Moreira, Paulo
Inman, Richard A.
Cloninger, Kevin
Cloninger, C. Robert

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Student engagement with school and personality: a biopsychosocial and person-centered approach

Paulo A.S. Moreira[1, 2], Richard A. Inman[2], Kevin Cloninger[3] and C. Robert Cloninger[4]

[1]Instituto de Psicologia e de Ciências da Educação, Universidade Lusíada Porto, Portugal
[2]Centro de Investigação em Psicologia para o Desenvolvimento (CIPD), Portugal
[3]Anthropedia Foundation, Washington, United States
[4]Washington University School of Medicine in St. Louis, Washington, United States

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Corresponding concerning this article should be addressed to Paulo Moreira, Centro de Investigação em Psicologia para o Desenvolvimento (CIPD), Rua de Moçambique 21 e 71, Porto 4100-348, Portugal. Email: paulomoreira@por.ulusiada.pt

CrEdiT Statement:
Paulo Moreira: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Richard Inman**: Data curation, Formal analysis, Software, Visualization, Writing-original draft, Writing – review & editing. **Kevin Cloninger**: Writing – review & editing. **Robert Cloninger**: Conceptualization, Writing – review & editing

Abstract

Background: Engagement with school is a key predictor of students' academic outcomes, yet little is known about its association with personality. No research has considered this association using Cloninger's biopsychosocial model of personality. This model may be particularly informative because it posits the structure of human personality corresponds to three systems of human learning and memory that regulate associative conditioning, intentionality and self-awareness, all of which are relevant for understanding engagement.

Aims: To test for defined personality phenotypes and describe how they relate to student engagement.

Sample: 469 adolescents (54.2% female) attending the eighth (M_{age} = 13.2, *SD* = .57) or 11th (M_{age} = 16.5, *SD* = .84) grades.

Methods: Students completed self-report measures of personality and engagement. We used mixture models to identify latent classes defined by common (a) temperament profiles, (b) character profiles, and (c) joint temperament-character networks, and then tested how these classes differed in engagement.

Results: Latent class analysis revealed three distinct joint temperament-character networks: *Emotional-Unreliable* (emotionally reactive, low self-control and low creativity), *Organized-Reliable* (self-control but not creative), and *Creative-Reliable* (highly creative and prosocial). These networks differed significantly in engagement, with the emotional-unreliable network linked to lower engagement. However, the magnitudes of these differences across engagement dimensions did not appear to be uniform.

Conclusions: Different integrated configurations of the biopsychosocial systems for associative conditioning, intentionality and self-awareness (differences in personality) underlie student engagement. Our results offer a fine-grained understanding of engagement dimensions in terms of their underlying personality networks, with implications for educational policies and practices.

Keywords: student engagement with school, personality, temperament, character, person-centred.

Student engagement with school and personality: a biopsychosocial and person-centered approach

Student engagement is a popular construct for understanding students' participation in, and subjective experiences of, school (Appleton, Christenson, & Furlong, 2008; Fredricks, Blumenfeld, & Paris, 2004). The associations between student engagement and important academic outcomes such as academic performance and school completion are now well-documented (Lee, 2014; Li & Lerner, 2011; Wang & Fredricks, 2014; Wang & Holcombe, 2010). Important developments have also been made to the current understanding of how engagement changes over time (Archambault & Dupéré, 2017; Zhen et al., 2019), and how this change is influenced by contextual factors (Moreira et al., 2018; Moreira & Lee, 2020; Wang & Eccles, 2012a).

Despite these empirical advances, researchers still know surprisingly little about how personality dimensions influence engagement (Wang & Degol, 2014). This is surprising because theory and research from the behavioural sciences have consistently highlighted that subjective experiences are an expression of the interactions between intrapersonal characteristics and contextual factors (e.g. Bronfenbrenner, 2005). Consequently, a current challenge in engagement research is to provide a description of how student engagement varies according to individual differences in personality (Wang & Degol, 2014). The broad objective of the present study was to meet this challenge using a biopsychosocial perspective of personality.

Student Engagement

Student engagement is commonly described as a multidimensional construct with three major indicators: behavioural, emotional, and cognitive (Appleton et al., 2008; Fredricks et al., 2004; Moreira, Cunha, & Inman, 2020; Wang, Degol, & Henry, 2019). Typically, behavioural engagement has been measured in terms of observable behaviours (Finn & Rock, 1997) including positive student conduct, involvement in

learning and schoolwork, and participation in school activities (Fredricks et al., 2004). Cognitive engagement integrates constructs from the motivation literature (psychological investment) and learning literature (self-regulatory behaviours and cognitive processes) (Fredricks et al., 2004). Measures of cognitive engagement incorporate subscales that assess perceptions of control and relevance of schoolwork, future aspirations and goals, and intrinsic motivation (Appleton et al., 2008), as well as problem-solving skills or ability to cope with failure (Fredricks et al., 2004). Finally, emotional engagement has been defined in terms of students' affective reactions to the school context (Ladd & Dinella, 2009), and feelings of identification and belonging (Appleton, Christenson, Kim, & Reschly, 2006). Students high in emotional engagement typically enjoy and give positive value to school activities (Finn, 1989).

Student engagement is conceptualized as a mediator between contextual factors and learning outcomes (Connell & Wellborn, 1991; Skinner, Wellborn, & Connell, 1990) and is maximized when students perceive that important contexts meet their basic psychological needs for competence, autonomy, and relatedness (*Self-Determination Theory*; Ryan & Deci, 2017; Vansteenkiste et al., 2020). Students with stronger prior academic performances, helping to satisfy the need for competence, are often more engaged (Chase, Hilliard, Geldhof, Warren, & Lerner, 2014). Moreover, the typical decline in student engagement over time is lessened when students perceive better support for autonomy by teachers and more social support from peers (Moreira & Lee, 2020). Considering this characteristic, it follows that student engagement is malleable and can be shaped by contextual influences (Wang & Holcombe, 2010). Consequently, it is becoming increasingly popular for measures of student engagement to incorporate students' *perceptions* of support from teachers, peers, and family alongside emotional, behavioural, and cognitive indicators to capture the fit between students and their environments (Appleton et al., 2006; Moreira, Cunha, et al., 2020).

Student Engagement and Personality: Current Research

A small body of work has considered the engagement-personality association using lexical models of personality, and namely the five-factor model (FFM; Costa & McCrae, 1992). Most of these studies, however, have not focused specifically on student engagement, and have used adult samples. For example, in a study of undergraduates, Komarraju and Karau (2005) found that extraversion and openness were significant predictors of a set of academic motivations, which the authors labelled "engagement motives". People with these engagement motives enjoy learning, have a desire for self-improvement, and enjoy the social aspect of education (indicators of emotional and cognitive engagement). In another study of undergraduates, agreeableness and conscientiousness were predictors of cognitive engagement; extraversion, agreeableness, conscientiousness and openness were predictors of behavioural engagement; and agreeableness was predictive of emotional engagement (Qureshi, Wall, Humphries, & Bahrami Balani, 2016). Finally, a meta-analysis of 114 independent samples found that conscientiousness and extraversion were the strongest predictors of employee engagement (Young, Glerum, Wang, & Joseph, 2018).

