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https://doi.org/10.1080/00313831.2020.1739137
http://hdl.handle.net/11067/6363

The psychobiological model of personality and its association with student approaches to learning: Integrating temperament and character

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Funding details: Support for this research comes from national funds from the Fundação para a Ciência e Tecnologia I.P. (FCT) [*Portuguese Foundation for Science and Technology*], under the Projects CIPD-BI-UID/PSI/04375/2016 and PTDC/MHC-CED/2224/2014.

Note. This document is the authors' version of the final accepted manuscript published in 2020 by *Scandinavian Journal of Educational Research.*

https://doi.org/10.1080/00313831.2020.1739137

https://www.tandfonline.com/doi/full/10.1080/00313831.2020.1739137

Abstract

Personality results from the complex interactions among multiple learning and memory systems. There is a need to examine the personality-learning association using a personality model that captures this complexity: Cloninger's psychobiological model. The study addresses this need using a person-centered approach. In total, 686 adolescents completed the Junior Temperament and Character Inventory (JTCI) and a measure of approaches to learning. Students with a 'steady' temperament showed a preference for the deep approach. Students with high character coherence also had this preference. A temperament profile-by-character profile interaction was crucial for understanding students' preferred approach to learning. These findings imply that adaptive learning approaches result from an integration of major systems of learning and memory, as measured by the Temperament and Character Inventory.

*Keywords***:** Approaches to learning; personality; temperament; character.

The psychobiological model of personality and its association with student approaches to learning: Integrating temperament and character

Individual differences in personality traits are associated with multiple aspects of learning (e.g. Laidra, Pullmann, & Allik, 2007). Personality also moderates the impact of contextual characteristics on learning (Hendriks, Kuyper, Lubbers, & Van de Werf, 2011), and these effects are often bi-directional. While variation in personality and emotionality have been shown to modify aspects of learning (Fredrickson, 2004; Shapiro, Brown, Thoresen, & Plante, 2011), various forms of learning have also been shown to impact on personality and emotionality (Campanella, Crescentini, Urgesi, & Fabbro, 2014).

Because the psychobiological model of personality (Cloninger, 2004) is a popular model that describes personality as expressions of interacting learning and memory systems (Zwir et al., 2019), it is ideal for developing a detailed understanding of the personality-learning approach association. However, most studies on this topic thus far have used lexical models of personality (Jensen, 2015). There is, therefore, a need for more research into the role of psychobiological personality dimensions (and their interactions) in learning approaches. There is also a need to conduct such research using person-centered approaches, as this is likely to help promote suitable learning contexts for developing positive academic outcomes in all students. The principle objective of this study was to address these research priorities.

Student Approaches to Learning

The cognitive and motivational strategies employed in self-regulated learning can be understood via the student approaches to learning framework, originally conceptualized by Marton and Säljö (Marton, 1976; Säljö, 1975), and later operationalized by Biggs in the Study Process Questionnaire (SPQ; Biggs, 1987). Originally, Biggs proposed three major approaches to learning - the deep approach, surface approach, and achieving approach – although the achieving approach was later disregarded because of poor construct validity (Biggs, 2001). In accordance with this framework, recent studies have championed a two higher-order factor structure for which surface and deep approach are subdivided into motive and strategy (Kember,

Biggs, & Leung, 2004; Moreira, Dias, Pettrachi, Vaz, & Duarte, 2012). When a student adopts a deep approach to an academic task, this is to say that their underlying guiding intention is to maximize intellectual understanding and extract meaning from the task. There is, in other words, an intrinsic motivation. The strategies employed under this approach will depend on the specific task, although they are commonly analytical and characterized by the establishment of relations between specific content and broader phenomena. When a student adopts a surface approach, the guiding motivation is extrinsic to the task. The resulting strategies for a given task under this approach, such as rote learning, are typically unanalytical and characterized by low investment and low effort. Research has demonstrated a detriment to academic performance by adopting a surface approach (Diseth, 2003, 2013). Studies, including meta-analyses, have also reported modest positive associations between deep approach and academic performance (Richardson, Abraham, & Bond, 2012; Watkins, 2001). It is, however, noteworthy that these associations have not been significant in all cases (Herrmann, McCune, & Bager-Elsborg, 2017).

Cloninger's Psychobiological Model of Personality

A popular framework for conceptualizing personality traits is the five-factor model (Costa & McCrae, 1992). This model is supported by a large body of evidence (Poropat, 2009; Saulsman & Page, 2004) and it's dimensions are predictive of a range of important outcomes such as health and wellbeing (Strickhouser, Zell, & Krizan, 2017). Despite its popularity, researchers have argued that models derived from linear factor analyses (including the five-factor model) do not provide a complete description of personality (Boyle, 2008; Cloninger, Svrakic, & Przybeck, 1993; Veselka, Schermer, & Vernon, 2012). Because psychobiological approaches to personality allow for a more comprehensive understanding of individual differences (Munafò & Flint, 2011; Veselka et al., 2012) there is a growing opinion that they should be adopted in the social sciences (Bates & Lewis, 2012). One such approach is Cloninger's psychobiological model of personality (Cloninger, 2004; Cloninger et al., 1993). This model describes personality as a complex expression of the interactions between multiple

learning and memory systems (Cloninger, 2004). Over recent years, this model has acquired substantial empirical validation for its suitability for describing normal and abnormal variations of human personality (Cloninger, Zohar, & Cloninger, 2010; Grucza & Goldberg, 2007).

According to the psychobiological model, temperament refers to innate individual differences in associative responses to basic emotional stimuli that shape habits and emotional responses (Cloninger, 2004). Such differences are captured by four temperament dimensions. Two of these dimensions, novelty seeking and harm avoidance, are responsible for the activation and inhibition of behaviors. Novelty seeking is the tendency to respond behaviorally to novel stimuli while harm avoidance is the tendency to inhibition behavior in the presence of aversive stimuli. These dimensions are theoretically proximal to the behavioral activation and behavioral inhibition motivational systems outlined by Gray (1970), and empirical studies have supported this close association (Mardaga & Hansenne, 2007). The two remaining dimensions pertain to the maintenance of behaviors. Reward dependence is the tendency to respond positively and maintain behavior in the presence of reward signals. Persistence, on the other hand, represents the tendency to continue with a behavior despite the absence of reward

In recent years, the use of person-centered methods has allowed researchers to assign individuals with temperament profiles based on their configurations of the novelty seeking, harm avoidance, reward dependence, and persistence. One of these studies (Rettew, Althoff, Dumenci, Ayer, & Hudziak, 2008) extracted three profiles based on participants' responses to the Junior Temperament and Character Inventory (JTCI; Cloninger et al., 1993). The first and most typical profile corresponded to a 'moderate' temperament phenotype characterized by average scores of all four dimensions. The second 'steady' temperament phenotype was characterized by high scores for persistence and low scores for novelty seeking. Finally, the third and least typical profile, the 'disengaged temperament phenotype, was characterized by low persistence and reward dependence, and high novelty seeking and harm avoidance. This latter profile is noteworthy because it implies a degree of impaired self-regulation and conflicting motivational drives, a drive to explore novel situations (high novelty seeking) but a

fear/anxiety of doing so (high harm avoidance), and has been associated with clinical levels of mood regulation problems (Tillman et al., 2003).

