gray & McNaughton, 2000). Similarly, DeYoung (2006, 2013) related stable individual differences in Stability and Plasticity to individual variation in the functioning of serotonergic and dopaminergic systems, respectively (see also DeYoung et al., 2002; DeYoung & Gray, 2009; Hirsh et al., 2009). As reviewed by DeYoung and colleagues (DeYoung, 2006; DeYoung et al., 2008), the dopaminergic activity is expected to modulate approach behavior, reward sensitivity, breadth of thinking, and cognitive flexibility, which are trait manifestations of Plasticity. On the other hand, serotonin is a neuromodulator that regulates the restraint of behavior and impulse control, which are trait manifestations of Stability.

Although BIS/BAS and the two metatraits have clear theoretical and neurobiological connections, there is a paucity of empirical studies designed to address their relationship. Most of previous attempts to link basic personality traits to dispositional sensitivities in the BIS and BAS have been conducted at the level of the Big Five (Corr et al., 2013). To the best of our knowledge, only one study has investigated the relationships between the BIS/BAS system and the two superordinate personality factors (Slobodskaya, 2011). This study examined the links between self-reported BIS and BAS and parent's ratings of personality traits in a sample of Russian adolescents. BIS and BAS were measured using a short form of the Gray-Wilson Personality Questionnaire (Slobodskaya et al., 2003). The metatraits were measured with the Inventory of Child Individual Differences (Halverson et al., 2003). Results, expressed as standardized beta coefficients, showed that BAS was negatively related to Stability (Alpha), $\beta = -.23$, and BIS was negatively related to Plasticity (Beta), albeit weakly, $\beta = -.11$. The other path coefficients (i.e., from BIS to Stability and from BAS to Plasticity) were not statistically significant.

The present research

The current study aims to examine relations of BIS and BAS with Stability and Plasticity in a large sample of Italian adults. To explore these relations, we specified a hierarchical model of personality, where Stability and Plasticity were posited as superordinate factors encompassing the Big Five. To control for potential sources of artifactual variance, we relied on multiple-informant data. Several approaches within the framework of structural equation modeling have been proposed for the analysis of Multitrait-Multimethod (MTMM) data (Eid et al., 2006, 2008; Marsh & Grayson, 1995; Pohl & Steyer, 2010; Widaman, 1985), among which the Correlated-Trait Correlated Method (CT-CM) model, the Correlated Trait-Correlated Method minus one [(CT-C(M–1)] model, and the Correlated Trait-Correlated Uniqueness (CT-CU) model. These models can be used to disentangle trait, method, and error variance, providing more reliable estimates of Stability and Plasticity, and of their relationship with other constructs. Within this approach, correlations among the Big Five are based on the variance common to different informants and are, therefore, relatively unaffected by methodological artifacts due to the use of a single rater.

Research hypotheses

As a preliminary analysis, we examined the relations of BIS and BAS with personality traits at the Five-Factor level. In accordance with literature (e.g., Carver & White, 1994; Keiser & Ross, 2011; Segarra et al., 2014), we expected the BAS to be positively related to extraversion, which appears to reflect sensitivity to reward (Depue & Collins, 1999; DeYoung, 2010; Gray, 1981; Mitchell et al., 2007); and we expected the BIS, which controls the experience of anxiety in response to conflict and uncertainty (McNaughton & Corr, 2004), to be negatively related to emotional stability. Moreover, although to a lesser extent, we expected that BIS would be positively related to agreeableness, and that BAS would be positively related to openness and negatively related to agreeableness. This would fit with previous research findings (e.g., Keiser & Ross, 2011; Smits & Boeck, 2006).

We then examined relations of BIS and BAS with the two higher-order factors of personality. Drawing upon DeYoung et al.'s conceptualization of metatraits (e.g., DeYoung, 2006, 2015; Hirsh et al., 2009), we expected BIS and BAS to exhibit differentiated relations with Plasticity and Stability. The BAS regulates explorative behavior and is referred to as the reward system. Its activation would be positively related to Plasticity, whose primary manifestations are exploration and incentive-related behaviors (DeYoung, 2006). A highly active BAS may also result in impulsive behavior and inability to delay gratification (Gray, 1991). Therefore, the BAS would be negatively related to Stability, which concerns inhibition or restraint from behaviors.

The BIS is expected to be positively related with Stability. Both constructs involve inhibition of behavior, although the implied mechanisms are different. The inhibition that characterize Stability is aimed to maintain goal-relevant pursuit (DeYoung, 2015). The BIS serves the primary function of detecting and resolving conflicts, such as when the pursuit of a rewarding goal involves a potential danger. It operates by suspending ongoing or prepotent actions until the conflicts is resolved, which may also result in goal abandonment (McNaughton & Corr, 2004). Finally, the BIS would be negatively related to Plasticity, since passive avoidance can imply the inhibition of approach behavior (DeYoung, 2015).

We also examined whether extraversion and emotional stability maintain their relationships with BIS and BAS once metatraits were controlled for. The Big Five contain both shared and unique construct variance. Being higher-order constructs, Stability and Plasticity reflect only the variance shared by the Big Five, which do not overlap with the unique component of each trait. Considering the consistent associations found in earlier research for emotional stability and extraversion (e.g., Corr et al., 2013; Keiser & Ross, 2011), we tested for the presence of significant direct effects of BIS and BAS on the unique part of these traits. This approach allows the examination of whether BIS and BAS relate primarily to the Big Five or metatraits (a similar approach was described by Hirsh et al., 2009).