Researchers have argued the FFM offers an incomplete description of personality (Ashton & Lee, 2007; Cloninger et al., 1993) because of its reliance on linear factor analysis to derive its personality factors (Veselka, Schermer, & Vernon, 2012). While personality dimensions derived from linear factor analyses have predictive validity (Grucza & Goldberg, 2007), they are problematic for describing the causal structure of personality (Cloninger et al., 1993). In many cases, such dimensions incorporate multiple qualitatively distinct biopsychosocial systems and are not etiologically independent (Cervone, 2005; Cloninger, 2008; de Fruyt et al., 2000). Because frameworks that integrate evidence from behavioural genetics, neurobiology, and psychology allow for a more comprehensive understanding of the structure of personality (Munafò & Flint, 2011; Veselka et al., 2012) there is a need to adopt them in student engagement research.

The Biopsychosocial Model of Personality

The biopsychosocial model conceptualizes personality as the dynamic organizations that regulate the way individuals learn to shape and adapt to internal and external environments. At its core, it describes two distinct components of personality, *temperament* and *character*, that are regulated by various different biopsychosocial systems (Cloninger et al., 1993). The temperament dimensions of this model reflect the innate dispositions that influence how individuals automatically and spontaneously learn to behave, react emotionally, and form attachments via the mechanisms of associative conditioning involved in the procedural system of learning and memory (Cloninger, Cloninger, Zwir & Keltikangas-Jarvinen, 2019). In turn, the character dimensions of the biopsychosocial model correspond to organizations of higher-order cognitive processes that shape what people intentionally make of themselves (Cloninger, 2004). This self-government involves two systems of learning that regulate intentionality and self-awareness; the former regulating self-control based on personal goals, values, and facts (*what* am I going to do?), and the second regulating evaluations and appraisals of one's intentions and values in context (addressing the questions *why*, *where*, and *when?*) (Zwir et al., 2019). In other words, the biopsychosocial model posits that human personality is founded on three genetically and biologically distinct systems of learning and memory: the procedural system (habits and skills via associative learning), the prepositional system (logical and semantic), and the episodic system (capacity for self-awareness and introspection).

Recent research demonstrates that human personality has a hierarchical architecture (Zwir et al., 2019). According to this architecture, personality can be organized in ascending descriptive complexity from: (a) individual temperament and character dimensions, (b) sets of genes linked to temperament and character dimensions (Zwir et al., 2018a, 2018b), (c) genetically independent multi-trait temperament and character profiles (Cloninger & Zwir, 2018; Zwir et al., 2018b, 2018a), and (d) joint networks of temperament and character profiles corresponding to

the three major systems of learning and memory (Zwir et al., 2019). For the purpose of the study, we will focus on personality dimensions, personality profiles, and joint personality networks:

Temperament and Character Dimensions

The biopsychosocial describes four temperament and three character dimensions that are measured by the scales of Cloninger's Temperament and Character Inventory (TCI; Cloninger, 1999). The four temperament dimensions have been shown to reflect structural differences in neuroanatomy (e.g. Gardini et al., 2009). Novelty seeking (impulsive vs. deliberate) relates to the behavioural activation motivation system and is responsible for the activation of behaviour in response to novelty. Harm avoidance (fearful vs. risk-taking) is related to the behavioural inhibition motivation system and the tendency to inhibit behaviour in the presence of aversion. Reward dependence (sentimental vs. detached) describes sensitivity to reward and tendency to maintain behaviour. Persistence (determined vs. easily discouraged) describes the resistance to behavioural extinction after the removal of reward.

The three character dimensions have been linked to brain networks associated with meta-cognitive processes, including self-reflection and goal setting (van Schuerbeek, Baeken, de Raedt, de Mey, & Luypaert, 2010). Self-directedness (purposeful vs. aimless) describes the ability to regulate behaviour in accordance with one's values and standards. Cooperativeness (helpful vs. self-centred) describes one's awareness of being a member of a group or community. Finally, self-transcendence (altruistic vs. individualistic) describes an awareness of being part of a holistic reality that transcends the individual and is associated with spirituality.

Temperament and Character Profiles

Various person-centred studies have demonstrated that individuals can be clustered according to distinct configurations of traits. For example, using latent profile analysis Rettew, Althoff, Dumenci, Ayer and Hudziak (2008) identified clusters of children characterized by either high persistence and low novelty seeking (the "steady"

profile), average levels across temperament dimensions (the “moderate” profile), or high novelty seeking and harm avoidance and low reward dependence and persistence (the “disengaged” profile). Using machine-learning methods, Zwir et al. (2018b) identified three heritable temperament profiles that they called the “reliable”, “antisocial” and “sensitive” profiles . These profiles were considered close matches to the more classic “easy”, “slow to warm-up” and “difficult” temperament types, respectively (Thomas, Chess, & Birch, 1968). Despite identifying slightly different profiles, these studies converge in their conclusion that temperament profiles influence learning processes and outcomes. Research indicates that individuals with more “difficult” temperament profiles (higher novelty seeking and lower persistence) have lower social functioning, higher levels of psychopathology, more ill-being (Rettew et al., 2008; Zwir et al., 2018b) and less adaptive approaches to learning (Moreira et al., 2020) than those with more “easy” temperaments. Given that engagement represents adaptive functioning in the context of school, it follows that individuals with “easy” temperaments may be more likely to be engaged. Indeed, the conscientiousness dimension from the FFM, which is associated with low novelty and high persistence (de Fruyt et al., 2000), has been linked to higher levels of engagement (Young et al., 2018).

Similarly, Zwir et al. (2018a) identified five clusters of individuals with unique heritable character profiles. Three of these profiles reflect healthy personalities: the “creative” (high in all three character dimensions), “organized” (high self-directedness and cooperativeness), and “resourceful” profiles (high self-directedness). The two remaining profiles -- the “dependent” (high cooperativeness) and “apathetic” profiles (low in all three dimensions) -- were regarded as unhealthy. Research has shown that healthy character profiles, and particularly the creative profile, are positively associated with health and wellbeing (Cloninger & Zohar, 2011; Josefsson et al., 2011; Moreira et al., 2015; Zwir et al., 2018a) and adaptive functioning in educational contexts (Moreira, Inman, Rosa, et al., 2020). Moreover, individuals with unhealthy character profiles are

considered at risk of illbeing and personality disorder (Svrakic, Whitehead, Przybeck, & Cloninger, 1993).

Joint Temperament-Character Networks

Researchers have shown a growing interest in studying the dynamic non-linear interactions among different biopsychosocial systems. As described above, various studies have begun to tap into such interactions via the identification of multi-trait profiles. However, almost all of these studies considered temperament profiles or character profiles *separately* (Cloninger & Zohar, 2011; Moreira et al., 2015; Rettew et al., 2008; Zwir et al., 2018b, 2018a). Recently, Zwir et al. (2019) have shown that the genetically separate temperament profiles and character profiles are integrated via genetic-environment interactions to form complex joint personality networks. Specifically, they identified three subgroups of individuals with distinct networks of temperament and character profiles; the *Creative-Reliable* (those who were more creative, prosocial, and insightful in appraisal of values and theories), *Organized-Reliable* (those with strong self-control of emotional conflicts and goals, but little creativity), and *Emotional-Unreliable* networks (those who are emotionally reactive with little regulation or creativity). These networks were highly correlated with three specific genetic sets, each of which regulates different biopsychosocial systems of learning and memory. In other words, the individuals occupying each network expressed prototypical features of one of the three major systems of learning and memory (i.e. the procedural system for associative learning, the prepositional system for intentionality, and the episodic system for self-awareness). Moreover, the creative-reliable network was made up of subjects who were typically healthy (increased wellbeing) while the emotional-unreliable network was made up of subjects who were less healthy (lowest wellbeing and highest illbeing). In short, this study demonstrated that heritable temperament and character profiles do not function independently, and that healthy functioning involves the integration of three biopsychosocial systems of learning and

memory that regulate associative conditioning, intentionality and self-awareness (Cloninger & Cloninger, 2020).

