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Psychobiosocial Experiences in Physical Education: A Semantic Differential Scale

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Abstract

The objective of this study was to develop and validate the Psychobiosocial Experience Semantic Differential in Physical Education (PESD-PE) scale, a new holistic measure of discrete emotion-related feelings (i.e., psychobiosocial experiences) as conceived within the individual zones of optimal functioning (IZOF) framework. A preliminary version of the PESD-PE was administered to 336 students (171 girls, 165 boys), while the final version was administered to a new sample of 352 students (186 girls, 166 boys) aged 14–19 years. Overall, findings provided evidence of factorial and construct validity for a model containing 33 items loading into 11 modalities, with 3 items each. Convergent, discriminant, and nomological validity of the PESD-PE was also found. This new measure of discrete experiences will help increase our knowledge about the reciprocal effects between emotion-related feelings and performance, and will also inform practical interventions aimed at creating more adaptive psychobiosocial experiences in accordance with physical education goals.

Keywords: assessment, emotions, IZOF model, performance, scale development

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A substantial amount of research provides compelling evidence that students' emotional experiences play a key role in academic engagement, motivation, learning, social interaction, behavior, and psychological health (Linnenbrink-Garcia et al., 2016; Pekrun, 2017). This research has clearly established that some emotions (e.g., enjoyment, happiness, pride, satisfaction) can benefit a range of relevant cognitive and motivational processes associated with academic learning, including attention, memory storage and retrieval, reasoning, problem solving, and decision making, while other emotions (e.g., anger, anxiety, frustration, boredom) can hamper the same processes (Pekrun, 2016; Pekrun et al., 2018).

The main focus of physical education research has been on the effect of student emotions on learning, achievement, and behavior (e.g., Simonton & Garn, 2019), and the long-term impact on physical activity during leisure time, health, and wellbeing (Di Battista et al., 2019; Shephard & Trudeau, 2000). Findings provide physical educators with evidence-based teaching strategies to create supportive contexts in which students experience enjoyment, feel competent, and learn motor skills to engage in physical activity, thus, laying the foundation for an active lifestyle (Adank et al., 2021). Therefore, emotions assessment can be helpful in increasing our understanding about student engagement and in stimulating exercise habits throughout life (Simonton & Garn, 2019).

In physical education, several measures have been developed to assess anxiety (e.g., Barkoukis et al., 2012), enjoyment (e.g., Carraro et al., 2008; Morano et al., 2019), positive and negative affect (e.g., Martin & Kulinna, 2005), boredom (Karagiannidis et al., 2015), anger (Simonton & Garn, 2020), and a range of emotions (e.g., Robazza & Bortoli, 2005; Simonton et al., 2023). Several instruments exist for the assessment of selected discrete emotions. For instance, Trigueros et al. (2019) proposed the Scale of Emotions in Physical Education (SEPE) to measure embarrassment, boredom, hopelessness, anxiety, confidence, pride, calmness, and enjoyment in a sample of 13–19-year-old Spanish students, while Fierro-Suero et al. (2020), proposed the Achievement Emotions Questionnaire for Physical Education (AEQ-PE) to measure pride,

enjoyment, anger, anxiety, hopelessness, and boredom in 11–17-year-old students. Moreover, Simonton et al. (2018) developed the Discrete Emotions in Physical Education Scale (DEPES) targeting three emotions students experience during an activity, namely, enjoyment, boredom, and anger. The scale was later expanded to distinguish between process-related or in-activity emotions, and outcome-related emotions with the addition of pride, shame, and relief (Simonton et al., 2023). Both process- and outcome-related emotions are theoretically based on the control-value theory of achievement emotions (Pekrun, 2006). A strength of these scales is that they target the assessment of selected emotions commonly experienced by students. However, one limitation is that they do not consider a number of important individual manifestations associated with emotions, such as cognitive, motivational, somatic, motor, performance, and communication aspects that characterize the emotional experiences of physical education students.

According to Pekrun's (2006) control-value theory, emotions are multifaceted phenomena conceptualized as a set of interrelated psychological processes involving subjective feelings (affective component of emotion), cognitions, motivational tendencies, physiological processes, and expressive behavior (Shuman & Scherer, 2014). In physical education, for example, a student involved in thrilling activities may feel energized, focused on the task, and eager to continue the experience. The resulting increase in heart rate can further enhance fun and its overt expression. On the other hand, tedious activities tend to cause boredom, disinterest, withdrawal tendencies, loss of energy, and related bodily expressions. Therefore, it is important to provide physical educators and researchers with reliable and sound measures to evaluate the multiple and different components of student emotional experiences. Self-assessment tools are easy to administer and appropriate to measure emotions and thoughts, which by definition, are subjective phenomena (Pekrun et al., 2018).

The multifaceted feature of emotions is also characteristic of the so-called psychobiosocial states (or emotion-related experiences) as construed within the individual zones of optimal functioning (IZOF) model initially applied to sport (Hanin, 2000, 2007, 2010). Psychobiosocial

experiences are viewed as an array of situational (state-like) or relatively stable (trait-like) emotional and non-emotional subjective manifestations of total human functioning linked to performance. In the most recent conceptualization, psychobiosocial experiences encompass several interrelated modalities including enjoyment, confidence, anxiety, motivation, volition, assertiveness, and cognitive (psychological component), bodily-somatic, motor-behavioral (biological component), operational, communicative, and social support (social component; for complete description and review, see Ruiz et al., 2016, 2017, 2021; Ruiz & Robazza, 2020). Emotions are key components of psychobiosocial experiences with specific valence (i.e., pleasant or unpleasant experience) and functionality (i.e., functional or dysfunctional effects on performance). Four categories of emotional experiences are identified: pleasant–functional, unpleasant–functional, pleasant–dysfunctional, and unpleasant–dysfunctional. The perceived effect of emotions and related psychobiosocial experiences on performance depends on the meaning and value people attribute to their interaction with the environment and others, their perceived level of available resources to manage the situation, and the ability to self-regulate (Hanin & Ekkekakis, 2014).