In accordance with the RST (Gray & McNaughton, 2000; McNaughton & Gray, 2002), one could expect that individual differences in personality dispositions are modeled by

underlying neuropsychological systems (Corr et al., 2013). However, our research design did not allow to infer causality. Thus, the associations among the examined constructs were investigated without making strong assumptions regarding the direction of the effect.

In examining the association with the metatraits, the BAS system was conceptualized at different levels of specificity: as a single dimension, reflecting the overall construct, and as a multifaceted construct, including its distinctive aspects, namely *Drive*, *Fun-Seeking*, and *Reward Responsiveness*. Carver and White (1994) have indeed shown that scores on these scales reflect distinct constructs. At the time this was an empirical finding not underpinned by theory. However, since that time reasons have been given as to why the BAS should be considered multidimensional. As discussed by Corr and McNaughton (2008), the main function of the BAS is to move the organism along a spatio-temporal gradient toward a final biological reinforcer. In order to reach this goal, there are a number of distinct but related BAS processes: "reward interest" and "goal-drive persistence" (BAS Drive) characterize the early stages of approach and these factors can be distinguished from "reward reactivity" (BAS Reward Responsivity) and "impulsivity" (BAS Fun Seeking), which are concerned with processes closer to the final reinforcer (Corr & Cooper, 2016). Activation of the BAS is said to lead to the experience of hopeful excitement, drive persistence to reach desired goals, and elation when they have been attained (Corr et al., 2013).[2] We examined how these different process within the reward system are related to the metatraits.

Methods

Participants and procedures

The sample was composed of 330 individuals (165 dyads, 60% females), ranging in age from 18 to 67 years ($M = 32.04$, $SD = 11.87$). Years of formal education ranged from 5 to 23, with a mean of 15.15 ($SD = 3.10$). Each participant in the study served both as a target and an observer. One member of each dyad was recruited among the adult general population by two master students from Sapienza University of Rome. She/he was required to identify a second person who was willing to take part in the study (the other member of the dyad). These were described as friends (31.6%), partners (41.8%), or acquaintances (26.6%). Each participant was asked to indicate how well they knew the other dyad member on a five-point Likert scale (from 1= 'not so well', to 5= 'very well'), and for how long. Mean familiarity ratings was 4.37 (SD = .82). Mean length of acquaintance was 14.53 years ($SD = 13.10$). This suggested that, on average, participants reported being well-acquainted with the person they rated.

All respondents were administered the Big Five Inventory, a scale designed to assess the Big Five personality traits (John et al., 1991), and the Behavioral Inhibition and Activation (BIS/BAS) Scales (Carver & White, 1994). The order of administration was counterbalanced for self- and informant-ratings. The two members of the dyad were separated from each other and completed the questionnaire in different rooms. They were told that data were being collected for research purposes, and that the informant-ratings would be completely confidential. Moreover, they were informed about the general aim of the research and consented to take part in the study. Participation was voluntary and no payment was made. Anonymity in reporting the data was guaranteed.

Measures

Personality traits

To assess the Big Five personality traits, we used the Big Five Inventory (BFI, John et al., 2008; see Ubbiali et al., 2013, for the Italian adaptation of the instrument). The instrument consists of 44 items, each describing a characteristic of the target (the self or the other person). Examples of items for the five domains included: "*has an assertive personality*" (extraversion), "*Likes to cooperate with others*" (agreeableness), "*is a reliable worker*" (conscientiousness), "*is relaxed, handles stress well*" (emotional stability), and "*is original, comes up with new ideas*" (openness). Respondents were asked to indicate the extent to which they agreed with the statement on a 5-point Likert scale, from "strongly disagree" to "strongly agree. In the present study, Cronbach's reliability coefficients for self- and other-ratings were: .79 and .81 for extraversion; .66 and .77 for agreeableness; .79 and .80 for conscientiousness; .79 and .81 for emotional stability; and .79 and .83 for openness to experience. Measures of stability and plasticity were derived from a hierarchical measurement model described in the results section.

BIS and BAS

To assess RST constructs, we used the BIS/BAS Scales (Carver & White, 1994). This is a 20-item scale for the assessment of behavioral inhibition (BIS) and behavioral activation (BAS) sensitivities. We used the Italian adaptation of the instrument (Leone et al., 2002). Thirteen items were designed to assess BAS, which comprises three subscales: Drive (DR − 4 items), Fun-Seeking (FS − 4 items), and Reward Responsiveness (RR − 5 items). Seven items were originally designed to assess BIS. As earlier studies (Heym et al., 2008; Poythress et al., 2008) have shown, however, BIS items have been constructed in accordance with the original RST (Gray, 1982). Only four of these items conceptually fit with the revised version of the RST, which conceive the BIS as a system responsible for the resolution of goal conflict (Gray & McNaughton, 2000). Therefore, BIS was assessed in the present study with four items, in line with the revised RST. Examples of items for the self-report version of the scale include: "*I go out of my way to get things I want*" (DR), "*I crave excitement and new experiences*" (FS), "*When good things happen to me, it affects me strongly*"

[2]The theoretical and empirical bases for a multidimensional BAS are detailed by Corr (2016).