Student Engagement as an Expression of Biopsychosocial Systems

We have described Cloninger's conceptualization of personality as the complex, dynamic, and non-linear interactions between multiple biopsychosocial systems that regulate associative conditioning (useful for rote learning), intentionality (useful for logical reasoning based on assumptions), and self-awareness (useful for integrating experiences into a narrative with theory and values). We argue this correspondence between human personality and human learning is highly relevant for understanding change in engagement because this process, which is highly dependent on the interaction between a student's environment and personal characteristics, involves the acquisition of adaptive habits, semantic knowledge and a pro-school identity (Moreira, Cunha, Inman, & Oliveira, 2019). Specifically, change in student engagement requires: a) the acquisition of adaptive (and extinction of maladaptive) pro-school habits and emotional responses via associative conditioning; b) the learning of pro-school concepts, values, beliefs, and goals to inform logical reasoning and foster intentional self-regulation at school; and c) self-actualization and the development of a pro-school identity via the episodic integration of experience with theory and values. In other words, they proposed that student engagement can be considered an expression of interacting systems of learning and memory (i.e. an expression of personality).

The Present Study

Our overarching objective was to describe how differences in personality relate to student engagement, and to do so using Cloninger's biopsychosocial model. By doing this, we aimed to provide novel insights into student engagement as an expression of interacting biopsychosocial systems that regulate associative conditioning, intentionality, and self-awareness (i.e. as an expression of personality). As described above, personality has a hierarchical structure, with joint temperament-character networks representing integrated configurations of genetically distinct temperament

and character profiles, which are themselves integrated configurations of individual temperament and character dimensions, respectively (Zwir et al., 2019). Considering this evidenced architecture, we chose first to identify groups of students with distinct temperament and character profiles, and then to use this profile membership to identify clusters of students with distinct combinations of temperament and character profiles. At each step, we explored differences in engagement as a function of personality. As far as we are aware, this study is the first to try and identify naturally occurring joint temperament-character networks in adolescents -- most prior studies have considered children (Rettew et al., 2008) or adults (Zwir et al., 2019) – and the first to consider the role of personality biopsychosocial profiles and networks in the context of education.

Based on prior research and theory, we had tentative expectations about the number of latent classes that would emerge (Cloninger, 2004; Rettew et al., 2008; Zwir et al., 2018b, 2018a, 2019). However, we refrained from making explicit predictions about the number of emergent classes, or their characteristics, because these are highly sample dependent. Nonetheless, we expected that the identified clusters would present differences in student engagement (Cloninger & Cloninger, 2013; Cloninger & Cloninger, 2020; Moreira, Inman, et al., 2020). We were particularly interested in differences in engagement as a function of students' integrated configurations of the three psychobiological systems for associative conditioning, intentionality and self-awareness. We therefore hypothesized that students occupying phenotypic networks that imply high levels of creativity and self-control would display the highest engagement. In contrast, we hypothesized that students occupying phenotypic networks that imply high emotional reactivity and low self-control and creativity would display the lowest engagement.

Method

Participants

The present study comprised adolescent students who participated in an ancillary wave of data collection as part of the **Portuguese Longitudinal Studies of**

Student Engagement in School. Details of this longitudinal study are provided online at osf.io/2qj4m. In total, 567 students from 22 schools participated in this wave of data collection. The schools and students in this sample were not significantly different from the wider sample participating in the longitudinal study (see Supplementary Table S1 and S2).

Prior to analysis, we excluded all students from three schools because all students from these schools omitted entire questionnaires, including the measure of engagement. Hence, the final study sample comprised 469 students (54.2% female) attending 19 schools. These schools were broadly representative of schools in Portugal, including middle schools (7^{th} to 9^{th} grades; *n* = 6), secondary schools (10^{th} to 12^{th} grades; *n* = 4) and mixed schools (7^{th} to 12^{th} grades; *n* = 9). Most schools were public (*n* = 16), and two schools were secondary schools offering vocational courses. In total, 230 students were in the first semester of eighth grade (mean age = 13.2 years, *SD* = .57), and 239 students were in the first semester of 11^{th} grade (mean age = 16.5 years, *SD* = .84).

Study Measures

As part of the broader longitudinal study, students completed a battery of self-report questionnaires (for full details see online at osf.io/83rpw). For the present article, we considered the following variables:

Temperament and Character

We used the Portuguese version of the Junior Temperament and Character Inventory (JTCI; Luby, Svrakic, Mccallum, Przybeck, & Cloninger, 1999) which has been validated for use with Portuguese adolescents (Moreira et al., 2012). This measure has 127 items scored on a five-point scale from 1 (*completely false*) to 5 (*completely true*). The JTCI has seven subscales corresponding to the temperament and character dimensions described by the biopsychosocial model of personality. In the present study sample, ordinal omega (ω) coefficients across subscales were > .72 (see Table 1).

Student Engagement

Participants completed the Student Engagement Instrument (Appleton et al., 2006) and the Student School Engagement Survey (National Center for School Engagement, 2006). We assessed student engagement using a comprehensive multidimensional scale that is derived by integrating items and dimensions from these two instruments: the 27-item Multifactorial Measure of Student Engagement (MMSE; Moreira, Cunha, et al., 2020). The MMSE has seven subscales. Two subscales assess subtypes of behavioural engagement: 1) behaviours related to student conduct ("I treat my teachers with respect"); and 2) study behaviours ("I check my schoolwork for mistakes"). The remaining subscales assess emotional engagement ("I feel like I belong in my school"), cognitive engagement ("What I'm learning in my classes will be important in my future"), and students' subjective *perceptions* of teacher, support for learning ("At my school, teachers care about students"), peer support for learning ("Other students at school care about me"), and family support for learning ("When I problems at school my family are willing to help me"). In the present study sample, ordinal ω coefficients across subscales were > .79 (Table 1).

Control Variables

We controlled for student prior academic performance, age, and gender (0 = male; 1 = female) in our analyses because these factors are shown to influence student engagement (Lietaert, Roorda, Laevers, Verschueren, & De Fraine, 2015; Moreira et al., 2018; Wang & Eccles, 2012b). We considered students' academic performances in standardized national exams to be a proxy for academic ability. We obtained students' grades for their most recent standardized national exams in Portuguese Language and Mathematics from school records. Students take these two exams at the end of the fourth, sixth, and ninth grades. Each is graded on a numerical scale from 0.0 (lowest) to 5.0 (highest). Given the strong correlation between these measures, r = .53, and a Cronbach's alpha coefficient of .68, we calculated a mean average grade as a higher-order indicator of prior academic performance. Student

gender and age were obtained from a socio-demographic questionnaire applied in the first wave of the broader longitudinal study.