The multimodal conceptualization of psychobiosocial experiences concurs with views typically endorsed in appraisal theories (Lazarus, 2001; Scherer et al., 2001), as well as in main theoretical frameworks of emotions, including basic (primary, fundamental, discrete) and dimensional (e.g., valence or arousal) theories of emotions (Coppin & Sander, 2021). This perspective is useful for both conceptualizing and measuring emotions (Mauss & Robinson, 2009) and related experiences. Numerous studies provide support to the multimodal conceptualization and applied advantages of measuring a range of psychobiosocial states in physical education (e.g., Bortoli et al., 2015, 2017; Di Battista et al., 2019) and sport (e.g., Di Corrado et al., 2015; Middleton et al., 2017; Nateri et al., 2020; Robazza et al., 2012, 218; Ruiz et al., 2019a). In particular, three scales have been proposed for the assessment of functional and dysfunctional psychobiosocial experiences, one targeting physical education (Bortoli et al., 2018) and two for

sport (Robazza et al., 2016; Ruiz et al., 2019b). An advantage of these scales is that they provide a two-dimensional evaluation of functional and dysfunctional experiences. However, factor analyses indicate that these are global assessments and, thus, do not capture the specific and discrete psychobiosocial modalities. For example, the functional and dysfunctional dimensions of the Psychobiosocial States in Physical Education (PBS-SPE) scale (Bortoli et al., 2018) are comprised of eight items each, which are then collapsed in the two dimensions. What is currently missing is a measure targeting discrete or separate psychobiosocial experiences of physical education students, as conceptualized within the IZOF model (Hanin, 2007, 2010) and the control-value theory of emotions (Pekrun, 2006). Both theoretical perspectives view emotions as a set of interconnected psychological processes entailing subjective feelings, cognitions, motivational tendencies, physiological processes, and expressive behavior. The present study, therefore, aims to extend the current body of work on the assessment of emotions in physical education by proposing a new tool to capture separate modalities of psychobiosocial experiences and, thus, going beyond assessment of two global functional and dysfunctional dimensions which are assessed through existing instruments. We believe a new discrete multimodality scale can offer more detailed information on the emotion-related experiences of physical education students.

To overcome the limitations of existing dimensional scales with a measure of discrete modalities, Robazza et al. (2021) developed the Psychobiosocial Experience Semantic Differential scale (PESD-Sport) for use with athletes. A preliminary version of a 53-item scale using a semantic differential format was administered to a sample of athletes to attain a clear and unequivocal distinction between opposite experiences along the functionality distinction (see Rosenberg & Navarro, 2018). The PESD-Sport was developed following the set of procedural guidelines for semantic differentials recommended by Verhagen et al. (2015). In particular, a large sample of bipolar items (adjectives and their opposites) was created, and agreement was reached on which items to consider representing each of the 12 modalities of psychobiosocial experiences. The preliminary version of the PESD-Sport was then administered to the athletes to select the best

indicators that would be retained in the final version of the scale. The final version was comprised of 30 items loading into 10 modalities (i.e., enjoyment, confidence, anxiety, assertiveness, cognitive, bodily-somatic, motor-behavioral, operational, communicative, and social support), 3 items each. The final PESD-Sport scale was then administered to a new sample of athletes to examine factorial, construct, convergent, discriminant, and nomological validity. Several items of the PESD-Sport are also included in the dimensional scale of psychobiosocial states in physical education (PBS-SPE; Bortoli et al., 2018), as both instruments are based on the conceptual framework of the IZOF model (Hanin 2000, 2007). With the aim of adopting the semantic differential format, in the development of the new discrete measure of psychobiosocial experiences, the 53 items contained in the preliminary version of the PESD-Sport we administered to students with adapted instructions to fit the physical education setting.

Study Purpose

Grounded in the IZOF model (Hanin, 2000, 2007) and extensive research on psychobiosocial experiences (see Ruiz et al., 2017), the purpose of this two-study investigation was to develop a multimodality scale in Italian language to assess discrete psychobiosocial experiences in physical education. Similar to the scale developed in sport (Robazza et al., 2021), and building upon the existing two-dimensional measure of psychobiosocial experiences in physical education (Bortoli et al., 2018), the new measure was intended to separately capture specific categories of psychobiosocial modalities representing a variety of meaningful student experiences. The format of this measure, called the Psychobiosocial Experience Semantic Differential scale in Physical Education (PESD-PE), was aimed to minimize the time and psychological burden that participants are subjected to during the data collection process. Therefore, the adjectives of the PESD-PE were arranged in a semantic differential format instead of using separate antonyms to create a relatively short measure easily applicable in the physical education context.

Method

In Study 1 we administered a large pool of items to high school students to identify the best indicators of each of the different psychobiosocial modalities and still maintained the expected factor structure. In Study 2 we cross validated the final version of the scale in a second sample of students. Construct validity of the measure was assessed through correlations with an enjoyment scale and two motivation scales often used in physical education. We expected to find support for the measure of discrete psychobiosocial experiences in physical education, which would reflect sound convergent, discriminant, and nomological validity.

Study 1

Study 1 aimed to examine items characteristics, factor structure, construct validity, reliability, convergent validity, and discriminant validity of the PESD-PE.

Participants

Participants were 336 students (171 girls, 165 boys), aged 14–19 years (M = 16.82, SD = 1.43), from 7 high schools in Central Italy. Students were involved in mandatory physical education classes twice a week during the academic year. According to the Italian physical education curriculum, a main goal is the development of physical, emotional, and cognitive skills of students (Italian Ministry of Education, University, and Research, 2009). Frequently proposed activities are aimed at developing postural control, flexibility, resistance, speed, physical fitness, and agility, as well as teaching different motor and sport skills. Girls and boys are involved in individual and group tasks, including preparatory skills for acrobatic gymnastics, track and field, and team sports (e.g., basketball, football, handball, and volleyball). Competitive events are held separately. Students are also taught how to achieve and maintain good fitness levels and a healthy lifestyle.