In addition to temperament, the psychobiological model of personality describes individual differences in higher-order socio-cognitive processes that determine voluntary intentions and attitudes, and shape our sense of self as an individual, member of society, and part of something transcending oneself (Svrakic, Whitehead, Przybeck, & Cloninger, 1993). These character traits, have been linked to brain networks involved in goal-setting, self-control, empathy, and episodic learning (Zwir et al., 2018). Self-directedness describes a self-awareness of being an autonomous individual, and an ability to adapt and regulate behavior to fit a given situation in accordance with one's values and standards. Cooperativeness describes one's acceptance of being a member of a group or community. Finally, self-transcendence describes an awareness of being part of a holistic reality that transcends the individual and is associated with spirituality.

Similar to temperament, individual differences in character can be considered by the formation of character profiles (Cloninger, 2004). Such profiles are typically based on combinations of high or low values (above or below median scores) for each of the three character dimensions (Cloninger & Zohar, 2011). These shall be notated when required as combinations of upper or lower case letters: high and low self-directedness notated as 'S' and 's', high and low cooperativeness notated as 'C' and 'c', and high and low self-transcendence notated as 'T' and 't'. In total, there are eight unique character profiles (e.g. sct and SCT). Generally, a larger summed score across all three dimensions (i.e. SCT compared to sct) is associated with maturity, happiness, and character coherence (Cloninger, 2004).

As noted above, nonlinearity is a fundamental characteristic of the complex functional relationships among temperament and character dimensions. While temperament dimensions do influence character development, there are no one-to-one (linear) relationships between one's temperament profile and one's character profile. Temperament and character dimensions also have non-linear effects on behavior and emotional responses (Cloninger, 2008). Only

individuals with high levels of harm avoidance, for example, show an increased startle response to unpleasant stimuli compared to neutral stimuli (Corr, Kumari, Wilson, Checkley, & Gray, 1997). In accordance with the non-linearity of personality, studies on the psychobiological model of personality typically use both linear and non-linear methods as a means to recognizing the complexity of personality (Cloninger & Zohar, 2011; Josefsson et al., 2011) and frequently analyze temperament and character dimensions separately (e.g. Hansenne, Delhez, & Cloninger, 2010).

Student Approaches to Learning and Personality

Presently, there are no published studies directly assessing the relations between psychobiological dimensions of personality and student approaches to learning. However, an extensive body of research has assessed the association between student approaches to learning and the Big Five personality factors. As is summarized in a literature review by Jensen (2015), multiple studies have shown a consistent positive association between the openness and conscientiousness personality factors and deep approach, and between neuroticism and surface approach (Chamorro-Premuzic & Furnham, 2008, 2009; Duff, Boyle, Dunleavy, & Ferguson, 2004; Rosander & Bäckström, 2012; Swanberg & Martinsen, 2010; Von Stumm & Furnham, 2012). Although this pattern of results indicates student approaches to learning are associated with multiple personality traits, some authors have argued that openness, which is linked to curiosity, is the principle factor for understanding students' motives and strategies (Chamorro-Premuzic & Furnham, 2009).

Some preliminary insight into how the psychobiological dimensions of temperament and character might be associated with student approaches to learning can be garnered by considering their reported correlations with the Big Five factors (de Fruyt, van De Wiele, & van Heeringen, 2000). The openness factor, which has been consistently linked to more deep approach and less surface approach, has been found to be correlated with high novelty seeking, high reward dependence, high cooperativeness, high self-transcendence, and low harm avoidance. Conscientiousness, which is also associated with deep approach, is linked to low

harm avoidance, low novelty seeking, high persistence, and high self-directedness. Finally, neuroticism, which has the opposite pattern of associations with student approaches to learning, has been linked with high harm avoidance and low self-directedness. Clearly, this pattern of associations suggests that multiple distinct psychobiological systems and process may be relevant for understanding student approaches to learning, but is unable to provide information about the relative contributions of each.

From a theoretical perspective, there are grounds to expect persistence temperament to be related to student approaches to learning. Individuals with high persistence can be characterized as being ambitious, enthusiastic, and tireless overachievers (Cloninger, Zohar, Hirschmann, & Dahan, 2012) and these traits are theoretically incompatible with the low investment, low effort surface strategies typical of the surface approach to learning and more consistent with the intrinsic motivation and high investment strategies typical of the deep approach. Following a similar rationale, the constructs of impulsivity, excitability, and disorderliness are embedded in the novelty seeking temperament dimension. Such constructs are theoretically close to the surface approach to learning: impulsivity in the face of novel stimuli in likely be a distraction from high-effort, high-investment study strategies. In terms of character, high self-directedness also has particularly strong theoretical reasons to be associated with deep approach to learning, although theory dictates that high levels of the three character dimensions should be linked to an integrated personality (Cloninger, 2004). High self-directedness is linked to self-determination and all three character traits have been shown via brain imaging studies to be associated with self-regulatory meta-cognitive processes such as self-reflection and goal setting (van Schuerbeek, Baeken, de Raedt, de Mey, & Luypaert, 2010; Zwir et al., 2018).

Research Aims and Hypotheses

Although the dispositional basis of student approaches to learning has been studied extensively using the Big Five framework, no study has explored this link considering alternative personality frameworks, including the psychobiological model. Because this endeavor is likely to provide some insight into the psychobiological processes relevant to

academic outcomes, our aim was to examine the relationship between temperament and character, as measured via the JTCI, and student approaches to learning. Our approach to this research question included; a) testing the linear and non-linear associations between personality dimensions and approaches to learning, b) identifying groups of students with similar temperament and character profiles and assessing how these groups differ in approaches to learning, and c) examining how students' temperament and character profiles interact to explain individual differences in approach to learning. Considering theory and empirical evidence related to personality and learning approaches, we hypothesized that multiple personality dimensions would be associated with students' approaches to learning, with particularly notable effects for persistence and self-directedness.

Method

Participants

Four schools from the north of Portugal (three middle schools and one vocational secondary school) were recruited using a convenience sampling strategy. These schools were approached because they enroll adolescents and because they represent student populations studying both academic and vocational courses. We invited all students in each participating school to take part in the study. Only students whose parents signed an informed consent were allowed to participate. At the termination of data collection we had data for 873 adolescent students. From this initial sample, we excluded 187 participants for having 100% missing data for either the JTCI or measure of learning approaches.

After exclusions, the final sample comprised 686 students (47.2% male; 49.0% female; 3.7% missing data). Students attending the middle schools were in the seventh (212 students; *M* = 12.9 years), eighth (180 students; *M* = 13.9 years), or ninth (135 students; *M* = 14.7 years) grade. From the vocational secondary school, students were enrolled in the first (149 students; M = 16.1 years) or second year (10 students; M = 16.4 years). Overall, the sample had an age range of 12 to 17 years, with a mean age of 14.3 years (SD = 1.5 years).