Procedures

All students obtained informed parental consent prior to participation. Within each school, a member of staff acted as a liaison between the school and the research team. This member of staff was responsible for their schools' internal procedure for data collection. Students completed the full battery of questionnaires (including measures not considered in the present study), split into three parts, in three hour-long classes. These three classes occurred on the same day and at the same time in three consecutive weeks, although the specific day and hour was dependent on the internal procedure of each school. The order in which the three parts of the battery of questionnaires was presented was counterbalanced at the school level. The measures considered in the present study (student engagement measures and the JTCI) were not administered in the same session. The questionnaires were headed with instructions to respond without over-thinking each item and to answer truthfully.

Data Analysis

All analyses were conducted using R (Version 3.6.1, R Core Team, 2019). Data is available online at osf.io/he6ut. R code is available at osf.io/3ycfq. Before formal analyses, we tested the randomness of missing data. For both the JTCI and MMSE, results showed no evidence to reject the hypothesis that data were missing completely at random. Hence, we used a median imputation to deal with missing values. Next, we conducted analyses in three stages to describe how student personality, described at ascending levels of complexity (from dimensions to independent temperament and character profiles to joint temperament-character networks; Zwir et al., 2019), relates to student engagement (see Moreira, Inman, & Cloninger, 2020, for an example of the same approach).

The first stage considered the linear relationships between personality and engagement dimensions, and thus required variable-centred methods. Thus, we calculated Pearson correlations between scales. We considered correlations > |.20| as being "practically" significant (Ferguson, 2009).

For the second stage, we used mixture models to identify groups of students characterized by a) common temperament profiles, and then b) common character profiles. Because these models were estimated using standardized mean scores (continuous data) for the four temperament and three character dimensions, respectively, it was necessary to use Latent Profile Analysis (LPA). We identified the optimal number of latent classes by comparing the fit of a series of models with increasing numbers of classes. Model fit was assessed using AIC (Akaike, 1974), BIC (Schwarz, 1978), sample-size adjusted BIC (Sclove, 1987), entropy (Celeux & Soromenho, 1996) and the results of an analytic hierarchy process (Akogul & Erisoglu, 2017)[1]. Low values for AIC, BIC and SABIC were favoured, while high values for entropy were favoured. When multiple solutions were possible, preference was given to the model chosen by the AHP. We then conducted MANCOVAs to test differences in student engagement dimensions across temperament and character classes after controlling for prior academic performance, student age and gender.

For the third stage, we used mixture models to identify groups of students characterized by common joint temperament-character networks. Because these joint networks represent the integration of distinct temperament and character profiles, and not individual dimensions (Zwir et al., 2019), models were estimated using students' assigned temperament and character profiles coded as categorical variables, thus requiring Latent Class Analysis (LCA). We identified the optimal number of latent classes using the same indices described above (but excluding the AHP). We then

[1] This hierarchical analytical process integrates information from several fit indices (AIC, AWE, BIC, CLC and KIC), weighted according to their tendency to extract the correct number of clusters, and selects the best model.

conducted a third MANCOVA to test differences in student engagement dimensions across joint temperament-character networks controlling for prior academic performance, student age, and gender.

Results

JTCI Dimensions and Student Engagement

Table 1 presents scale descriptive statistics and zero-order correlations between JTCI and student engagement dimensions. The results showed that novelty seeking had negative associations with student engagement dimensions, while reward dependence, persistence, self-directedness and cooperativeness had positive associations with student engagement dimensions.

Temperament and Character Profiles and Student Engagement

Temperament Profiles

Latent Profile Analysis. Table 2 Panel A presents model fit indices for the five temperament LPA solutions. We identified the 3-class solution as the optimal solution based on the combination of low BIC (5239.4) and support from the analytic hierarchy process. Students in class one (n = 232) had a temperament profile characterized by moderately high novelty seeking, and moderately low reward dependence and persistence (see Figure 1A), and therefore resembled individuals with a “slow to warm up” temperament. Students in class two (n = 200) had a temperament profile characterized by moderately low novelty Seeking, and moderately high reward dependence and persistence, and therefore resembled individuals with an “easy” temperament. The smaller number of students in class three (n = 37) had an extreme variant of the easy profile, and we therefore labelled this the “very easy” temperament. Table 3 shows these temperament profiles had significantly different gender compositions, $\chi^2(2) = 13.20$, $p = .001$, and differed in age, $F(2, 466) = 3.15$, $p = .044$, $\omega^2 = .009$.

Effect of Temperament Profile on Student Engagement. A MANCOVA revealed a significant effect of temperament profile on student engagement

dimensions, $F(14, 912) = 6.62$, $p < .001$, Pillai's trace = .18, after controlling for student age ($p < .001$, Pillai's trace = .11), gender ($p = .004$, Pillai's trace = .04), and prior academic performance ($p < .001$, Pillai's trace = .05). Follow-up univariate analyses showed that there was a significant main effect of temperament profile for all seven of the student engagement dimensions. Post-hoc comparisons for each of the univariate analyses (Table 3) indicated that the slow to warm up profile had significantly lower engagement than the easy and very easy profiles. The easy and very easy profiles did not differ significantly for any of the engagement dimensions apart from study behaviours, where the very easy profile had higher levels.

Character Profiles

Latent Profile Analysis. Table 2 Panel B presents model fit indices for the eight character LPA solutions. We identified the 5-class solution as the best solution based on the low values for BIC (3882.1) and support from the analytic hierarchy process. We assigned labels to these profiles considering traditional descriptions by Cloninger (2004). Students with an "apathetic" character profile ($n = 58$) had low levels of all character dimensions (see Figure 1B). Students with a "diffuse" character profile ($n = 218$) had slightly lower than average levels of all three character dimensions. Students with a "moody" profile ($n = 130$) had elevated cooperativeness and self-transcendence compared to self-directedness. Students with an "organized" profile ($n = 24$) had high self-directedness and cooperativeness, but low self-transcendence. Finally, students with a "creative" character profile ($n = 39$) had high levels of all three character dimensions. These character profiles differed in terms of gender composition, $\chi^2(4) = 29.62$, $p < .001$, but not age ($p = .285$) (Table 3).

Effect of Character Profile on Student Engagement. A MANCOVA revealed a significant effect of character profile on student engagement dimensions, $F(28, 1824) = 2.98$, $p < .001$, Pillai's trace = .18, after controlling for student age ($p < .001$, Pillai's trace = .10), gender ($p = .004$, Pillai's trace = .05), and prior academic performance ($p = .001$, Pillai's trace = .05). Follow-up univariate analyses showed that there was a

significant main effect of character profile for six of the seven student engagement dimensions. However, there was a non-significant effect of character profile for family support for learning, $F(4, 459) = 1.94$, $p = .103$. Post-hoc comparisons showed the apathetic profile had significantly lower engagement than the creative profile. It was also notable that the organized and creative profiles were only significantly different for peer support for learning.