(RR), and "*I feel worried when I think I have done poorly on something*" (BIS).

The informant version was created by rephrasing the pronouns and verbs from the first to the third person. All items are on a 4-point Likert scale, ranging from "strongly disagree" to "strongly agree". Cronbach's reliability coefficients for self- and other-ratings were: .81 and .79 for BIS; .79 and .81 for DR; .76 and .76 for FS; and .78 and .81 for RR.

Statistical analysis

As a first step, we examined the hierarchical structure of the Big Five. To this aim, we applied a CT-CM model to self- and other-ratings of the five BFI domains, by considering each rater as a different method (Lance et al., 2002; Widaman, 1985). The model included ten first-order factors, which correspond to self- and other-ratings of the Big Five. Within each rater, first-order traits loaded on two observed indicators, formed by randomly splitting BFI scales into two test halves. Five second-order Big Five factors were posited, each loading on self- and other-ratings of the same trait. Finally, two third-order trait factors, corresponding to Stability and Plasticity, were added. Stability loaded on Agreeableness, Conscientiousness, and Emotional stability. Plasticity loaded on Extraversion and Openness. All the trait factor loadings were fixed to 1. This helps to prevent identification problems that might derive from the use of two indicators per factors, as well as to increase the ratio between estimated parameters and number of cases.

Method effects were represented by a method factor for each rater. The uniqueness of self- and other-ratings of the same test half were allowed to correlate. This allow us to take into account trait-specific method effects. Finally, the two higher-order trait factors were allowed to correlate, as well as the two method factors. The posited model is represented in Figure 1.

As a next step, RST constructs were added: BIS and BAS were modeled as correlated latent trait-factors, by using the same approach as for the Big Five (i.e., the CT-CM model) - they were allowed to correlate with Stability and Plasticity. Consistent with our research questions, this model also included a direct effect from BIS to the residual term of emotional stability, and from BAS to the residual term of extraversion. This permitted us to examine whether BIS and BAS account for additional variance at the level of the Big Five, above and beyond the metatraits. This model is represented in Figure 2. Finally, we examined associations of Stability and Plasticity with different aspects of incentive sensitivity. We tested three further CT-CM models, one for each BAS subscale. As an illustrative example, the model for the Drive scale is represented in Figure 3.

Analyses were performed with *Mplus* version 6.1 (Muthén & Muthén, 2010). Given the dyadic structure of the data (i.e., individuals are nested within dyads), parameters were estimated via the 'type is complex' procedure, using the dyad membership as clustering variable. This provided adjusted chi-square test statistics and standard errors of model parameters that accounted for nesting (Muthén & Muthén, 2010; Stapleton, 2006). Model fit was assessed with the chi-square test, the Comparative Fit Index (CFI, Bentler, 1990), the Root Mean Square Error of Approximation (RMSEA, Steiger & Lind, 1990), with associated confidence intervals, and the Standardized Root Mean Square Residuals (SRMR, Jöreskog & Sorbom, 1993). We regarded CFI values greater than .90 (Bentler, 1990), RMSEA values lower than .08 (Browne & Cudek, 1993), and SRMR values lower than .06 (Hu & Bentler, 1998) as indicative of adequate model fit. The magnitude of associations among constructs of interest was interpreted according to standard recommendations (Cohen, 1988).

Results

Descriptive statistics

Preliminary analyses examined the distributional properties of the personality variables. Their univariate distributions did not substantially deviate from normality, with skewness and kurtosis < 1 in absolute value (Tabachnick & Fidell, 2013). The complete correlation matrix for self- and other-ratings of observed indicators used in the CT-CM models is reported in the online Supplementary Materials, Appendix A.

Relations of BIS, and BAS with personality traits at the Five-Factor level

Table 1 presents the within-informant correlations and the self-other agreement of the study variables. Moderate relations were found among self-ratings of the Big Five, with higher correlations between traits representing the same higher-order dimension (e.g., Extraversion and Openness). A similar pattern was found for self- and other-ratings.

BIS and BAS were correlated in meaningful ways with the Big Five. BIS sensitivity was negatively related to emotional stability, positively related to agreeableness, and negatively related to extraversion, although more weakly. Individual differences in BAS sensitivity were positively related to extraversion and openness, and negatively related to agreeableness. Analysis of BAS subscales showed that Reward Responsiveness, Drive, and Fun-Seeking were all positively related to extraversion and openness. Some differences emerged with respect to their relations with the other traits. Drive and Fun- Seeking, but not Reward Responsiveness, showed a negative relation with agreeableness. Fun-Seeking correlated negatively with conscientiousness. Reward Responsiveness showed a weak positive correlation with conscientiousness, but only for other-ratings. Overall, the observed correlations were weak to moderate (Cohen, 1988). They are consistent with results of earlier studies (e.g., Keiser & Ross, 2011; Segarra et al., 2014).