Measures

Temperament and character. We used the Portuguese version of the JTCI (Moreira, Oliveira, et al., 2012) to measure the temperament and character dimensions described by Cloninger's psychobiological model: novelty seeking (22 items), harm avoidance (19 items), reward dependence (15 items), persistence (18 items), self-directedness (23 items), cooperativeness (19 items), and self-transcendence (7 items). JTCI items were scored on a five-point scale from 1 (*completely false*) to 5 (*completely true*). In the study sample, the internal consistency of JTCI subscales, measured using *omega* (McDonald, 1999), were: novelty seeking (ω = .82), harm avoidance (ω = .75), reward dependence (ω = .70), persistence (ω = .76), self-directedness (ω = .83), cooperativeness (ω = .89), and self-transcendence (ω = .66). Note, we used omega as our measure of reliability given arguments that it outperforms the more commonly used Cronbach's alpha (Dunn, Baguley, & Brunsden, 2014). Omega coefficients closer to 1 indicate better scale reliability, and consistent with psychometric literature, we considered .70 as a general heuristic for acceptability (Lance, Butts, & Michels, 2006).

Approach to learning. We used a version of the Learning Processes Inventory for University Students (LPI-u; Duarte, 2007) that has been adapted for secondary school students and validated in a Portuguese sample (LPI-s; Moreira, Dias, Pettrachi, Vaz, & Duarte, 2012). Items for the original LPI-u were based on those from questionnaires by Biggs (1987), Entwistle and Ramsden (1983), and Thomas and Bain (Thomas & Bain, 1982), and are designed to measure student motivation and learning strategies. The LPI-s has 33 statements that are rated on a 5-point scale from 1 (*never or rarely true for me*) to 5 (*always or almost always true for me*). A deep approach score was calculated as the mean of three subscales: the deep strategy subscale (7 items), intrinsic motivation subscale (8 items), and organization strategy subscale (4 items). A surface approach score was calculated as the mean of the instrumental motivation subscale (3 items), surface strategy subscale (4 items), performance motivation relating to grades subscale (3 items), and performance motivation relating to competition subscales (4 items). In the study sample, the reliability of the deep and surface scales was high (ω = .95 and .91, respectively).

To account for within-group variation, the mean scores for deep and surface approach were transformed into preference ratios. Scores were transformed to a scale from 0 to 4 by subtracting 1. Ratios were then calculated using the equation $A/(A + B)$, where A = score for deep approach, and B = score for surface approach. A ratio > .50 indicates a preference for the deep approach over the surface approach. Conversely, a ratio < .50 indicates a preference for the surface approach.

Prior academic performance. We obtained students' Mathematics and Portuguese grades from school records for the school year before the study. We calculated prior academic performance as the mean grade across these two subjects. Studies suggest that individual differences in academic achievement are highly stable across time (Rimfeld et al., 2018). In Portugal, middle school students' exams are graded on a numerical scale ranging from 0 to 5, and in secondary school, exams are graded on a numerical scale from 0 to 20. We therefore standardized these composite academic performance scores within each grading system by calculating z scores.

Statistical Analyses

Analyses were conducted using R (R Core Team, 2019). Missing data for the JTCI and LPI-s (< 2%) were imputed using the scale median. Missing data for academic performance (14%) were uniquely from students attending the vocational secondary school, and were therefore designated missing at random (MAR). These missing values were imputed using the pooled sample mean.

Profile formation. Person-centered studies have typically studied temperament and character independently (e.g. Cloninger & Zohar, 2011; Rettew et al., 2008). Such studies adopt different classification techniques to form personality profiles: temperament studies using cluster or latent profile analysis, and character studies using a simple algorithm outlined by Cloninger (2004). To facilitate cross-study comparisons, we opted to continue with these methodologies.

Temperament. Temperament profiles were extracted using a k-medoid clustering method, the Partitioning Around Medoids (PAM) algorithm (Kaufman & Rousseeuw, 1990), to

partition the data into clusters. K-medoid clustering is a robust alternative to k-means clustering, which is important when many participants may have a temperament profile that does not belong well to any cluster (van der Laan, Pollard, & Bryan, 2003). The number of clusters to extract was determined using the NbClust package (Charrad, Ghazzali, Boiteau, & Niknafs, 2014). This package calculates 30 different indices and the solution is chosen using a majority rule. When two solutions are supported by an equal number of indices, the solution with the fewest clusters is chosen.

Character. The sample was divided into participants above and below the median for the three character dimensions. Participants were then grouped according to the eight possible character configurations: sct "depressive" (n = 145), scT "disorganized" (n = 102), sCt "dependent" (n = 38), sCT "moody" (n = 62), Sct "autocratic" (n = 67), ScT "fanatical" (n = 46), SCt "organized" (n = 89), and SCT "creative" (n = 137). This method is frequently used in person-centered research on character (Cloninger & Zohar, 2011; Josefsson et al., 2011; Moreira et al., 2015).

JTCI dimensions. First, we used multiple linear regression to test linear associations between JTCI dimensions and students preferred learning approach. Student age and gender were included in the model as control variables. Next, we conducted a series of independent 2-sample t-tests to assess the non-linear effects of character dimensions on preferred learning approach. This method evaluates the difference between two extremes of a single character dimension while keeping the other two character dimensions constant.

JTCI profiles. The preferred learning approach for each temperament and character profile group was assessed using a series of one-sample t-tests. A significant p-value for these analyses indicated that the group average ratio was significantly different from 0.50 (indicating a preference for either deep or surface approach). ANOVA was then used to tested whether the two temperament profile groups differed in their preferred learning approach. In cases where there was a violation of homogeneity of variance, a non-parametric Kruskal-Wallis test was used. Similar analyses were used to test differences across character profile groups. Finally, we

used a hierarchical multiple linear regression to test the additive effects of temperament and character profiles on student learning approach preference, as well as their interaction.

Results

Descriptive Statistics

Table 1 shows descriptive statistics for the study variables. Scale scores for the LPI-s deep and surface approach subscales were generally in the middle of the scale, with little skew. Preference ratios indicated that students ranged from a total preference for the surface approach (0.00) to a total preference for the deep approach (1.00), although the very high kurtosis (7.01) indicated that most students had no clear preference (M = 0.51).

JTCI Dimensions and Student Approaches to Learning

Linear associations. Linear regression was used to test the linear associations between JTCI dimensions and student preference for deep approach (Table 2). The model explained 12.8% of the variance in student preference, R^2 = .13, $F(10, 650) = 10.62$, $p < .001$. The model indicated that students with higher persistence were more likely to prefer a deep approach to a surface approach (β = .15, p = .004). The model also indicated that students with lower novelty seeking were also more likely to have this preference (β = -.13, p = .004).

TABLE 2 ABOUT HERE

Non-linear effects. To test the non-linear effects of character dimensions on student preference for deep approach, we conducted paired-comparisons between pairs of character profiles for which two dimensions were held constant and the third varied in the extremes (Table 3). Higher self-directedness was associated with a preference for the deep approach in the contrast between the "creative" and "moody" character configurations (SCT vs. sCT, d = .55). Higher cooperativeness was associated with higher a preference for the deep approach in the contrasts between "creative" and "fanatical" (SCT vs. ScT, d = .49), and "organized" and "autocratic" (SCt vs. Sct, d = .45) configurations. Changes in self-transcendence were not associated with changes in student preference for any of the paired contrasts.