Joint Temperament-Character Networks and Engagement

Latent Class Analysis*.* Table 2 Panel C presents model fit indices for the LCA solutions. We identified the 3-class model as the optimal solution because of the minimum values for AIC (1972.2) and SABIC (1937.8)[2]. Figures 3A and 3B illustrate the compositions of these joint temperament-character networks. Given their similarities to the networks of Zwir et al. (2019), we used the same labels. The *Emotional-Unreliable* network ($n = 192$) comprised students with a slow to warm up temperament profile (98%) and either a diffuse (70%) or apathetic (30%) character profile. The *Organized-Reliable* network ($n = 220$) mostly comprised individuals with an easy temperament profile (81%) combined with either a moody (54%) or diffuse (36%) character profile. Thus, the overall tendency was for moderately developed self-directedness and cooperativeness, and low self-transcendence. The *Creative-Reliable* network ($n = 57$) mostly consisted of students with a very easy (65%) or easy (30%) temperament profile, with a large percentage also having a creative (68%) character profile (with 21% having a moody character). These networks differed in terms of gender composition, $\chi^2(2) = 25.61$, $p < .001$, but not age ($p = .158$) (Table 3)

Effect of Joint Network on Student Engagement. A MANCOVA revealed a significant effect of personality network on student engagement dimensions, $F(14, 912) = 5.95$, $p < .001$, Pillai's trace = .17, after controlling for student age ($p < .001$, Pillai's

[2] We gave preference to the 3-class solution over the 2-class solution (supported by BIC and entropy) because research suggests AIC and SABIC are more accurate than BIC (Henson, Reise, & Kim, 2007; Yang & Yang, 2007).

trace = .11), gender (p =.004, Pillai's trace = .04), and prior academic performance (p < .001, Pillai's trace = .05). Follow-up univariate analyses showed that there was a significant main effect of personality network for all seven of the student engagement dimensions. Post-hoc comparisons indicated that the creative-reliable and organized-reliable networks generally had significantly higher engagement than the emotional-unreliable network (apart from family support for learning, where the organized-reliable network was not significantly higher than the emotional-unreliable network). In contrast, the creative-reliable and organized-reliable networks only differed significantly for study behaviours, cognitive engagement, and perceptions of support from teachers and peers.

Discussion

The present study contributes to current research on the link between student engagement with school and personality by being the first to consider this association using Cloninger's biopsychosocial model of personality (Cloninger, 2004). A first finding of the study was the identification of distinct subgroups in our sample of adolescents defined by similar configurations of temperament and character traits. Crucially, these emergent latent classes were broadly consistent with temperament and character profiles that have been identified in prior person-centred studies on personality using child and adult samples (Rettew et al., 2008; Thomas et al., 1968; Zwir et al., 2018b).

We identified two main temperamental styles across three profiles. One of these styles described individuals who have a tendency to be more independent, easily discouraged and rule breaking. In contrast, the second style (i.e. the easy and very easy profiles) captured individuals with a tendency to be friendly, determined and orderly. Furthermore, we found that "slow to warm up" students tended to be less engaged in school than "easy" students. Our study therefore contributes to the current understanding of the role of personality in engagement by demonstrating students' subjective experiences of school are related to these individual differences in temperament. In other words, *how* students tend to behave and express themselves

spontaneously as an expression of individual differences in associative conditioning (e.g. habit acquisition) is fundamental for understanding student engagement in school. This aligns with current evidence that individual differences in temperament are relevant to understanding broader positive functioning, including wellbeing and longevity (Zwir et al., 2019).

In addition to temperament styles, we also identified five distinct character profiles. Three of these profiles -- the apathetic, diffuse and moody profiles -- were considered more unhealthy characters due to the average-to-low levels of self-directedness (Svrakic et al., 1993). The two remaining profiles (the organized and creative characters) reflected healthy characters. People with organized or creative characters are typically the most healthy and happy (Cloninger & Zohar, 2011) and have more adaptive functioning at school (Moreira et al., 2020), although those with a creative profile are more intuitive, meditative, spiritual, tolerant of ambiguity and receptive to change (Cloninger, 2013), and thus typically experience a more joyful life (Cloninger & Cloninger, 2020). Our study broadly suggested that students with healthy characters were more engaged with school than those with unhealthy characters. However, the trend was clearly nonlinear, as can be expected given that the components of personality are fundamentally nonlinear in their functional effects and relationships with one another (Cloninger, 2008). The fact that the moody and creative characters had the highest engagement suggests that self-transcendence (the ability to become absorbed in what one enjoys doing and thus identify with something that transcends the self; Cloninger, 2004) has a non-linear effect on engagement. In short, our study suggests that engagement in school may be an expression of the dynamic nonlinear interactions between character dimensions.

A major finding of the study was the identification of three joint temperament-character networks that were similar to those identified by Zwir et al (2019). Each of these networks had within them a complex set of temperament-character relationships but, critically, each had configurations that implied differences in how students learn to

shape and adapt to internal and external environments via the three dissociable systems of learning and memory. Students occupying the creative-reliable network were characterised by developed self-awareness and intentional self-control (implying high creativity, prosociality and insightfulness). Students occupying the organized-reliable network were characterised by developed intentional self-control but less developed self-awareness (implying developed ability to regulate emotional conflicts and goals, but little creativity). Finally, students occupying the emotional-unreliable network were characterised by low intentional self-control and self-awareness, implying high emotional reactivity and little self-control or creativity.

Consistent with our hypotheses, the three networks differed in their levels of student engagement. Specifically, creative and self-aware students had higher than average engagement compared to their peers. Students with developed self-control, but little creativity, had roughly average levels of engagement. This result aligns with theory and prior works that describe healthy human personality and the importance of the creative character (Cloninger, 2004, 2013). In comparison, emotionally reactive students with low self-control and creativity had lower engagement. Our results are thus consistent with current conceptualizations of engagement as a developmental process that depends on adaptive organizations of self-regulation (e.g. the use of adaptive learning strategies), self-actualization (e.g. identification with school), and positive automatic behaviours and emotions (e.g. affective reactions to school and student conduct) (Appleton et al., 2008; Fredricks et al., 2004; Moreira, Cunha, et al., 2020). It was noteworthy that this broad multivariate effect was replicated across the individual student engagement dimensions, but that the patterns and magnitudes of these effects did not appear to be uniform across dimensions. Specifically, for study behaviours, cognitive engagement, teacher support and peer support there were significant differences between all three networks. In contrast, for student conduct, emotional engagement and family support for learning the differences between the organized-reliable and creative-reliable networks were nonsignificant. While we did not

test if these differences in trends were statistically meaningful, these observations suggest that different biopsychosocial processes may be of varying relevance across engagement dimensions. For example, higher-order regulatory processes for self-awareness (those that give coherence and meaning to behaviours, thus addressing the question *why*?) appear to be relevant to promoting and understanding adaptive study behaviours, but less important for the adherence to rules and basic standards for conduct (which are linked to *how* a student tends to be and their ability to regulate *what* they do).