Replicating earlier findings (e.g., Keiser & Ross, 2011), BIS showed a near zero correlation with the BAS, for both self- and other-ratings. Substantial self-other agreement was observed for the Big Five, in accordance with earlier findings (e.g., John & Robins, 1993; McCrae & Costa, 1987; Paulhus & Reynolds, 1995). Correlations between self-ratings and

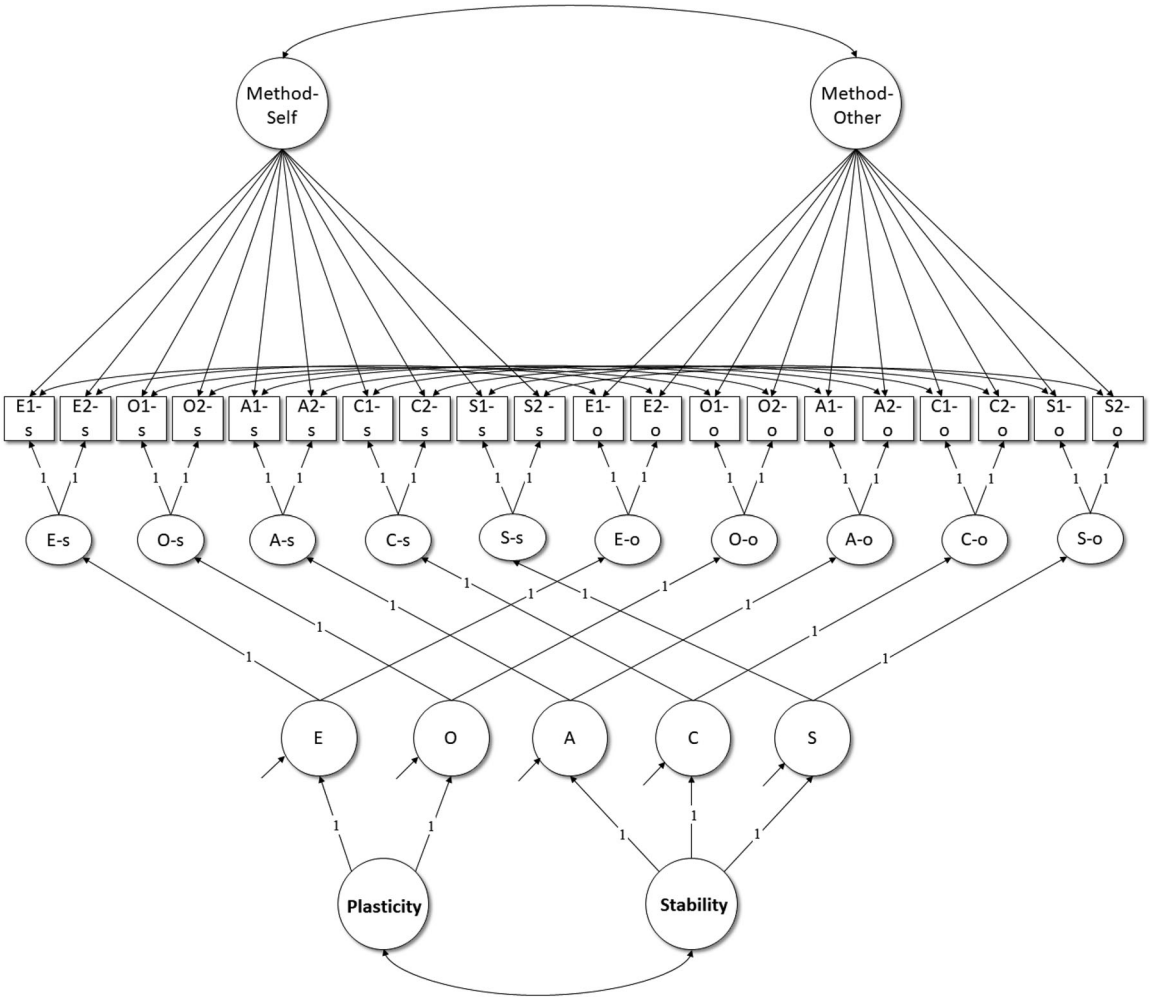

Figure 1. A Correlated Trait-Correlated Method (CT-CM) model of the Big Five and higher-order traits of plasticity and stability. E = Extraversion; A = Agreeableness; C = Conscientiousness; S = Emotional stability; O = Openness; s = Self-report; o = Other report.

informant ratings ranged between .48 (Agreeableness) and .61 (Extraversion). Lower agreement correlations were found for BIS (.39) and BAS (.43). For the three BAS-related subscales, cross-raters correlations ranged between .36 (Reward Responsiveness) and .44 (Fun-Seeking). The lower agreement found for BIS and BAS might reflect a kind of visibility effect, according to which less observable traits are characterized by lower agreement (e.g., John & Robins, 1993). This might be especially true for sensitivity to BIS, whose manifestations could be less easily observable, being related to behavioral inhibition and avoidance motivation.

Assessing the hierarchical structure of the Big Five

The CT-CM model with self- and other-ratings of the five BFI domains provided an adequate fit to the data, $\chi^2(142) = 303.58$, $p < .001$, CFI = .939, RMSEA = .059 (.050, .068), SRMR = .063. All observed indicators loaded significantly ($p < .001$) on their respective first-order factors. Standardized loadings ranged from .58 (Extraversion) to .77 (Conscientiousness) for self-ratings ($M = .70$, $SD = .06$), and from .56 (Extraversion) to .81 (Agreeableness) for other-ratings ($M = .69$, $SD = .08$). At the second-order level, self- and other-ratings of the same trait loaded significantly ($p < .001$) on the latent Big Five factors. Standardized loadings were all $\geq .70$. At the third-order level, the Big Five factors had significant loadings ($p < .001$) on Stability and Plasticity, ranging from .47 (Extraversion) to .64 (Agreeableness). The correlation between Stability and Plasticity was not significantly different from zero ($r = -.05$, $p = .91$), as in other multi-informant studies (see DeYoung, 2015). The two method factors were moderately correlated ($r = .36$, $p < .01$). This may reflect a shared evaluative bias or some kind of common evaluative schemas shared by the individual and her/his evaluator (Funder & West, 1993; Sneed et al., 1998).