TABLE 3 ABOUT HERE

JTCI Profiles and Student Approaches to Learning

Temperament profiles: cluster analysis. The distribution of cluster solutions from the 30 indices was as follows: zero clusters (*n* = 2), one cluster (*n* = 1), two clusters (*n* = 7), three clusters (*n* = 7), four clusters (*n* = 4), five clusters (*n* = 2), more than five clusters (*n* = 3). Figure 1 presents temperament z scores for the two temperament profiles from the two-cluster solution. The first profile (*n* = 333) was defined by lower novelty seeking, and higher reward dependence and persistence. Because this profile was similar to one identified by Rettew et al. (2008), we used the same label: the *steady* profile. The second profile (*n* = 353) was defined by higher novelty seeking, and lower reward dependence and persistence. Based on these characteristics we labelled this profile the *disinhibited* profile.

FIGURE 1 ABOUT HERE

Temperament profiles. The left-hand panel of Figure 2 presents the preference ratios for the two temperament profile groups. Values greater than 0.50 indicate a preference for the deep approach. A one-sample t-test indicated that the steady temperament profile group had a significant preference for the deep approach, $t(332) = 6.32$, $p < .001$. In contrast, the disinhibited temperament profile group showed no significant preference, $t(352) = -1.76$, $p = .080$. An ANOVA indicated that the steady temperament profile group had a higher preference for deep approach than the disinhibited temperament profile group, $F(1, 684) = 32.07$, $p < .001$.

Character profiles. The right-hand panel of Figure 2 presents the preference ratios for the eight character profile groups. Students with different character profiles differed in terms of preference for deep approach, $\chi^2(7) = 43.36$, $p < .001$. Specifically, students with an SCt "organized" or SCT "creative" character profile had a clear preference for deep approach over surface approach. In contrast, there was no clear preference for the remaining profiles. A series of one-sample t-tests confirmed that the SCT "creative", $t(136) = 5.31$, $p < .001$, and SCt "organized", $t(88) = 3.74$, $p < .001$, character profile groups had a significant preference for deep approach. For the remaining groups, discrimination ratios were not significantly different from .50, indicating no preference for either approach.

FIGURE 2 ABOUT HERE

Temperament profile-by-character profile interactions. The hierarchical regression (Table 4) showed that at step 1 student age and gender contributed significantly to the model and accounted for 4.2% of the variance in student preference for deep approach, $F(2, 657) = 14.47$, $p < .001$. At step 2, the addition of temperament profile to the model increased the amount of variance explained to 7.8%. This change in R^2 was significant, $F(1, 656) = 26.20$, $p < .001$. At step 3, the addition of character profile increased the amount of variance explained to 9.1%. This change in R^2 was also significant, $F(1, 655) = 9.14$, $p = .003$. At step 4, the addition of the interaction increased the amount of variance explained to 9.7%. This final change in R^2 was significant, $F(1, 654) = 4.23$, $p = .040$. In this final model, the temperament profile-by-character profile interaction term has the strongest association with student learning approach preference ($\beta = .22$, $p = .040$). Thus, character profile was a significant moderator of the relationship between temperament profile and preferred approach to learning.

TABLE 4 ABOUT HERE

Figure 3 presents the estimated simple slopes for this interaction. The unstandardized simple slopes for students with the sct, scT, and sCt character profiles ($b = .002$, .008, and .014 respectively) were not statistically significant. In contrast, the unstandardized simple slopes for students with the sCT ($b = .019$), Sct ($b = .025$), ScT ($b = .031$), SCt ($b = .037$), and SCT ($b = .042$) character profiles were statistically significant ($p < .05$).

FIGURE 3 ABOUT HERE

To further examine this interaction, we split the sample into four groups according to temperament profile and character coherence (immature = sct, scT, sCt, and sCT; mature = Sct, ScT, SCt, and SCT): steady immature ($n = 100$), steady mature ($n = 233$), disinhibited immature ($n = 247$), and disinhibited mature ($n = 106$). We then compared preference for deep approach across these groups. Figure 4 shows that the steady-mature group had a clear preference for deep approach. A one-sample t-test confirmed that the preference ratio for this group was significantly higher than 0.50, $t(232) = 6.84$, $p < .001$. Similar t-tests for the remaining three groups were not significant, implying no clear preference. A Kruskal-Wallis rank sum test confirmed the main effect of learning approach preference across groups, $\chi^2(3) = 43.52$, $p < .001$.

Follow-up multiple comparisons with adjusted p-values indicated the steady-mature group had a significantly higher preference for deep approach than all other groups ($p < .001$).

FIGURE 4 ABOUT HERE

Theory dictates a functional relationship between the way student approach to learning and academic outcomes, including academic performance (Biggs, 1987). A large body of evidence supports this association (Richardson et al., 2012; Watkins, 2001). Thus, as a final ancillary analysis, we sought to validate the results by testing whether the steady-mature group (the only group with a preference for the deep approach) had increased academic performance. As is evident in Figure 5, the steady-mature group had higher than average academic performances (z score = .31). A Kruskal-Wallis rank sum test confirmed this main effect of academic performance across groups, $\chi^2(3) = 37.37$, $p < .001$. Follow-up multiple comparisons showed that the steady-mature group had significantly higher academic performance than all other groups ($p < .001$).

FIGURE 5 ABOUT HERE

Discussion

Researchers continue to debate the extent to which preference-based constructs, including students' preferred approach to learning, reflect broad individual differences in personality. The current study makes several contributions to this literature. Firstly, it highlights that the relationships between individual psychobiological personality dimensions and student approach to learning are non-linear. Secondly, it shows that broad groupings of students based on shared personality characteristics can account for a significant, albeit modest, amount of variance in student approach to learning. Thirdly, temperament and character profiles had both additive and interactive effects on student approach to learning. It is also noteworthy that the present study is the first to consider the dispositional basis of learning approaches using a personality model that captures individual differences in systems of learning and memory.

Consistent with the study hypotheses, persistence and novelty seeking temperament dimensions had linear associations with student preference for deep approach. Specifically, high persistence was positively associated with a preference for deep approach while high novelty

seeking was negatively associated with this preference. This result is consistent with multiple studies that have shown the Big Five conscientiousness factor, which has a moderate positive correlation with persistence and moderate negative correlation with novelty seeking (De Fruyt, Van De Wiele, & Van Heeringen, 2000), is associated with a preference for deep motives and strategies (see Chamorro-Premuzic & Furnham, 2009).

A surprising outcome of the regression analysis, given prior theory, was that none of the three character dimensions presented a statistically significant association with student's preferred learning approach. One explanation for this finding is that the effects of character dimensions are non-linear. This was supported by the non-linear analyses. When comparing paired character configurations that differed in the extremes for just one dimension, higher self-directedness and cooperativeness were linked to a preference for deep approach, but only for some specific combinations. For example, higher self-directedness was associated with increased preference for deep approach for the paired comparison between the "creative" versus "moody" configurations. Cooperativeness had similar non-linear effects for the paired comparison between the "creative" versus "fanatical", and "organized" versus "autocratic" configurations. As has been noted in similar prior studies (Cloninger & Zohar, 2011; Josefsson et al., 2011), the fact that the regression analyses missed these non-linear effects highlights the importance of considering the non-linear nature of personality in its functional effects.