Measure

The preliminary 53 items included in the Italian version of the PESD-Sport (Robazza et al., 2021) were administered, asking participants to think about how they usually felt during physical education classes. The 53 bipolar items were derived from an initial list of 93 adjectives included in

individualized multidimensional profiling of psychobiosocial states in sport, which was proposed to assess 12 functional and dysfunctional state modalities (Ruiz et al., 2021). Most of these items were also contained in the PBS-SPE scale (Bortoli et al., 2018; for more details, see Robazza et al., 2021). The 12 modalities were enjoyment, confidence, anxiety, motivation, volition, assertiveness, and cognitive (psychological component), bodily-somatic, motor-behavioral (biological component), operational, communicative, and social support (social component; Ruiz et al., 2021). The enjoyment modality comprised unhappy, sad, and dejected, and their antonyms happy, joyful, and cheerful. These emotions were also included in the dejection and happiness subscales of the Sport Emotion Questionnaire (SEQ; Jones et al., 2005), while tense and nervous, comprised in the anxiety modality, were also included in the anxiety subscale of the SEQ.

Each item was rated on a 9-point, bipolar Likert-type scale ranging from 4 (*very much*) to 0 (*neither… nor*) on the "dysfunctional" side and from 0 to 4 on the "functional" side. The scores on the dysfunctional side are transformed into negative scores. Therefore, an item score could range from –4 to 4, where 0 indicates no effect. Dysfunctional adjectives were placed on the left of the Likert scale while their functional antonyms were placed on the right to facilitate respondents' judgments and reduce their mental effort (Rosenberg & Navarro, 2018). Examples of bipolar items are Unhappy–Happy and Unconfident–Confident. In the case of anxiety and communicative modalities, antonyms were not used because research results have consistently shown that some performers can perceive anxiety symptoms as being functional for performance, while others can appraise the same symptoms as dysfunctional (Mellalieu et al., 2006; Neil et al., 2012). Idiosyncratic perceptions were also observed for communication, with some individuals preferring to isolate themselves to better focus on the task, while others seek support from peers or other people (Rees & Freeman, 2012). Therefore, on the anxiety and communicative modalities bipolar items were formulated as either "harmful" or "useful" (e.g., "Nervous in a harmful way–Nervous in a useful way", "Being sociable is harmful–Being sociable is useful").

Procedure

Both studies were conducted in accordance with the Declaration of Helsinki and after ethical approval of the ethics committee of the local university (EC 19, 09/09/2021). School headmasters, physical education teachers, and parents of minors were contacted and explained the general purpose of the study. Those students who decided to participate and the parents of minors signed an informed consent form. Individual assessments took place at school, in groups of four or five students just before lessons, in a secluded location without the presence of the teacher. Those students who were preparing for the physical education class and were not immediately involved in the assessment waited briefly for their turn in the dressing room. Before scale administration, students were advised that participation in the study was voluntary, they could end the session at any time without any consequences, and individual responses would remain confidential. They were also briefed on the overall purpose of the study and presented with instructions indicating that there were no right or wrong answers. Students were then asked to complete the 53-item scale referring to how they usually feel during physical education classes. For each row of items, they had to choose a functional or dysfunctional descriptor representative of their experiences and evaluate its intensity on the 4–0–4 scale. The whole procedure took approximately 20–30 min.

Data Analysis

The factor structure of the preliminary 53-item scale was examined using exploratory structural equation modeling (ESEM; Marsh et al., 2009; Morin & Maïano, 2011) and Target oblique rotation relying on a priori specification of the items pertaining to the psychobiosocial modalities, with all cross-loadings being freely estimated but with a target value close to zero. The use of Target rotation provides a way to rely on a more confirmatory than an exploratory approach to the estimation of factors, but without imposing the highly restrictive feature of exactly zero loadings that typify a more restrictive confirmatory factor analysis. Target rotation is appropriate when researchers are guided by a nonmechanical exploratory process and, thus, have a clear view of the predicted factor structure (see Myers et al., 2013, 2015). According to Myers et al.'s (2016, 2018) indications, sample size for ESEM was determined using the root mean square error of

approximation (RMSEA). We computed the minimum sample size for RMSEA using the code developed by Preacher and Coffman (2006) for the R program (https://cran.r-project.org/). A sample size of 205 resulted after setting type I error rate to $\alpha = .05$, power = .80, null RMSE = .05, alternative RMSE = .04, and $df = 676$. Thus, the initial sample of 336 participants was adequate.

The parameters were estimated using the robust maximum likelihood estimator (MLR) for non-normal data. Model fit was assessed using several criteria (Hu & Bentler, 1999; Schumacker & Lomax, 2016), which included chi-square (χ^2) goodness-of-fit index, normed chi-square (χ^2/df), comparative fit index (CFI), Tucker Lewis fit index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). To establish whether items were reasonable indicators of latent factors, we considered statistically significant standardized values above .50 (Hair et al., 2019). The fit of alternative models was compared using the Akaike's Information Criterion (AIC) values and the parsimony comparative fit index (PCFI). Higher values of CFI, TLI, and PCFI, and lower values of χ^2, χ^2/df, RMSEA, SRMR, and AIC indicate model fit improvement. All data analyses were performed in M*plus* version 8.5 (Muthén & Muthén, 2017).

The internal consistency of the subscale scores was ascertained by Cronbach's alpha, McDonald's omega, and composite reliability values. Alpha and omega coefficients should be at least .50, preferably greater than .70 (Watkins, 2017). Convergence among a set of items representing a latent construct was examined by the average variance extracted (AVE) of the latent variables. AVE values close to or larger than .50 suggest adequate convergence of items (Hair et al., 2019). Finally, discriminant validity was determined by comparing the AVE estimates for each factor with the squared interconstruct correlations related to that factor. Discriminant validity is assumed when variance extracted estimates are larger than the corresponding interconstruct squared correlation values (Hair et al., 2019).