The distributions of student engagement scores within each joint temperament-character network indicated personality is not deterministic of student engagement. Instead, our results suggested that certain types of student are more at risk of lower engagement. For example, many students occupying the emotional-unreliable network were highly engaged in school. Oppositely, many students occupying the organized-reliable and creative-reliable networks had lower than average engagement. Such results can be explained by the malleable and contextually influenced nature of engagement. Research has shown that certain school features and teacher practices (e.g. support for autonomy in class) are beneficial for student engagement (Moreira & Lee, 2020; Olivier, Galand, Hospel, & Dellisse, 2020; Wang & Eccles, 2012b). Having offered new insights into how different types of students typically differ in student engagement, we acknowledge that future research needs to examine how personality profiles and networks interact with environmental contexts to shape student engagement.

Study Limitations

A first limitation of the study was that it had a cross sectional design, meaning the causal influence of personality on engagement cannot be demonstrated. However, Cloninger's temperament and character dimensions have been shown to have predictive validity in prospective studies (Grucza & Goldberg, 2007). Future studies

with longitudinal designs are required to determine the longitudinal effects of different temperament and character profiles on student engagement and academic outcomes.

Second, it is important to recognize that all study measures were self-reported. This methodological choice is frequently criticized for issues such as low construct validity (due to method biases resulting from acquiescence and social desirability) and common method variance, although these limitations are arguably exaggerated (Chan, 2009). Future studies will benefit from considering alternative sources of information, such as teacher- and parent-reports, or by controlling for bias, such as by including measures of social-desirability response bias (van de Mortel, 2008).

Finally, we acknowledge that the emergent personality profiles and networks may not be generalizable to other student samples, particularly those outside of Portugal and those of different ages (such as elementary school students). Nevertheless, their consistency with other profiles identified in independent samples (Rettew et al., 2008; Thomas et al., 1968; Zwir et al., 2019) serves as good evidence for their validity.

Implications for Educational Practice

What teachers do, and how schools are organized, have important influences on students' subjective experiences and, therefore, positive development. By developing a nuanced understanding of how students with various personality characteristics experience school subjectively, our findings may help identify which students are most at risk of lower engagement (or disengagement) and inform the development of targeted learning strategies and educational contexts for promoting the most positive developmental outcomes in all types of student. Specifically, our results imply that engagement with school is linked to student self-actualization and identity formation, which are optimized by a developed sense of self-awareness and intentionality. Thus, the promotion of engagement requires the provision of educational conditions and interventions that allow students to develop an integrated synergy between self-directedness, cooperativeness and self-transcendence (i.e. conditions that promote

holistic creative development) (Cloninger & Cloninger, 2013) and adaptive student identity (Moreira, Inman Cunha & Cardoso, 2019). At a broad level, this might be achieved by shifting current educational paradigms to person-centred schooling as a means to promoting personality development (Moreira & Garcia, 2019).

Conclusions

The present study provides novel insights into how personality traits and profiles interact to influence student engagement. We identified three temperament profiles and five character profiles that differed in student engagement. These differences highlight the importance of focusing on configurations of temperament and character that describe students as whole individuals. Moreover, we found that students were clustered into three joint temperament-character networks that represent different integrated configurations of three major systems of learning and memory that regulate associative conditioning, intentional self-control and self-awareness. These networks were linked to differences in student engagement, and there was some indication the magnitudes of these differences varied across engagement dimensions. These results imply that student engagement is an expression of a healthy and creative personality defined by high intentional self-control and self-awareness, and offer a fine-grained understanding of engagement dimensions in terms of their underlying personality processes, with implications for educational policies and practices.

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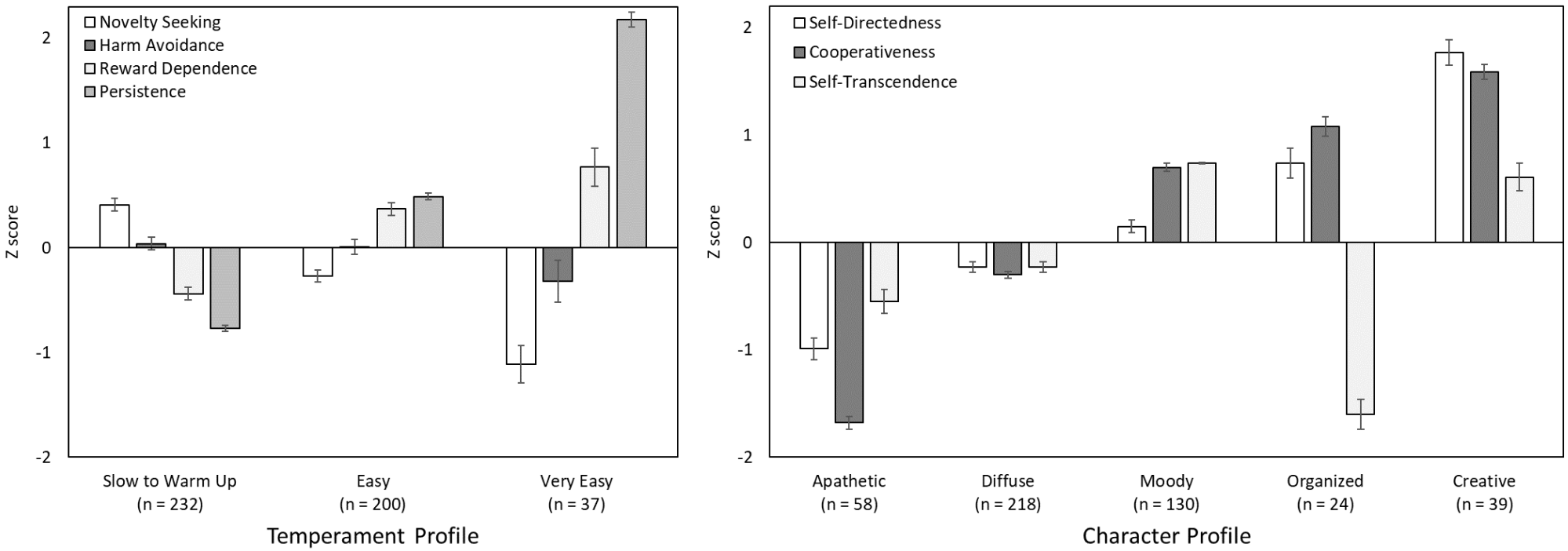

Figure 1. Z scores for the three temperament profiles (left-hand panel) and five character profiles (right-hand panel). Error bars indicate ±1 95% CIs.