Personality profiles and preferred approach to learning

To our knowledge, this study is the first to use a person-centered approach to assess the relationship between personality and students preferred approach to learning. By grouping participants based on their personality profiles, our study offers a description of how subgroups of students with common personality characteristics prefer to approach learning tasks at school. In short, differences in preferred approach to learning were observed when students were classified uniquely by temperament, and when classified uniquely by character.

A cluster analysis based on temperament dimensions indicated that the study sample could be clustered into two broad subgroups defined by their opposing levels of novelty seeking versus reward dependence and persistence: the steady and disinhibited profiles. Note that these

subgroups were heterogeneous (with a large within-cluster variation in temperament scores) meaning that they represented a basic categorization of a larger range of temperamental styles in students. Despite this property, the steady temperament group showed a preference, albeit modest, for deep approach while, in contrast, the disinhibited temperament group did not have a preference for either approach. These findings align with those of a prior person-centered study that found children and adolescents with a similar steady temperament profile had increased school competency and adaptive functioning (Rettew et al., 2008) compared to those with a disengaged temperament profile (which was also characterized by high novelty seeking, and low reward dependence and persistence).

The sample was also divided into eight subgroups based on students' configurations of character dimensions. The analyses indicated that students with high levels of both self-directedness and cooperativeness (regardless of their self-transcendence; i.e. the SCT "creative" and SCt "organized" profiles) had a clear preference for a deep approach to learning. For all other character profiles, students displayed no clear preference for one type of learning approach. High values for self-directedness and cooperativeness indicate that an individual has an autonomous sense of self and is socially adapted (Cloninger, 2004) and tend to indicate that a persons' adaptive functioning is healthy (Cloninger, 2013). These character dimensions have been linked to brain networks for meta-cognitive processes such as self-reflection, goal setting, empathy, and episodic memory (Zwir et al., 2018). These results imply that these self-regulatory components of personality are important for helping students adopt a more adaptive approach to learning.

Thus far, the study findings have illustrated that student temperamental styles and character coherence have independent effects on preferred learning approach. A major finding of the study was that the interaction between these factors is critical for understanding individual differences in students' preferred approach to learning. In other words, a students' tendency to approach learning tasks in either a deep or surface fashion is dependent on the interaction between their temperamental style (the way in which they are inclined to react to basic stimuli), and their socio-cognitive resources. This finding is noteworthy because character

dimensions are experience-dependent and socially influenced (Cloninger et al., 1993). Because character is changeable, it can be developed and improved with the help of interventions (Cloninger, 2006). Such interventions focus on the development of a sense of hope and mastery, kindness and forgiveness, and awareness and greater meaning. The study showed that increased character coherence was linked to a preference for more adaptive learning motives and strategies, but largely for students with a steady temperament profile. Adolescents with a coherent and mature character might be described as responsible, resourceful, socially tolerant, empathic, principled, patient, and creative (Cloninger, 2004). Consequently, one practical implication of the study is that teachers and schools may be able to use character-development interventions with certain types of students (i.e. those with a steady temperament profile) to encourage more adaptive approaches to learning and their associated positive academic outcomes. Mindfulness-based interventions influencing students to give and receive help (Brown, West, Loverich, & Biegel, 2011), for example, may strengthen self-esteem and sense of mastery (i.e. self-directedness). Conversely, our results suggest that for other students (e.g. those with a disinhibited temperament profile) other types of intervention may be more effective.

Study Limitations

A limitation of the study design was that it was cross-sectional design, meaning that that it is not possible from this data to infer any temporal or causal relationships between student personality and student approaches to learning. Studies with longitudinal designs are required to demonstrate causation. A second limitation was that student personality and approaches to learning were measured via self-report. Having a common data source for predictor and criterion variables can lead to a number of method biases including those arising from raters' desires to be consistent, implicit theories, acquiescence, and social desirability (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), which threatens internal validity. To deal with this source of bias, future studies on the association between psychobiological personality dimensions and approaches to learning should aim to collect data from multiple sources. A further threat to the internal validity of the results is that the regression analyses tested the associations between

personality and learning approaches while only controlling for student age and gender. Future studies may wish to include additional control variables, such as student SES, as a way to describe more accurately the unique influence of personality in student learning.

Another limitation concerns the ability to generalize findings beyond the study sample. The relatively large and heterogeneous sample of the present study might be considered sufficient to allow for generalizations across the population of adolescent students in Portugal, although it is important to note that students were from a limited number of schools. Generalizations to different age groups within the same culture, such as children or university students are unadvised, as are generalizations to populations from different cultural backgrounds. This is relevant because the sample was selected based on convenience rather than a strict sampling procedure. Before such generalizations can be made, future studies are need to replicate the findings of the present study in different samples.

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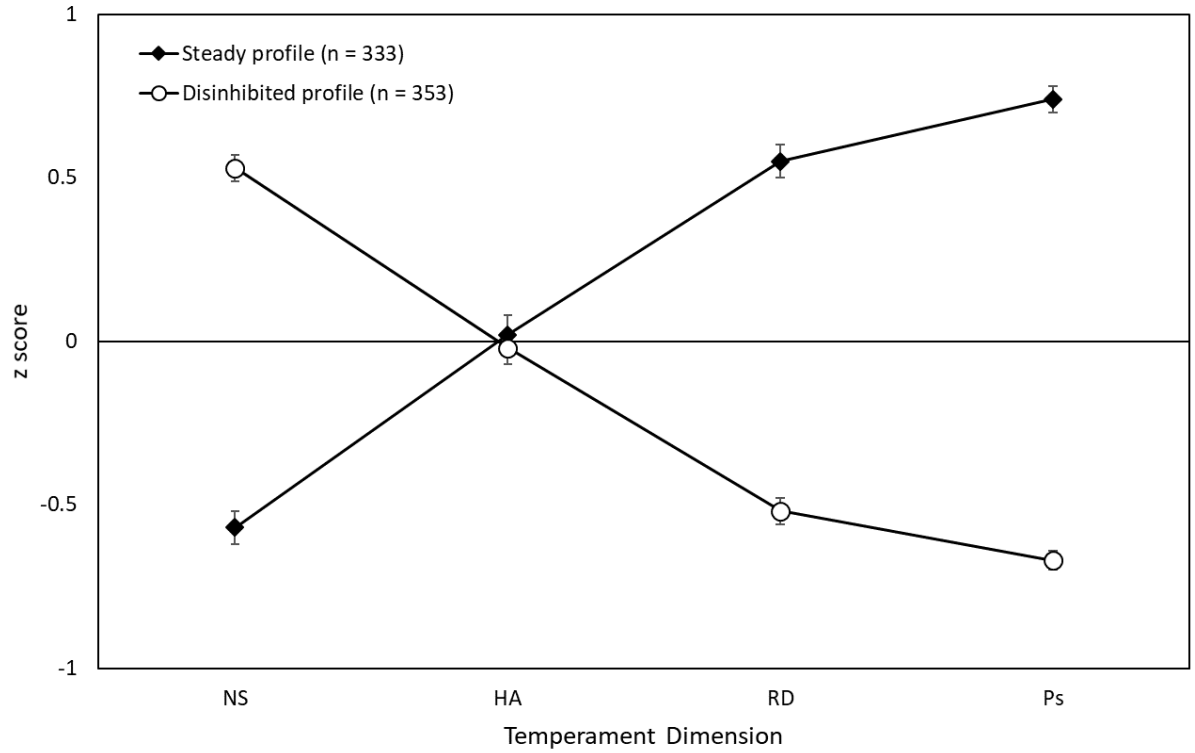

Figure 1. Temperament z scores for the two participant subgroups extracted via cluster analysis.