In sum, this model supports the hypothesized two-dimensional structure of the Big Five. Most importantly, it represents a preliminary step needed for modeling the construct variance of Stability and Plasticity. It allowed us to examine how metatraits of personality relate to BIS and BAS, after method variance and measurement error were partialled-out.

Relationship of BIS and BAS with metatraits of personality

To examine relations of metatraits with RST constructs, the CT-CM model was extended to include BIS and BAS. The

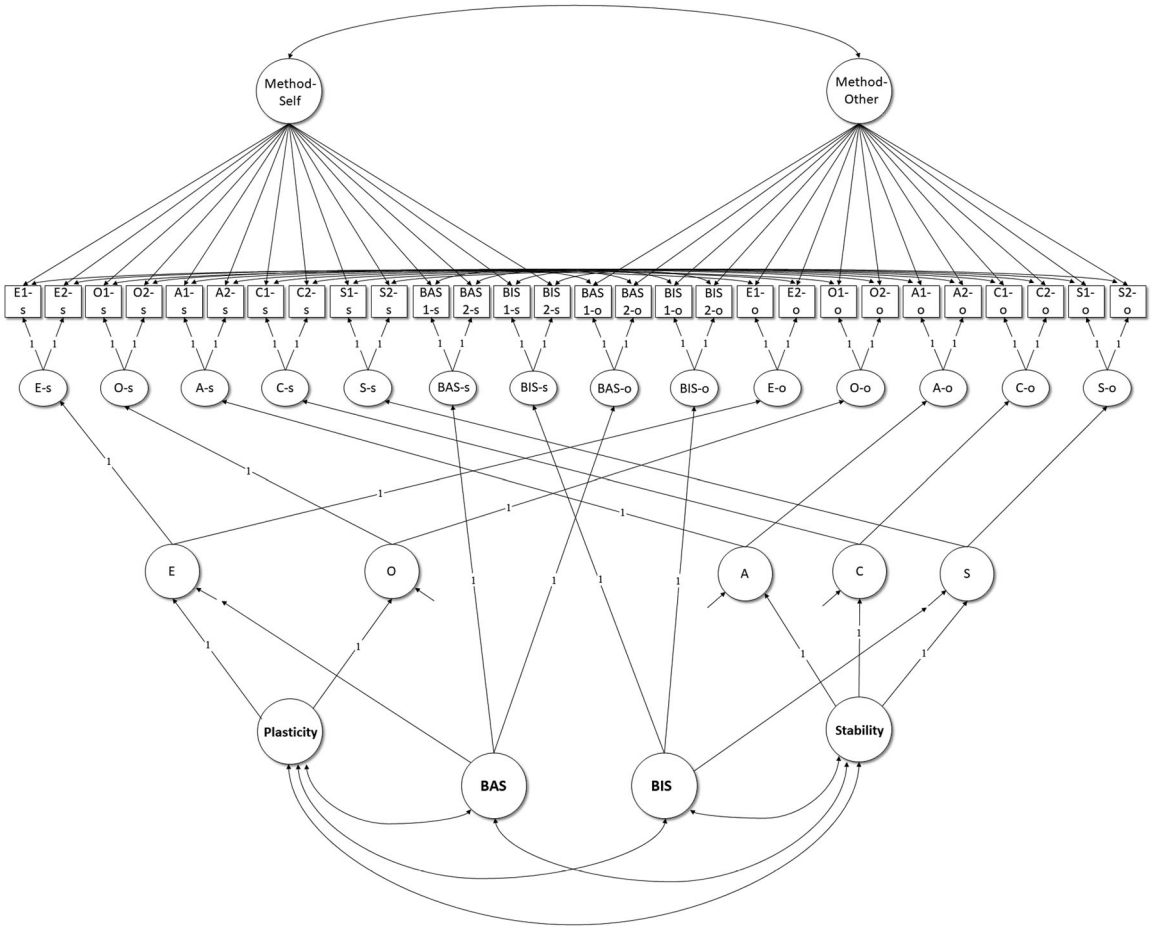

Figure 2. Relationship of personality traits with BIS and BAS. E = Extraversion; A = Agreeableness; C = Conscientiousness; S = Emotional stability; O = Openness; s = Self-report; o = Other report.

model yielded marginal to acceptable fit: $\chi^2(304) = 758.85$, $p < .001$, CFI=.890, RMSEA=.068 (.062, .074), SRMR =.078. The RMSEA and the SRMR were in the adequate range, whereas the CFI was slightly below the minimum requirement of .90. Although this is not ideal, the model appears to provide a reasonable fit to the data, considering the relatively high number of variables. Some studies, in this regard, have shown that, even in correctly specified models, the CFI tend to decrease as the number of variables increase es (e.g., Shi et al., 2019). As suggested by Kenny and McCoach (2003), when the CFI is "slightly lower than hoped, but the RMSEA seems a bit better, then there may be no real cause for concern" (p. 349).