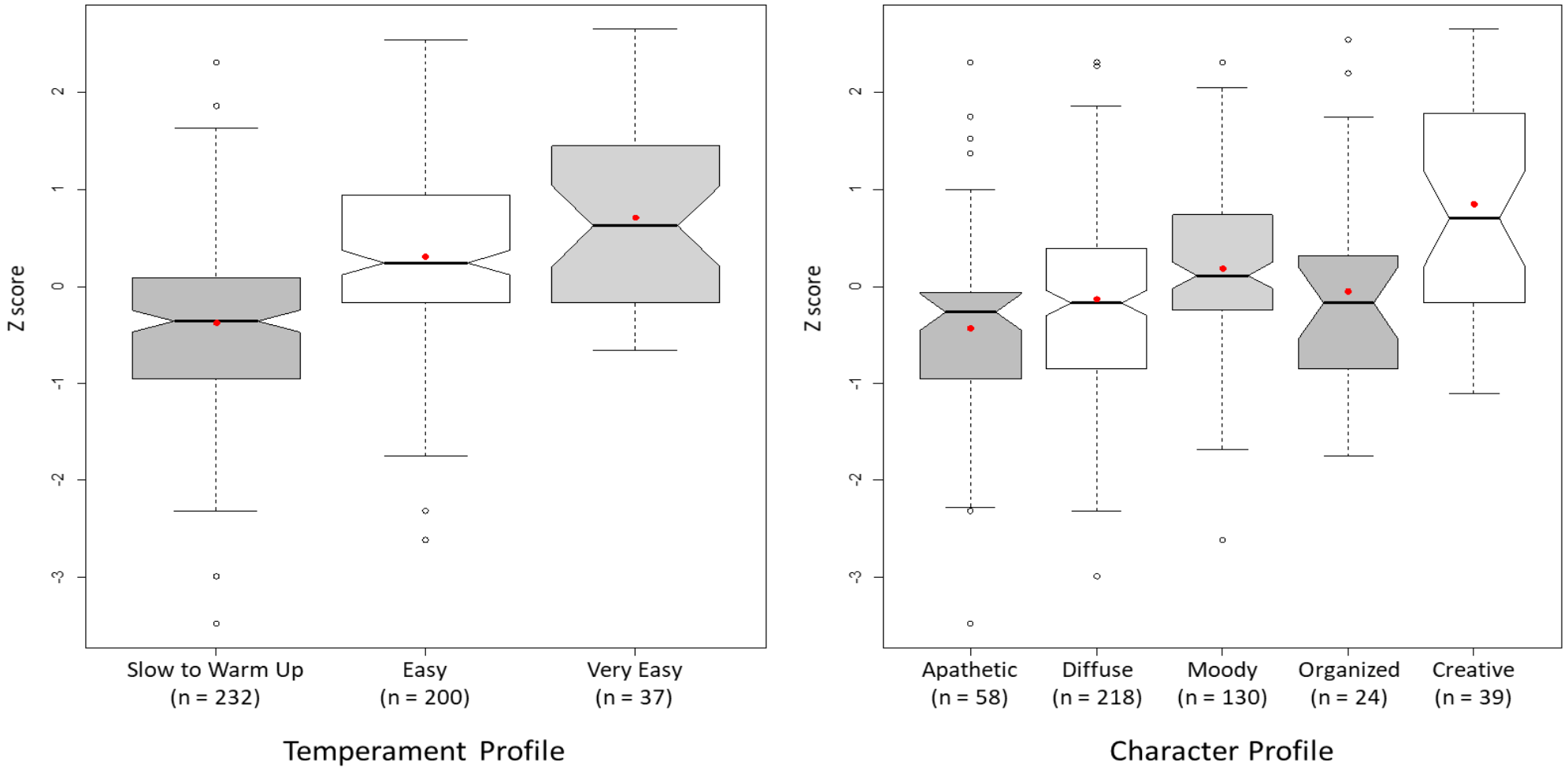

Figure 2. Notched box plot of global student engagement z scores for the three temperament profiles and five character profiles. Notches correspond to 95% CIs for group medians. White circles represent outliers. Filled red circles represent group means. Plots with the same letters are not significantly different.

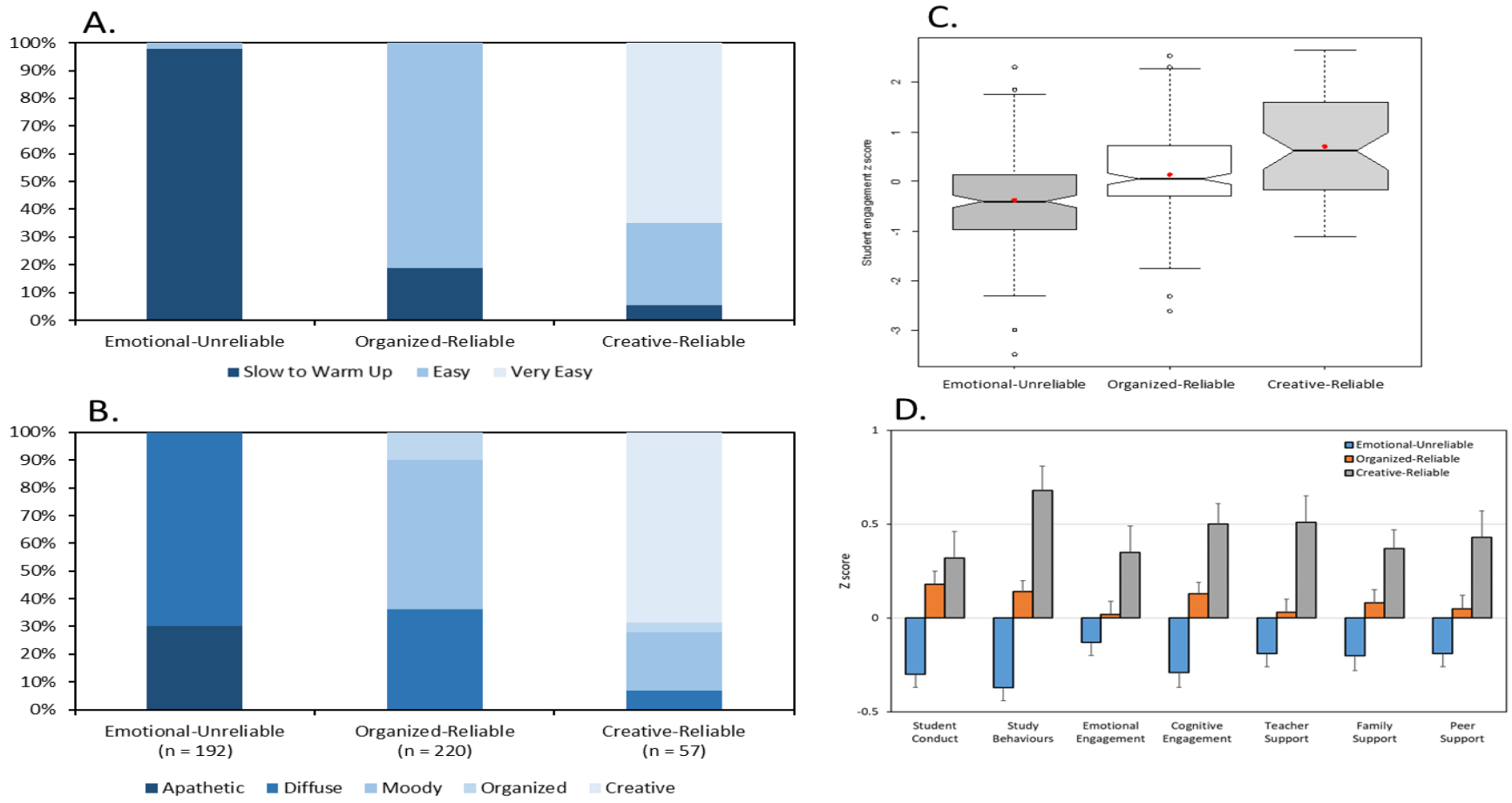

Figure 3. Segmented bar charts representing the proportion of students in the joint temperament-character networks with each (**A**) temperament and (**B**) character profile. (**C**) Notched box plot of global student engagement z scores for the joint temperament-character networks. Notches correspond to 95% CIs for group medians. White circles represent outliers. Filled red circles represent group means. (**D**) Z scores across engagement dimensions for the joint temperament-character networks.