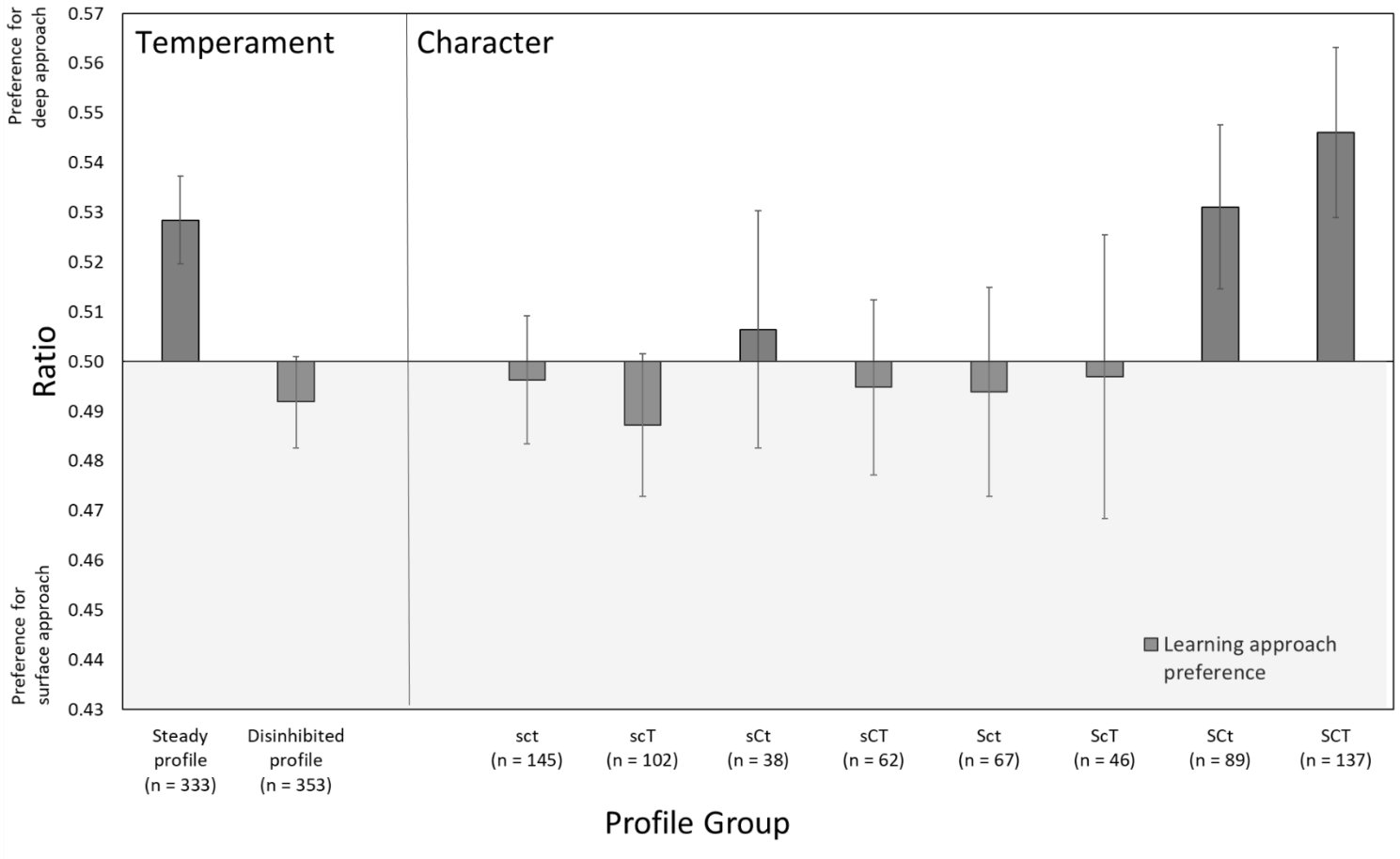

Figure 2. Learning approach preference ratios for the two temperament profile groups (left-hand panel) and eight character profile groups (right-hand panel). Values greater than 0.50 (in white area of the graph) indicate preference for deep approach over surface approach. Values lower than 0.50 (in the shaded area of the graph) indicate preference for surface approach. A value of 0.50 indicates equal preference for both approaches. Error bars reflect 95% confidence intervals.