Results

Eight cases were removed because of missing values or identified as outliers (Mahalanobis' distance, $p < .001$). Minimum and maximum values for skewness and kurtosis of the 53 items ranged from −1.625 to −0.146 and from −.828 to 2.777, respectively.

ESEM model for 12 modalities and 53 items configuration provided poor fit to the data (Table 1). Several items had poor standardized factor loadings (< .30), cross-loadings on unintended factors (> .30), and two or more moderate or large modification indices (over 15). Twenty items, out of 53 items, were systematically removed in different iterations. The resulting final scale was comprised of 33 items loading in 11 modalities consisting of 3 items each and represented in a first-order factor model (see Table 1 and Supplemental Figure 1a). We retained three items in each modality to ensure a relatively short measure easily applicable in the physical education context, which at the same time provided coverage of the theoretical domain of a construct as well as adequate identification of the construct in a factor analysis (Hair et al., 2019). The retained items were the best indicators of latent factors reflecting 11 out of 12 theoretical constructs of the scale, with standardized factor loadings greater than .65 (Supplemental Table 1). The 11 modalities were: enjoyment, confidence, anxiety, assertiveness, cognitive, and motivational (psychological modality); bodily-somatic and motor-behavioral (bodily modality); and operational, communicative, and social support (social modality). The volitional modality was the only one removed after inspection of the modification indices and because of cross-loadings indicating substantial overlapping with the motivational modality. ESEM on the final 11-modality, 33-item model showed good fit to the data. The PESD-PE is reported as Appendix 1 in the Supplemental file.

All standardized factor loadings were above .600 (λ = .662–.882) and item residual variances ranged from δ = .222 to .562 (see Supplemental Table 1). Latent factor correlation values ranged from .349 to .801. Six correlations were low (r between .20 and .39; Zhu, 2012), 24 were moderate (r between .40 and .59), 24 were moderately high (r between .60 and .79), and 1 was high (r > .80). Correlation coefficients and reliability indices are shown in Supplemental Table 2.

Discussion

Preliminary evidence of construct validity of the PESD-PE was found. ESEM yielded satisfactory fit indices for the 11-modality, 33-item model supporting the factor structure of the scale based on the theoretical conceptualization of psychobiosocial experiences. Scale reliability was demonstrated via internal consistency values (α, ω, and CR), which were all higher than .70. Adequate convergent validity of the scale modalities was also shown with standardized loading estimates and AVE values higher than .50, with the exception of the AVE value for the communicative modality that was .499. Taking as a reference this minimum AVE value, AVE estimates were greater than the squared correlations between two modalities for 45 correlations out of 55. The discriminant validity of the scale modalities was thus proved.

Study 2

The objectives of Study 2, in which a new sample was involved, were (a) to cross validate the 11-modality, 33-item solution resulting from Study 1, (b) to assess convergent and discriminant validities through correlations with an emotion related measure, and (c) determine nomological validity (i.e., the extent to which a scale relates to existing theory-based concepts) in comparison with a perceived motivational climate scale and a motivational scale often used in physical education.

Participants

Participants in Study 2 had similar demographic characteristics to those who took part in Study 1. The sample consisted of 352 students (186 girls, 166 boys), aged 14–19 years (M = 16.86, SD = 1.41), from 7 high schools in Central Italy.

Measures

The measures administered were the 11-modality, 33-item solution of the PESD-PE obtained in Study 1 (see Appendix 1 in Supplemental file), the Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991), the Teacher-Initiated Motivational Climate in Physical Education Questionnaire (TIMCPEQ; Papaioannou, 1998), and the Basic Psychological Needs in Physical

Education scale (BPN-PE; Vlachopoulos et al., 2011). The PACES was used to evaluate convergent and discriminant validity of the PESD-PE, while the TIMCPEQ and the BPN-PE were used to evaluate nomological validity.

The PACES comprises 16 items gauging enjoyment feelings related to physical activity. Nine items load onto a pleasant-feelings factor (e.g., "I enjoy it") and other seven load onto an unpleasant-feelings factor (e.g., "I dislike it"). Students rated the items on a 5-point Likert scale ranging from 1 = *totally disagree* to 5 = *totally agree*, based on the feelings they usually experience during physical education classes. Support to the two-factor solution was provided in Italian girls and boys aged from 11 to 19 years (Carraro et al., 2008).

The TIMCPEQ includes 12 items assessing student perceptions of task-involving and ego-involving motivational climates. Six items are designed to measure the task-involving climate created when the teacher's emphasis is placed on skill mastery and effort (e.g., "The physical education teacher is most satisfied when every student learns something new"), and other six items assess the ego-involving climate when the teacher's emphasis is on social comparison and competition (e.g., "Only the students with the best records are rewarded"). Students were asked to think about the climate their teachers create in physical education classes and rate the items on a 5-point scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. Confirmatory factor analysis (CFA) supported the two-dimensional structure of the questionnaire translated and adapted into the Italian language (Bortoli et al., 2008, 2017).

The BPN-PE consists of 12 items to measure student perceptions of autonomy, competence, and relatedness. These are central constructs in self-determination theory and believed to be innate, universal, and capable of affecting wellness and thriving outcomes (Ryan & Deci, 2017). The three 4-item subscales reflect the theorized constructs of autonomy (e.g., "I feel like the activities we are doing have been chosen by me"), competence (e.g., "I feel that I improve even in the tasks considered difficult by most of my peers"), and relatedness (e.g., "I feel like a valued member of a group of close friends"). Ratings were made on a 7-point scale ranging from 1 = *does not*

correspond at all to 7 = *corresponds exactly*, thinking about themselves while engaging in physical education classes. The factor structure, reliability, and nomological validity of the BPN-PE was supported across samples of elementary, middle, and high school Greek students (Vlachopoulos et al., 2011). For the purposes of this study, the items were adapted to the Italian language using the backward translation procedures.

Procedure

Assessment was conducted using the same procedure described in Study 1 (i.e., institutional approval and administration of questionnaires). Students were asked to complete the measures by thinking about their usual experiences and feelings during physical education classes.