As expected, BIS was positively related to Stability. The correlation was .57 ($p < .001$), indicating a large effect size (Cohen, 1988). BIS and Plasticity, by contrast, were unrelated ($r = .00$, $p = .98$). Moreover, BIS exhibited a negative, large and significant relation with the residual term of emotional stability ($\beta = -.71$, $p < .001$).

BAS exhibited large correlations of opposite sign with the two metatraits. It was positively related to Plasticity ($r = .49$, $p < .05$) and negatively related to Stability ($r = -.69$, $p < .05$). The association of BAS with the residual term of extraversion was also significant ($\beta = .20$, $p < .05$), although it was smaller than those with the higher-order traits. The correlation between BIS and BAS was close to zero ($r = -.08$, $p = .45$). A moderate positive relation ($r = .35$, $p < .001$) was found between the two method factors. A more detailed summary of results is reported in the online Supplementary Materials, Appendix B.

Relationship of BAS components with metatraits of personality

Supplementary analyses have been performed with the three BAS subscales. Results showed acceptable fit for all tested models: Drive, $\chi^2(217) = 463.04$, $p<.001$, CFI=.925, RMSEA=.059 (.052, .066), SRMR =.073; Fun-Seeking, $\chi^2(217) = 560.62$, $p<.001$, CFI=.900, RMSEA=.070 (.063, .077), SRMR =.079; Reward Responsiveness, $\chi^2(217) = 500.41$, $p<.001$, CFI=.911, RMSEA=.063 (.056, .071), SRMR =.064. Looking at the correlations between latent trait-factors, it has been found that Stability was highly and negatively related with Drive ($r = -.75$, $p<.001$) and Fun-Seeking ($r = -.67$, $p<.01$), but not with Reward Responsiveness ($r = -.15$, $p = .35$). Plasticity was positively related to Reward Responsiveness ($r = .55$, $p < .01$) and Fun-Seeking ($r = .44$, $p < .01$), but not with Drive ($r = .00$, $p=.99$). The residual term of extraversion was not significantly related to the BAS subscales in all tested models (β's ranged from .16 to .17).

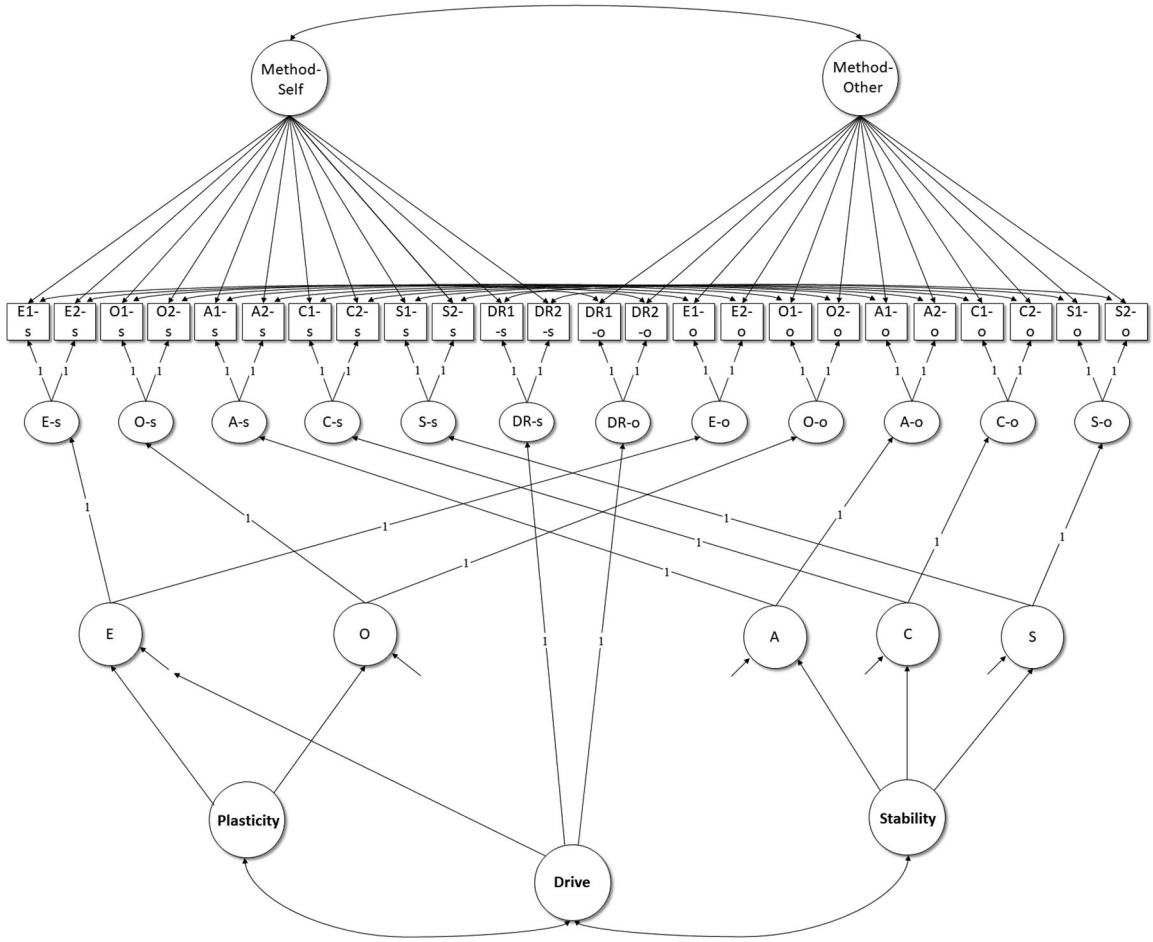

Figure 3. Relationship of personality traits with the three BAS subscales (Drive in this example). E = Extraversion; A = Agreeableness; C = Conscientiousness; S = Emotional stability; O = Openness; DR = BAS Drive; s = Self-report; o = Other report.