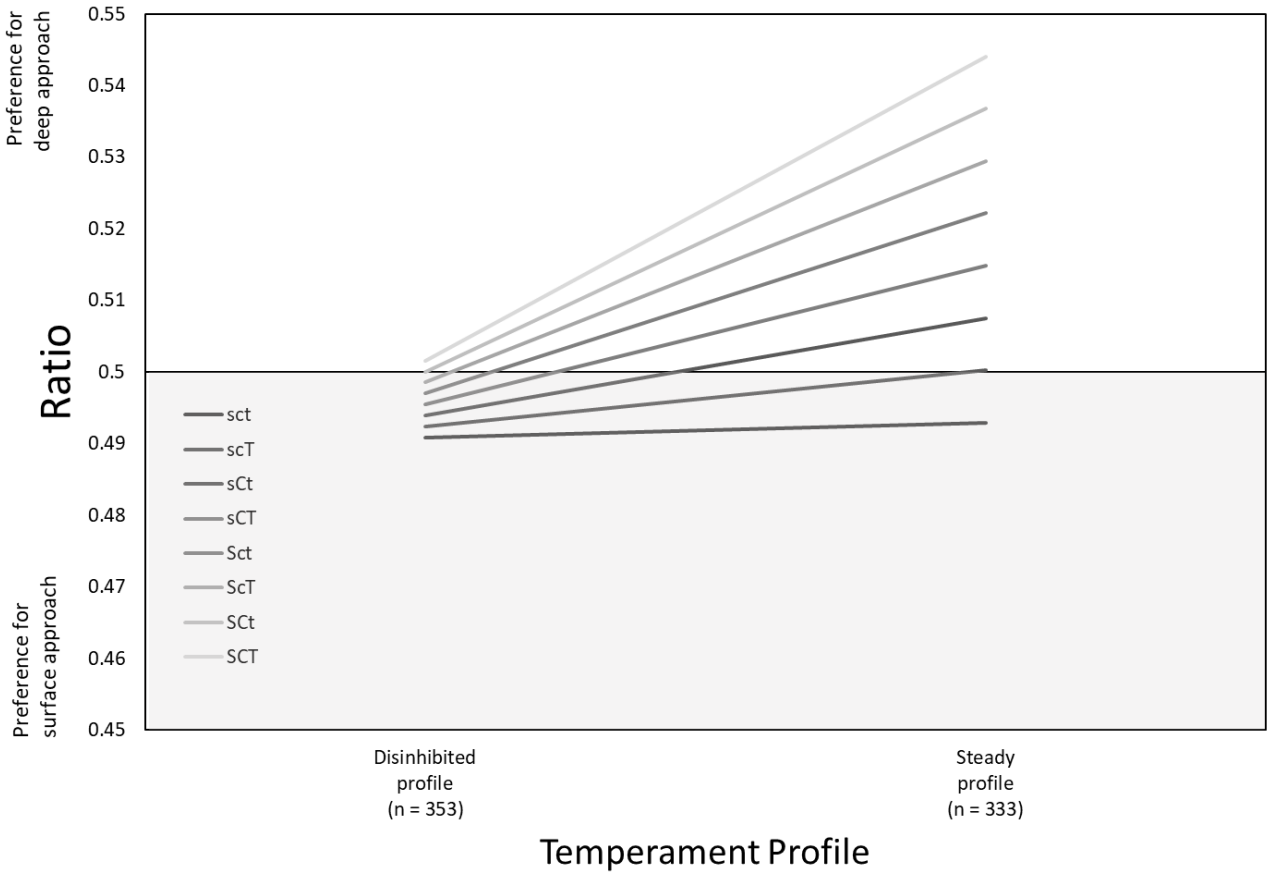

Figure 3. Simple slopes for the effect of temperament profile on student learning approach preference for the eight character configurations. Values greater than 0.50 (in white area of the graph) indicate preference for deep approach over surface approach. Values lower than 0.50 (in the shaded area of the graph) indicate preference for surface approach. A value of 0.50 indicates equal preference for both approaches.

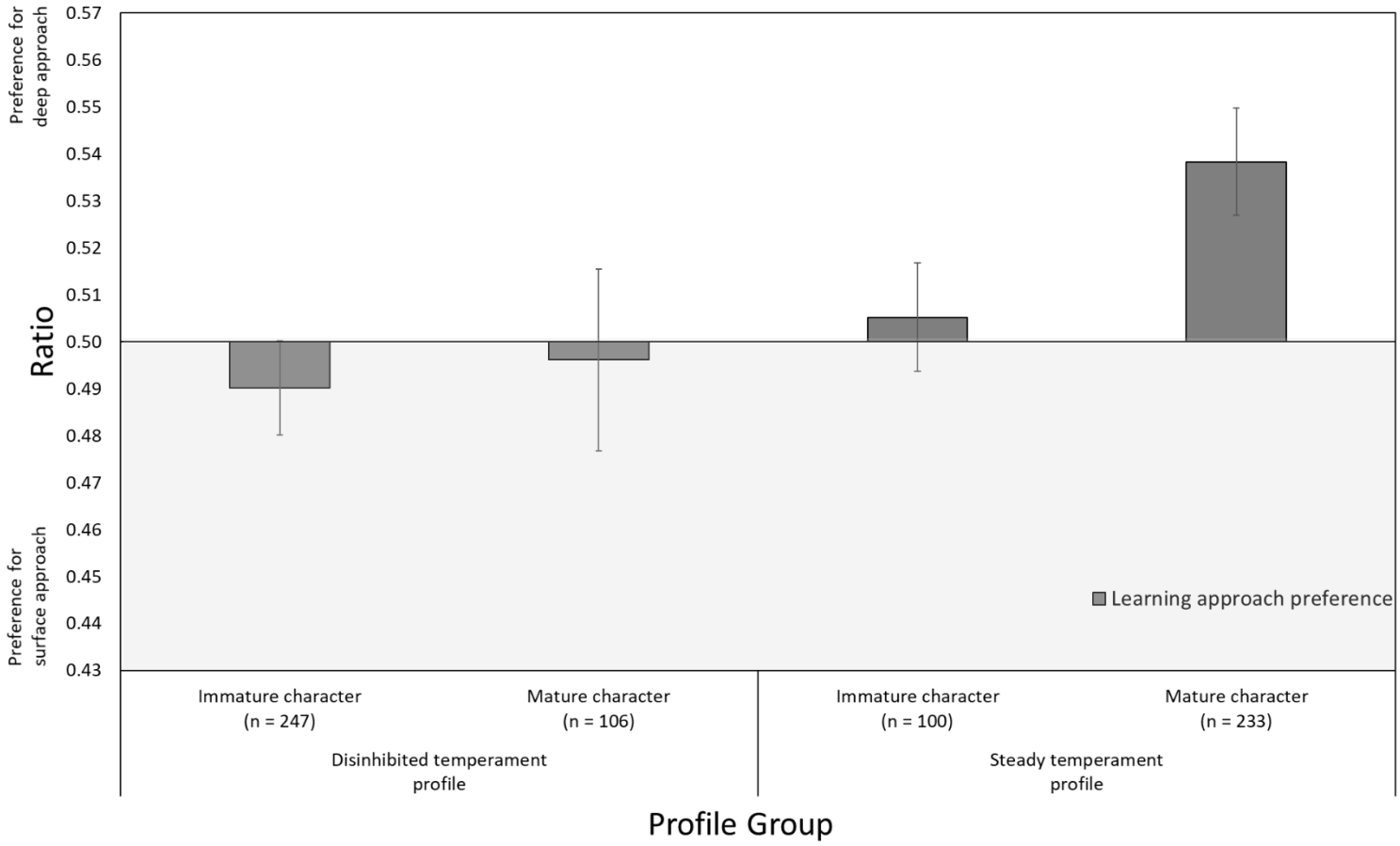

Figure 4. Learning approach preference ratios for the four combinations of temperament profile (disinhibited vs. steady) and character coherence (immature vs. mature). Values greater than 0.50 (in white area of the graph) indicate preference for deep approach over surface approach. Values lower than 0.50 (in the shaded area of the graph) indicate preference for surface approach. A value of 0.50 indicates equal preference for both approaches. Error bars reflect 95% confidence intervals.