Data Analysis

The factorial validity of the PESD-PE resulting from Study 1 was assessed through CFA using the maximum likelihood parameter estimates (MLM) with standard errors and a mean-adjusted chi-square test statistic that is robust to non-normality (Byrne, 2012). CFA is more restrictive than ESEM because cross-loadings are constraint to zero. A minimum sample size of 165 for RMSEA was found with $\alpha = .05$, power = .80, null RMSE = .05, alternative RMSE = .02, and $df = 154$.

According to Robazza et al. (2021), and in line with theoretical assumptions, the psychobiosocial modalities were expected to be correlated. As a consequence, different competing first-order, higher-order, and nested-factor measurement models could represent the structure of the instrument (Brunner et al., 2012; Canivez, 2016). We therefore tested several competing measurement models that fall within the IZOF conceptual framework (Hanin, 2000, 2007) and could reasonably reflect distinct structures of the new measure (see Supplemental file). In particular, we compared seven competing measurement models possibly representing the final version of the scale structure: (1) a first-order factor model with correlated psychobiosocial modalities with paths leading to the observed variables (this model was tested using ESEM in Study 1 and CFA in Study 2; see Supplemental Figures 1a and 1b); (2) a second-order factor model with

paths specified from a second-order factor (i.e., global psychobiosocial experiences) to the first-order factors (i.e., the psychobiosocial modalities) with paths leading to the observed indicators (Supplemental Figure 2); (3) a second-order factor model with paths specified from three second-order factors representing psychological, biological, and social components leading to the first-order factors (Supplemental Figure 3a); (4) a second-order factor model with three second-order factors in which the operational modality is included in the biological component rather than the social component (Supplemental Figure 3b); (5) a nested-factor model (i.e., bifactor measurement model) in which both a general factor and the first-order factors had direct paths to the observed indicators (Supplemental Figure 4); (6) a nested-factor model with three factors, representing psychological, biological, and social states, and the first-order factors having direct paths to the observed indicators (Supplemental Figure 5a); and (7) a nested-factor model with three factors in which the operational modality of the social component is included in the biological component (Supplemental Figure 5b).

After computing descriptive statistics, correlation coefficients, and reliability values of the study variables, we examined measurement and structural invariance of the scale across the two study samples. To this purpose, multigroup CFAs were conducted increasing parameter constraints one at a time (Byrne, 2012; Wang & Wang, 2020). Analysis began with an unconstrained or configural model and continued step by step toward more restricted (nested) models so to evaluate measurement and structural invariance between groups (Farmer & Farmer, 2014). Measurement invariance was assessed through configural (i.e., same number of factors and factor loading patterns across groups), weak or metric (i.e., equivalence of factor loadings), strong or scalar (i.e., equality of factor loadings and intercepts), and strict (i.e., equality of factor loadings, intercepts, and error variances) invariance. Structural invariance was ascertained through factor variance (i.e., equality of variance of factor scores) and factor covariance (i.e., equality of covariance of factor scores) invariance. The Satorra-Bentler scaled chi-square difference (ΔS-B χ^2) between models was used to test model comparisons (i.e., configural model vs. a specified model). Non-significant ΔS-B χ^2 and

differences in CFI < .010, RMSEA < .015, and SRMR < .030 are considered criteria of invariance (Chen, 2007; Cheung & Rensvold, 2002).

Invariance across gender and age categories (14-16 vs. 17-19 years) and their interaction was assessed using a multiple indicator, multiple cause (MIMIC) model, also known as CFA with covariates (Brown, 2015). The first and second age categories roughly correspond to early adolescence and late adolescence, respectively (Haywood & Getchell, 2020). We were interested in examining whether gender and age had an effect on the latent means and item intercepts. Following Morin et al.'s (2016) indications, in a first step we performed a MIMIC model (null) in which the predictors had no effect on the latent means and item intercepts. In a second (saturated) model, the predictors were allowed to influence the item intercepts only. In a third (invariant) model, the predictors were allowed to influence the latent means only. Gender and age were coded to represent group membership (i.e., girl = 0, boy = 1; and 14-16 yrs. = 0, 17-19 yrs. = 1). We conducted MIMIC modeling instead of multi-group CFA because of the relatively unbalanced sample sizes across gender and age (i.e., girls, n = 186; boys, n = 166; 14-16 yrs., n = 129; 17-19 yrs., n = 223). MIMIC modeling provides a robust and parsimonious test of measurement invariance (indicator intercepts) and population heterogeneity (factor means) between groups.

Finally, we ascertained the factorial validity of the PACES, TIMCPEQ, and BPN-PE. Then, the PACES was used to establish convergent and discriminant validity of the PESD-PE, while the TIMCPEQ and BPN-PE served to determine its nomological validity.

Results

Data screening led to the removal of nine cases from further analyses due to missing values or values identified as outliers (Mahalanobis' distance, $p < .001$). Minimum and maximum values for skewness and kurtosis of the 33 items ranged from −1.571 to −0.164 and from −0.702 to 2.845, respectively. Also, in this Study we used the robust maximum likelihood method for factor analysis.

CFA results supported the 11-modality, 33-item solution of the PESD-PE found in Study 1 (Table 1). Higher-order and nested-factor models did not fit the data well. All standardized factor

loadings were above .600 (λ = .640–.863) and item residual variances ranged from δ = .255 to .591 (Supplemental Table 1). In both studies, mean item intensity ratings of the anxiety modality were lower than mean item ratings of other modalities. Item mean values ranged from 0.66 to 2.34 in Sample 1, and from 0.52 to 2.49 in Sample 2 (Supplemental Table 1). Latent factor correlation values ranged from .365 to .837. (Supplemental Table 2). Four correlations were low (r between .20 and .39), 28 were moderate (r between .40 and .59), 21 were moderately high (r between .60 and .79), and 2 were high (r > .80). Supplemental Table 2 contains correlation coefficients and reliability values.