Table 1. Within-informant correlations and self-other agreement of the Big Five personality traits and the BIS/BAS scales.

	1	2	3	4	5	6	7	8	9	10
1. Extraversion	*.61***	.13*	.16**	.26**	.36**	−.19**	.36**	.32**	.24**	.31**
2. Agreeableness	.05	*.48***	.30**	.34**	.26**	.29**	−.16**	.03	−.27**	−.17**
3. Conscientiousness	.19**	.23**	*.58***	.28**	.31**	.01	−.04	.11*	.04	−.24**
4. Emotional stability	.14*	.23**	.25**	*.55***	.17**	−.31**	−.05	−.02	−.06	−.05
5. Openness	.33**	.06	.05	.09	*.50***	−.01	.21**	.24**	.10	.17**
6. BIS	−.11*	.31**	−.01	−.35**	−.09	*.39***	.02	.17**	−.11*	−.04
7. BAS	.33**	−.22**	−.03	−.08	.25**	.00	*.43***	.79**	.81**	.84**
8. BAS-Reward	.23**	−.03	.08	−.08	.15**	.13*	.78**	*.36***	.45**	.48**
9. BAS-Drive	.28**	−.28**	.09	.01	.18**	−.10	.84**	.49**	*.38***	*.55***
10. BAS-Fun	.28**	−.21**	−.25**	−.13*	.27**	−.03	.81**	.43**	.54**	*.44***

*$p<.05$;
**$p<.01$.
Note. Correlations below the diagonal refer to self-ratings. Correlations above the diagonal refer to other-ratings. Self-other agreement correlations appear on the diagonal.

Discussion

Gray's biopsychological theory and the Big Five traits originate from different research traditions and address different aspects of the individual's functioning. The biopsychological theory has a strong biological basis: BIS and BAS are conceived as biologically rooted individual differences in behavioral regulation - they derive from a neurobiological approach originally applied to studies with nonhuman animals (Gray, 1972). The Big Five traits of personality represent a descriptive framework for organizing major individual differences in human personality. The five factors have been identified by reducing large numbers of person descriptors (adjectives or terms) to few basic personality dimensions through the use of factor-analytic procedures. This approach draws on the lexical hypothesis, according to which most salient and socially relevant individual differences are encoded into the human language (Allport & Odbert, 1936; Cattell, 1946).

Previous studies identified empirical links of BIS/BAS with the five factors of personality (e.g., Keiser & Ross, 2011; Smits & Boeck, 2006). These studies mostly reveal a

negative relation of BIS with emotional stability, and a positive relation of BAS with extraversion. The other correlations were lower and scattered over different traits. A similar pattern was replicated in the present study, which extends the analysis to a higher level of trait description, represented by Stability and Plasticity. The two metatraits are conceived as general tendencies, located at a higher level of the trait hierarchy, which "are likely to reflect biological systems with very broad impact on both brain function and personality" (DeYoung, 2010, p. 1070).

As previously discussed, Stability and Plasticity seem to provide an appropriate conceptual framework from which to understand the personality underpinnings of BIS ad BAS. In this regard, the current research offers a novel approach to assess the relations of metatraits with other variables. This approach requires multiple (at least two) informants and has methodological benefits over classical approaches relying on self-report data.

First, it allows to mitigate the effect of measurement artifacts in the assessment of higher-order-traits, using appropriate modeling strategies for the analysis of MTMM data, such as CT-CM model. These modeling strategies do not allow to obtain pure measures of the higher-order factors. Estimates of stability and plasticity, indeed, cannot be regarded as completely free from measurement artifacts. Nevertheless, they are likely to obtain more valid estimates than scores derived from a single rater.

Second, it permits to examine the association of lower-order traits (i.e., the Big Five) with external variables, after the effect of higher-order traits (i.e., plasticity and stability) is controlled for. In other words, it permits to assess whether higher-order factors exhibit incremental validity with respect to lower-order factors (and vice versa), while taking into account measurement error.

Using this approach (in our case, a CT-CM model with two informants), we found meaningful and substantial associations between the examined variables. Specifically, BAS was positively related to Plasticity, and negatively related to Stability. This suggests that, in accordance with the hypothesis, individuals who are sensitive to cues for rewarding consequences (i.e., individuals with high dispositional sensitivity to BAS) are more inclined to actively explore and engage with the possibilities provided by the environment, which is a trait manifestation of Plasticity (DeYoung, 2010). This relation is consistent with a conception of exploration as any behavior or cognition that is rewarding in itself, because of the innate incentive value of uncertainty (for a thoughtful discussion, see DeYoung, 2013). At the same time, individuals with high BAS are less inclined to restraint from behaviors related with disruptive impulses, which is a trait manifestation of Stability (Hirsh et al., 2009).