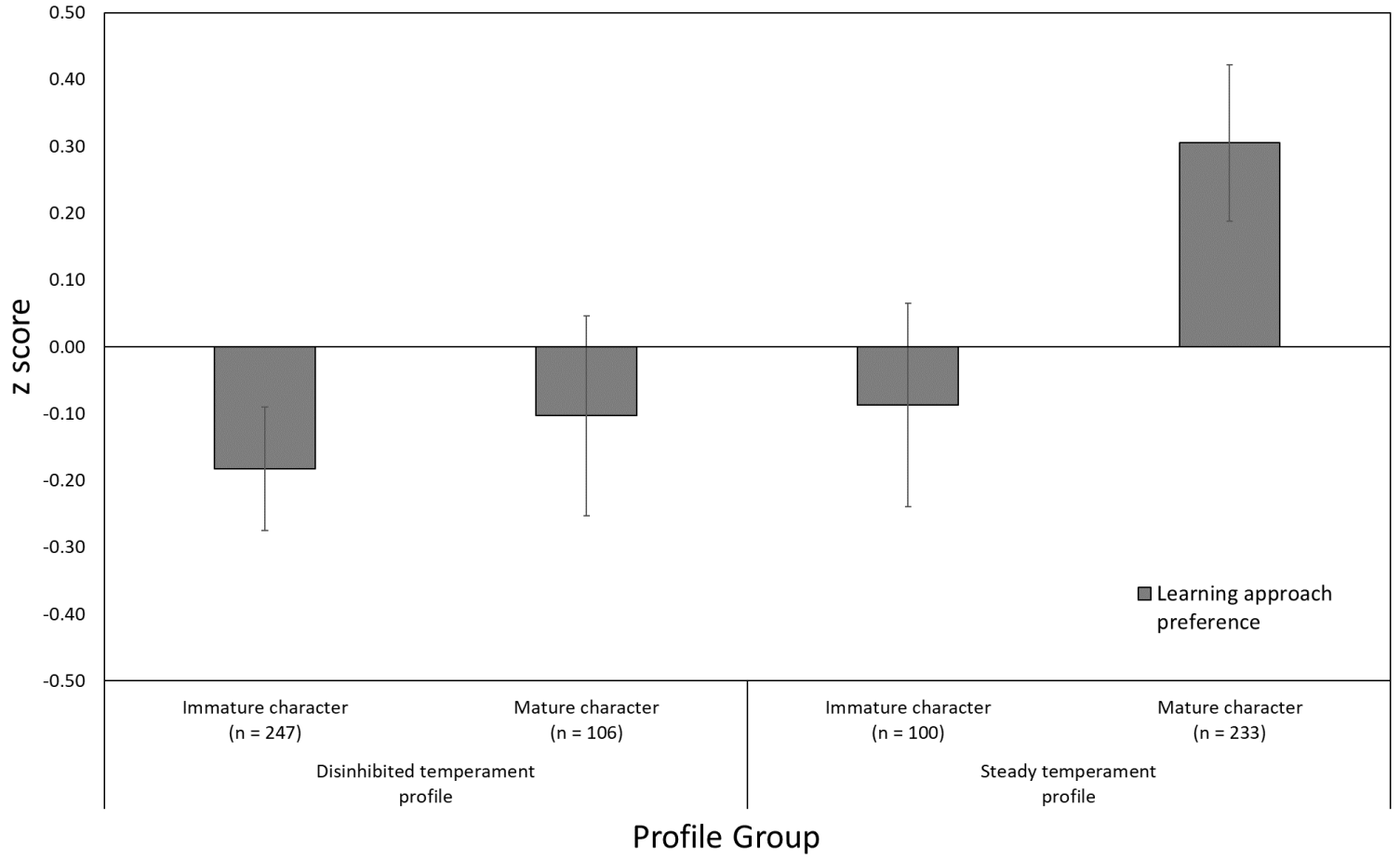

Figure 5. Academic performance z scores for the four combinations of temperament profile (disinhibited vs. steady) and character coherence (immature vs. mature).

Table 1.

Descriptive statistics for LPI-s subscales, learning approach preference ratio, JTCI subscales, and standardized academic performance (n = 686).

	M	*SD*	Min	Max	Skew	Kurtosis
LPI-s						
Deep approach	3.12	.71	1.00	5.00	-0.05	0.26
Surface approach	3.04	.68	1.00	5.00	-0.02	0.13
Preference ratio	0.51	.09	0.00	1.00	-0.36	7.04
JTCI						
Novelty seeking	2.87	.45	1.35	4.09	-0.05	-0.01
Harm avoidance	2.78	.42	1.47	4.05	-0.19	0.03
Reward dependence	3.42	.43	2.20	4.93	0.54	0.33
Persistence	3.45	.40	2.28	4.83	0.33	0.00
Self-directedness	3.51	.41	2.52	4.96	0.37	-0.16
Cooperativeness	3.80	.45	2.16	4.95	-0.06	-0.40
Self-transcendence	3.50	.47	2.00	5.00	0.07	0.21
Standardized academic performance	0.01	.84	-1.53	2.35	0.67	0.28

Note. LPI-s = Learning Process Inventory –Student version; JTCI = Junior Temperament and Character Inventory. Preference ratio calculated as A/(A+B) where A = deep approach score and B = surface approach score.

Table 2.

Summary statistics for multiple regression models testing direct associations of temperament and character with student preference for deep approach (n = 686).

				Model Properties			
Dependent Variable	Predictive Variables	*β*	*p-value*	R^2	*Adjusted* R^2	*F*	*p-value*
Preference for deep approach	Gender	.12	.003	.128	.116	10.62	<.001
	Age	.18	<.001				
	Novelty seeking	-.13	.004				
	Harm avoidance	-.04	.319				
	Reward dependence	.00	.982				
	Persistence	.15	.004				
	Self-directedness	.07	.231				
	Cooperativeness	.03	.643				
	Self-transcendence	.00	.939				

Note. β = standardized beta coefficients. Gender is a dummy variable coded as: Female = 1, Male = 0.

Table 3.

Summary statistics for two-sample t-tests testing the unique effects of self-directedness, cooperativeness, and self-transcendence on student preference for deep approach.

	Preference for deep approach			
	t	*df*	*p*	*d*
Self-directedness				
SCT vs. sCT	3.61	197	<.001	**.55**
SCt vs. sCt	1.66	125	.100	.32
ScT vs. scT	0.68	146	.498	.12
Sct vs. sct	-0.20	210	.841	.03
Cooperativeness				
SCT vs. ScT	2.88	181	.004	**.49**
SCt vs. Sct	2.81	154	.006	**.45**
sCT vs. scT	0.66	162	.511	.11
sCt vs. sct	0.72	181	.471	.13
Self-transcendence				
SCT vs. SCt	1.18	224	.240	.16
ScT vs. Sct	0.17	111	.860	.03
sCT vs. sCt	-0.80	98	.425	.16
scT vs. sct	-0.93	245	.356	.12

Note. SCT = creative. SCt = Organized. ScT = Fanatical. Sct = Autocratic. sCT = Moody. sCt = Dependent. scT = Disorganized. sct = Depressive. Values in bold correspond to "practically" significant effect sizes (d > .41; Ferguson, 2009).

Table 4.

Summary output of hierarchical multiple regression testing predictors of student preference for deep approach.

		R^2	R^2_{adj}	F	β	p
Step 1		.042	.039	14.47		
	Gender				.17	<.001
	Age				.12	.001
Step 2		.078	.074	18.60		
	Gender				.12	.002
	Age				.15	<.001
	Temperament profile				.20	<.001
Step 3		.091	.085	16.39		
	Gender				.11	.003
	Age				.15	<.001
	Temperament profile				.13	.003
	Character profile				.13	.003
Step 4		.097	.090	14.02		
	Gender				.12	.002
	Age				.15	<.001
	Temperament profile				-.02	.808
	Character profile				.05	.423
	Temperament × Character				.22	.040

Note. Gender coded as a dummy variable with female = 1; Temperament coded as a dummy variable with steady profile = 1; Character coded as an ordinal variable ranging from 1 = sct to 8 = SCT