The adequate fit indices observed for the CFA configural model (Supplemental Table 3) indicate a same factor structure (i.e., same number of factors and same patterns of free and fixed factor loadings) of the PESD-PE across the two study samples. Full measurement and structural invariance of the scale was also demonstrated with ΔCFI, ΔRMSEA, and ΔSMR values smaller than their thresholds (i.e., .010, .015, and .030 respectively) and non-significant ΔS-B χ^2 tests.

The null MIMIC model using gender, age (14-16 vs. 17-19 years), and their interaction as covariates showed acceptable fit to the data. The saturated and invariant models provided small improvements, indicating limited effects of the grouping variables (Supplemental Table 3). Results suggest same factor structure and item functioning by gender and age even though significant effects (p < .01) were observed for gender on all modalities, with boys reporting higher mean scores than girls.

To examine convergent, discriminant, and nomological validity of PESD-PE, we first verified the factorial validity and reliability of the PACES, TIMCPEQ, and BPN-PE (Supplemental Table 4). The hypothesized two-factor structure of the PACES was improved after specification of two correlated errors on both the pleasant and unpleasant experiences subscales. Support for the two-factor structure of the TIMCPEQ was also found after removal of two items with poor standardized factor loadings from the performance climate subscale and then correlating two errors on the same

subscale. Finally, the four-factor structure of the BPN-PE was confirmed. Overall, acceptable fit indices and reliability values of the three measures were shown (Supplemental Table 4).

The pattern of relationships between the PESD-PE and the criterion-related measures was in the expected direction (see latent factor correlations in Supplemental Table 5). Psychobiosocial modality scores related positively with scores of pleasant, mastery, competence, autonomy, and relatedness subscales, and negatively with scores of unpleasant and performance subscales. In the relationship with the PACES subscales, 5 correlations were moderately high, 12 were moderate, and 5 were low (Zhu, 2012). This pattern of correlations suggests convergent validity (i.e., the degree of the relationship between two measures of similar concepts). The low to moderately high range of correlation coefficients also suggests discriminant validity (i.e., the PESD-PE taps unique constructs).

To examine nomological validity, two structural equation modeling (SEM) analyses were performed by entering the TIMCPEQ and BPN-PE separately as antecedents of the PESD-PE modalities. The measurement models yielded acceptable fit to the data: PESD-PE and TIMCPEQ, $\chi^2/df = 1.686$, CFI = .932, TLI = .921, RMSE = .044 (.040–.048), SMR = .033; PESD-PE and BPN-PE, $\chi^2/df = 1.766$, CFI = .928, TLI = .916, RMSE = .047 (.043–.050), SMR = .054. Significant paths ($p < .01$) were observed between: mastery climate and emotion, assertiveness, cognitive, motivational, bodily-somatic, communicative, and social support modalities (β ranging from .163 to .398); competence and all modalities (β ranging from .252 to .791); autonomy and enjoyment, cognitive, motivational, and support modalities (β ranging from .204 to .405); and relatedness with enjoyment, cognitive, motivational, communicative, and social support modalities (β ranging from .152 to .457).

Discussion

Study 2 findings supported the factor structure, full measurement invariance, and structural invariance of the final 33-item PESD-PE. Gender and age variable scores included as covariates in CFA did not alter the factor structure or influence item functioning, although boys reported higher

mean scores than girls in six modalities. Construct validity and reliability of the PESD-PE was found, with acceptable CFA fit indices and internal consistency values (α, ω, and CR) all above .70. Standardized loading estimates higher than .60 and AVE values higher than .50 on all modalities, except one, indicated adequate convergent validity of the scale modalities. The discriminant validity of the PESD-PE modalities was also supported. Taking as a reference the minimum AVE value of .445 for the communicative modality, AVE estimates were higher than the squared correlations between two modalities for 42 correlations out of 55.

The low to moderate correlation values between the PESD-PE modalities and the subscales of the criterion-related measure (i.e., the PACES) suggest both convergent validity and discriminant validity. Finally, mastery climate, competence, autonomy, and relatedness scores were significant predictors of most of the psychobiosocial modalities, thereby indicating nomological validity.

General Discussion

Emotions and related feelings are widely acknowledged as an inherent part of the academic setting and continue to receive extensive research attention (Pekrun, 2016; Pekrun et al., 2011, 2018; Simonton & Garn, 2019). In physical education and sport contexts, psychobiosocial experiences have been previously assessed using two-dimensional measures of functional and dysfunctional experiences, one in physical education (Bortoli et al., 2018) and two in sport (Robazza et al., 2016; Ruiz et al., 2019b). A further instrument (the PESD-Sport; Robazza et al., 2021) was later proposed for the assessment of discrete modalities of psychobiosocial experiences of athletes. An equivalent measure to be used in physical education was missing. Therefore, the aim of this study was to integrate the existing dimensional measure (Bortoli et al., 2018) with a new measure of discrete modalities of students' psychobiosocial experiences. The scale was constructed in agreement with the multimodal view emphasized in the IZOF model (Hanin, 2007) as applied to sport, as well as in appraisal, basic emotion, and dimensional theories of emotions in mainstream psychology (see Coppin & Sander, 2021).

PESD-PE Modalities

In the construction of the PESD-PE, we administered the preliminary 53-item version of the PESD-Sport (Robazza et al., 2021), which included the adjectives proposed by Ruiz et al. (2021) for individualized assessments of 12 functional and dysfunctional modalities of psychobiosocial experiences. The final version of the PESD-PE deriving from both ESEM and CFA consists of 33 items loading into 11 modalities (see Appendix 1 in Supplemental file). Ten of these are the same contained in the PESD-Sport, plus the motivational modality. The volitional modality was removed because of substantial overlapping with items contained in the motivational modality. Although motivational and volitional aspects entail different processes related to predecisional states (e.g., unmotivated–motivated) or postdecisional states (e.g., undetermined–determined) of the course of action, respectively, participants in this study were not able to discern such a subtle distinction, and therefore may have perceived feelings included in the motivation and volition modalities as comparable.