Results also indicate that BIS was positively related to Stability. That is, individuals with high dispositional sensitivity to BIS are characterized by high levels of Stability and are, therefore, more inclined to constraint and self-regulate their behavior. According to the revised RST, the BIS is responsible for detection and resolution of conflicting stimuli, such as when reward and punishment are approximately equal in value, and approach and avoidance motivation are in opposition (Corr, 2013). This has relevant implications for the process of self-control, which has been regarded the core characteristic of Stability (Olson, 2005). Indeed, as reviewed by Inzlicht and Legault (2014), increasing evidence shows that the detection of a conflict between two goals or response tendencies plays a critical role in activating effortful self-control processes (see also Hofmann & Kotabe, 2012).

BIS, by contrast, proved to be non-significantly related to plasticity. This unexpected result appears to suggest that behavioral inhibition does not necessarily conflict with the individual's tendency to exploratory behavior. In fact, passive avoidance can still implies approach behaviors, although with increased vigilance and cautiousness (Corr, 2013). It might be possible that high or low levels of BIS may condition the specific kind of exploratory style that is used.

Another conclusion we can draw from the study is that BIS exhibited a large negative effect on the unique part of emotional stability, that is not shared with agreeableness and conscientiousness. Thus, the relation with emotional stability is maintained even after statistical control of the metatraits. This supports the claim that anxiety and vulnerability to stress represent relevant dispositional correlates of BIS sensitivity. By contrast, the BAS effect on extraversion was largely subsumed by Stability and Plasticity. Therefore, it appears that investigating the personality correlates of BAS at the level of metatraits, rather than focusing on the Big Five, allows to increase predictability, while maintaining parsimony.

When BAS was considered as a multifaceted construct, interesting differences emerged with respect to the correlations with metatraits. The negative relation of BAS with Stability was mostly explained by the Drive and Fun-Seeking subscales. Items in these scale include aspects such as striving for the accomplishment of the desired goal (Drive, e.g., "When I want something, I usually go all-out to get it"), and acting impulsively to approach rewarding events (Fun-Seeking, e.g., "I often act on the spur of the moment"). These aspects resemble the opposite pole of delay of gratification and self-control, thus being in contrast with the general tendency to regulate or restrain behavior and emotion that are potentially disruptive (Stability).

The positive relation of BAS with Plasticity was mostly explained by the Reward Responsiveness and Fun-Seeking scales. Drive, by contrast, was unrelated to Plasticity. Interestingly, although dopamine plays a major role in the functioning of the reward system, recent evidence seems to suggest that individual differences in the BAS-Drive scale are related to the functioning of the serotonergic neurotransmitter system (see Krupić & Corr, 2017, for a review), which has been linked to Stability (DeYoung, 2006; DeYoung et al., 2002). This might explain the high negative correlation that Drive exhibited with this metatrait.

The present study has several limitations. First, we relied on other ratings obtained by only one informant. Future studies may benefit by the use of more informants, which would allow testing more complex models with the

Multitrait-Multimethod approach (Kenny & Kashy, 1992; Widaman, 1985). Future research should also explore the generalizability of the findings by gathering data from larger, representative samples Second, although the Big Five model represents an established framework for organizing individual differences in basic traits, this model attracted criticism (e.g., Block, 1995). Future studies should extend our investigation to alternative descriptions of the personality structure (e.g., the HEXACO; Ashton & Lee, 2007). Third, the statistical approach employed in the study does not allow us to take into account dependencies that may exist between participants' self-ratings and their ratings of the other dyad member. We treated the dyadic structure of the data as nuisance variance, because it is not of central interest for the aim of the study. Finally, BIS and BAS were measured with Carver and White (1994) BIS/BAS Scales. Although this is one of the most frequently used RST questionnaires, it is based on the original version of the theory and has several limitations within the revised RST (see Krupić et al., 2016). Future studies should adopt more appropriate measures of the revised RST, such as the Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ, Corr & Cooper, 2016).

Despite these limitations, our study provides a novel contribution to a better understanding of Stability and Plasticity. Linking the hierarchical structure of personality to a broad and established theory of human functioning, like the RST, may help to shed lights on the nature and correlates of metatraits. This could also have implications for personality assessment in a broader sense. A growing number of studies has suggested the role of Stability and Plasticity in understanding and predicting consequential outcomes in several areas of inquiry, including clinical and organizational psychology (e.g., Alessandri & Vecchione, 2012; Şimşek, 2014). The possibility to draw on a refined description of metatraits, along with the availability of appropriate modeling strategies, such as that described here, may enable researchers and practitioners to exploit their potential in research and applied settings.

Like metatraits, BIS and BAS have shown to be valid predictors of a number of relevant criteria (e.g., Li et al., 2015; Renn et al., 2014). Taking both models and their intersections into account may enable scholars to shed light on important research questions, and ultimately to acquire a deeper understanding of personality functioning. As Corr et al. (2013) wrote, "an important goal for personality psychology is integrating theory-driven research on traits associated with neuropsychological systems with empirically-driven research on the structure of personality traits" (p. 171). Our research contributes in this direction.

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