Table 1.

Descriptive statistics and zero-order correlations for JTCI and student engagement dimensions (n = 469).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Novelty seeking															
2. Harm avoidance	.05														
3. Reward dependence	-.10*	.07													
4. Persistence	-.11*	-.09	**.40***												
5. Self-directedness	**-.37***	**-.31***	**.35***	**.64***											
6. Cooperativeness	**-.31***	.00	**.62***	**.52***	**.54***										
7. Self-transcendence	.14*	.09	**.20***	.14*	.10*	**.27***									
8. Student conduct	-.17*	-.04	.16*	**.29***	**.27***	**.21***	.03								
9. Study behaviour	**-.26***	.07	**.24***	**.42***	**.29***	**.28***	.10*	**.36***							
10. Emotional engagement	-.14*	-.19*	.14*	.16*	**.26***	.14*	.06	**.36***	**.38***						
11. Cognitive engagement	-.11*	-.08	**.25***	**.30***	**.26***	**.23***	.08	**.30***	**.43***	**.39***					
12. Teacher support for learning	-.12*	-.08	.16*	**.21***	**.26***	.19*	.03	**.36***	**.40***	**.45***	**.46***				
13. Family support for learning	-.14*	-.03	.12*	**.25***	**.23***	.06	.01	**.35***	**.26***	**.23***	**.40***	**.26***			
14. Peer support for learning	-.05	-.16*	.14*	.16*	**.21***	.12*	.07	**.23***	**.21***	**.47***	**.32***	**.29***	**.27***		
15. Global Student Engagement	**-.23***	-.10*	**.27***	**.40***	**.39***	**.28***	.09	**.62***	**.73***	**.70***	**.72***	**.69***	**.56***	**.59***	
M	2.91	2.84	3.49	3.42	3.62	3.86	3.56	3.41	3.16	3.08	3.60	3.11	3.68	3.10	3.30
SD	0.41	0.39	0.41	0.39	0.37	0.47	0.53	0.42	0.71	0.48	0.48	0.41	0.37	0.46	0.32
Lower 95% CI	2.87	2.80	3.45	3.38	3.59	3.82	3.51	3.37	3.10	3.04	3.56	3.07	3.65	3.06	3.27
Upper 95% CI	2.95	2.88	3.53	3.46	3.65	3.90	3.61	3.45	3.22	3.12	3.64	3.15	3.15	3.14	3.33
Skewness	-0.10	-0.24	-0.07	0.53	0.47	-0.14	-0.10	0.15	-0.04	0.13	0.09	-0.77	-0.10	-1.12	-0.23
Ordinal ω	.83	.73	.72	.81	.84	.90	.80	.88	.79	.84	.81	.84	.87	.87	.93

Note. * $p < .05$. Correlation coefficients in bold-type are $r > |.20|$, representing recommended minimum effect size for practically significant effect (Ferguson, 2009).

Table 2

Fit indices for Latent Profile Analysis based on students' mean scores for each of the temperament dimensions (Panel A) and each of the character dimensions (Panel B), and for Latent Class Analysis based on students temperament and character profiles (Panel C).

Classes	AIC	BIC	SABIC	Entropy
Panel A. LPA based on temperament dimensions				
1	5335.85	5369.06	5343.67	1.00
2	5202.12	5256.08	5214.82	0.69
3	5164.71	5239.42*	5182.29	0.69
4	5151.79*	5247.25	5174.26*	0.75
5	5160.50	5276.72	5187.85	0.75
Panel B. LPA based on character dimensions				
1	4001.89	4026.79	4007.75	1.00
2	3877.85	3919.36	3887.62	0.56
3	3866.04	3924.15	3879.72	0.61
4	3813.33	3888.04	3830.91	0.73
5	3790.81	3882.12*	3812.29	0.70
6	3789.53	3897.44	3814.92	0.66
7	3785.59	3910.11	3814.90	0.68
8	3761.29*	3902.41	3794.50*	0.71
Panel C. LCA based on temperament and character profiles				
1	2114.20	2139.10	2104.25	1.00
2	1991.96	2045.92*	1969.81	0.69
3	1972.17*	2055.18	1937.81*	0.65
4	1986.17	2098.24	1939.60	0.50
5	2000.17	2141.29	1941.40	0.49

Note. AIC = Akaike Information Criterion. BIC = Bayesian Information Criterion. SABIC = Size Adjusted BIC. * = The minimum value of information criterion

Table 3.

Class ages, gender distributions and engagement dimension Z scores.

	Temperament Profiles		
	Slow to Warm Up (*n* = 232)	Easy (*n* = 200)	Very Easy (*n* = 37)
Mean age (years)	14.1[a]	13.7[b]	13.6[ab]
% Female	46	64	54
Student conduct	-0.28[a]	0.25[b]	0.38[b]
Study behaviors	-0.39[a]	0.31[b]	0.74[c]
Emotional engagement	-0.15[a]	0.12[b]	0.29[b]
Cognitive engagement.	-0.26[a]	0.20[b]	0.57[b]
Teacher support	-0.20[a]	0.14[b]	0.50[b]
Family support	-0.21[a]	0.19[b]	0.34[b]
Peer support	-0.17[a]	0.14[b]	0.29[b]

	Character Profiles				
	Apathetic (*n* = 58)	Diffuse (*n* = 218)	Moody (*n* = 130)	Organized (*n* = 24)	Creative (*n* = 39)
Mean age (years)	13.8[a]	14.0[a]	13.7[a]	14.3[a]	13.5[a]
% Female	40	45	71	75	59
Student conduct	-0.49[a]	-0.05[b]	0.19[b]	0.22[b]	0.24[b]
Study behaviors	-0.37[a]	-0.14[a]	0.19[b]	-0.03[abc]	0.72[c]
Emotional engagement	-0.30[a]	-0.03[ac]	0.04[c]	-0.16[abc]	0.59[b]
Cognitive engagement.	-0.31[a]	-0.13[ab]	0.20[bc]	-0.05[ac]	0.54[c]
Teacher support	-0.42[a]	-0.03[b]	0.01[b]	0.11[bc]	0.70[c]
Family support	-0.02[a]	-0.10[a]	0.08[a]	-0.13[a]	0.42[a]
Peer support	-0.06[a]	-0.12[a]	0.09[ab]	-0.20[a]	0.59[b]

	Joint temperament-character networks		
	Emotional-Unreliable (*n* = 192)	Organized-Reliable (*n* = 220)	Creative-Reliable (*n* = 57)
Mean age (years)	14.1[a]	13.7[a]	13.7[a]
% Female	41	66	56
Student conduct	-0.30[a]	0.18[b]	0.32[b]
Study behaviors	-0.37[a]	0.14[b]	0.68[c]
Emotional engagement	-0.13[a]	0.02[b]	0.35[b]
Cognitive engagement.	-0.29[a]	0.13[b]	0.50[c]
Teacher support	-0.19[a]	0.03[b]	0.51[c]
Family support	-0.20[a]	0.08[ab]	0.37[b]
Peer support	-0.19[a]	0.05[b]	0.43[c]

Note: Profiles sharing the same letter are not significantly different at $p < .05$