Based on the IZOF model (Hanin, 2007, 2010), which informed the instrument development, we examined several first-order, higher-order, and nested-factor models to identify the best structure of the scale. In line with Robazza et al.'s (2021) study, we found the correlated first-order model to yield the best fit to the data compared to a second-order factor representing global psychobiosocial experiences and three second-order factors representing global psychological, biological, and social components. Thus, inclusion of psychobiosocial experiences in higher-order psychological, biological, and social latent factors as conceived in the IZOF model was not supported. On the other hand, support was found for the multimodal representation of emotion and related feelings as construed in the IZOF model. For practical purposes, the scores of the three items comprised in each of the 11 modalities of the PESD-PE can be used to form complete or aggregated multimodal profiles displaying the level of psychobiosocial experiences at the individual or group level (see Appendix 1 in Supplemental file). PESD-PE data and their display can help teachers

identify potential areas of intervention aimed at creating, developing, and maintaining adaptive psychobiosocial experiences in their students.

Among the 11 interrelated modalities, the enjoyment modality is a key component of psychobiosocial experiences (Hanin, 2000, 2007) deriving from the interaction between valence (i.e., pleasant or unpleasant experience) and functionality (i.e., adaptive or maladaptive effect). This interaction leads to pleasant–adaptive feelings or unpleasant–maladaptive feelings reflecting the meaning students attribute to their interaction with the physical education environment and their perceived resources to manage the situation. In this view, pleasant–adaptive feelings can be useful in mobilizing resources to face a physical education task, while unpleasant–maladaptive feelings (e.g., dejected, worried) may indicate low energy or failure to activate resources.

It is interesting to note that the item intensity scores of the anxiety modality were positive and low in magnitude. They were lower than those of all other modalities across the two samples of students (Supplemental Table 1), indicating that a low level of worry, tension, and nervousness was perceived as useful for performance at the group level. This finding concurs with empirical evidence in sport showing that athletes can perceive anxiety as either functional or dysfunctional based on the individual perception of the impact of the symptoms on performance (Mellalieu et al., 2006; Neil et al., 2012). It is also noteworthy that the mean scores of all PESD-PE items were positive at the group level, meaning that adaptive experiences of students involved in physical education classes prevail over maladaptive ones. These findings are consistent with the objectives of the national physical education curriculum (Ministry of Education, University, and Research, 2009) and previous studies conducted within the Italian physical education context, which found students reporting higher scores in functional versus dysfunctional psychobiosocial experiences (e.g., Bortoli et al., 2015, 2018).

Along with emotions, functionality (i.e., helpful vs. harmful effects) is inherent in all modalities of psychobiosocial experiences included in the PESD-PE. Feelings of confidence (or self-confidence) share similarities with the notion of self-efficacy, with the two terms (confidence

and self-efficacy) being often used interchangeably. In particular, self-confidence refers to the degree of certainty individuals possess about their capability to be successful in a domain (Feltz & Moss, 2019), such as physical education and sport, while self-efficacy refers to the belief of being successful in performing an activity to achieve a certain result, and therefore is more task-specific (Bandura, 1977, 1997). Self-efficacy has been identified as an important correlate of physical activity and fitness in supporting achievement strivings of youngsters (Barnett et al., 2011; McAuley & Blissmer, 2000). Confidence and self-efficacy can relate to feelings of motivation and assertiveness. These can manifest themselves overtly, for example in a fighting spirit and a gritty attitude aimed at energizing achievement behavior toward the mastery of a task and goal attainment (Strycharczyk et al., 2020).

The cognitive, bodily-somatic, motor-behavioral, and operational modalities of the PESD-PE are also instrumental to enable students to achieve the goals of school physical education. Indeed, being focused on the task and feeling physically ready, coordinated, and skillful are key conditions for motor learning and performance. Finally, being communicative and feeling supported are fundamental components of the emotional experience. It is widely acknowledged that emotions and related feelings are social phenomena that are experienced, expressed, and regulated within social contexts in interaction with significant others, such as teachers and peers (Tamminen & Gaudreau, 2014; Tamminen & Neely, 2021). Social support has been found to exert beneficial effects on self-confidence (Freeman & Rees, 2010), burnout and self-determined motivation (DeFreese & Smith, 2013), well-being (DeFreese & Smith, 2014), and performance (Freeman & Rees, 2009).

Measurement Invariance and Construct Validity

Support was found to the factor structure, full measurement invariance, and structural invariance of the PESD-PE across the two study samples. Substantial differences in item responses with the inclusion of gender and age categories as covariates were not found, although boys reported higher mean scores than girls in some modalities (i.e., enjoyment, confidence, assertiveness, bodily-somatic, motor-behavioral, and social support) suggesting they experience

higher levels of adaptive feelings. These differences are similar to those shown in the PESD-Sport scores (Robazza et al., 2021). They likely derive from gender-stereotyped beliefs and behaviors formed during the socialization process mediated by significant others, such as parents, peers, and teachers, which shape emotions and perceived competence (Gill, 2020).

Convergent, discriminant, and nomological validity of the PESD-PE was also supported. Convergent and discriminant validity was determined in both studies with high standardized loading estimates, cross-loadings on unintended factors smaller than the target factor loadings, and AVE values greater than the squared correlation between two modalities for most correlations. Moreover, the pattern from low to moderately high correlations of the PESD-PE modalities with the PACES subscales observed in Study 2 was in the expected direction, thus indicating both convergent and discriminant validity. In particular, the latent factor correlations between the PESD-PE and the PACES (i.e., the criterion-related measure) were as expected, with all psychobiosocial modalities correlating positively and negatively with the pleasant and unpleasant scales of the PACES, respectively.

Nomological validity was established in the relationship of the TIMCPEQ and the BPN-PE with the PESD-PE. Indeed, mastery climate scores from the TIMCPEQ, and competence, autonomy, and relatedness scores from the BPN-PE were found to predict most of the psychobiosocial modalities. These findings are consistent with the extant research showing a clear relationship between functional psychobiosocial experiences and mastery climate in physical education (Bortoli et al., 2015, 2018; Di Battista et al., 2019) as well as basic psychological needs of competence, autonomy, and relatedness in young athletes (Morano et al., 2020).

Limitations and Future Research

The validity of the scale developed in Italian language should be examined across students of different cultures, also taking into consideration factors that can influence psychobiosocial experiences, such as the possible amount of sport experience and different competitive levels. Convergent, discriminant, and nomological validity should be further investigated in comparison

with other measures specifically developed to assess relevant discrete emotions in the physical education domain, such as the SEPE (Trigueros et al., 2019), the AEQ-PE (Fierro-Suero et al., 2020), and the DEPES (Simonton et al., 2023). It would be also worth investigating the commonalities and differences between the current scale, developed as a discrete measure of psychobiosocial experiences, and the PBS-SPE scale (Bortoli et al., 2018) developed as a dimensional measure of same experiences. Longitudinal data collection and intervention studies are also recommended to evaluate trends and reciprocal relationships between psychobiosocial experiences, learning, and behavior of physical education students, and the predictive validity of the single and interactive effects of the psychobiosocial modalities on performance process and outcome.

Conclusion

The PESD-PE was developed to assess relevant psychobiosocial experiences of students participating in physical education classes. Grounded in a substantive theoretical framework (i.e., the IZOF model; Hanin, 2000, 2007), the purpose of this study was to provide researchers and teachers with a new tool to evaluate a range of discrete emotion-related feelings. With this new measure, we intend to contribute to the current body of knowledge on psychobiosocial experiences, stimulate further research in this area, and provide teachers with useful information about their students. Indeed, data collected through the PESD-PE could deepen our understanding of the reciprocal effects of emotions and performance, and also inform applied interventions aimed at creating adaptive psychobiosocial experiences aligned with physical education objectives. The overall findings support the construct, convergent, discriminant, and nomological validity of the measure, as well as the invariance across gender and age categories, but further research is warranted.

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Table 1

Fit Indices for the Factor Models of the PESD-PE from Study 1 (N = 336) and Study 2 (N = 352)

Model	χ^2 (*df*)	χ^2/df	CFI	TLI	RMSEA (90% CI)	SRMR	AIC	PCFI
Study 1								
12 mod, 53 items, ESEM	1880.070 (808)	2.327	.885	.805	.063 (.059–.067)	.019	59722.400	.740
11 mod, 33 items, ESEM	303.990 (220)	1.382	.984	.962	.034 (.024–.043)	.013	36106.398	1.673
Study 2								
11 mod, 33 items, CFA – first-order	806.731 (440)	1.833	.936	.923	.049 (.043–.054)	.042	37877.589	.328
11 mod, 33 items, CFA – higher-order	1358.540 (495)	2.745	.850	.840	.070 (.066–.075)	.082	38590.280	.170
11 mod, 33 items, CFA – 3 higher-order	1372.935 (495)	2.774	.847	.837	.071 (.067–.075)	.171	38601.896	.169
11 mod, 33 items, CFA – 3 higher-order[1]	1369.261 (495)	2.766	.848	.838	.071 (.066–.075)	.147	38599.230	.170
11 mod, 33 items, CFA – nested-factor	1186.764 (473)	2.509	.876	.861	.065 (.061–.070)	.070	38372.906	.224
11 mod, 33 items, CFA – 3 nested-factor	1096.340 (470)	2.333	.891	.877	.062 (.057–.066)	.075	38241.022	.235
11 mod, 33 items, CFA – 3 nested-factor[1]	1032.420 (470)	2.197	.902	.890	.058 (.053–.063)	.065	38148.726	.238

Note. Mod = modalities, ESEM = Exploratory Structural Equation Modeling, CFA = Confirmatory Factor Analysis, χ^2(df) = chi-square (degrees of freedom), CFI = comparative fit index, TLI = Tucker Lewis fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, AIC = Akaike's Information Criterion, PCFI = Parsimony comparative fit index. [1]The operational modality of the social component is included in the biological component.

Supplemental Table 1

Descriptive Statistics and Factor Loadings of the PESD-PE for Study 1 and Study 2

Modality / Item	Sample 1 (*N* = 336)						Sample 2 (*N* = 352)					
	M	*SD*	SK	K	*λ*	*δ*	*M*	*SD*	SK	K	*λ*	*δ*
Enjoyment												
1	2.300	1.845	-1.555	2.364	.845	.286	2.290	1.701	-1.254	1.466	.863	.255
12	2.110	1.651	-1.234	1.868	.882	.222	2.110	1.525	-0.950	0.899	.859	.261
23	2.290	1.636	-1.462	2.651	.861	.258	2.200	1.608	-1.232	1.366	.858	.263
Confidence												
2	2.140	1.804	-1.625	2.667	.798	.364	2.110	1.746	-1.462	2.080	.846	.284
13	1.740	1.948	-1.168	0.698	.827	.316	1.760	2.067	-1.170	0.611	.815	.335
24	1.790	1.872	-1.105	0.702	.761	.420	1.740	1.919	-0.979	0.284	.832	.308
Anxiety												
3	0.890	1.534	-0.183	0.311	.756	.429	0.780	1.566	-0.232	0.626	.751	.435
14	0.990	1.499	-0.199	-0.139	.782	.388	0.760	1.666	-0.283	0.144	.839	.297
25	0.660	1.644	-0.502	0.558	.690	.524	0.520	1.772	-0.357	0.294	.833	.306
Assertiveness												
4	1.910	1.776	-1.033	0.973	.747	.442	1.920	1.671	-0.614	-0.351	.655	.571
15	2.040	1.802	-1.135	0.908	.769	.409	1.890	1.825	-1.001	0.582	.819	.329
26	1.580	1.750	-0.627	0.061	.727	.471	1.510	1.920	-0.682	-0.073	.690	.524
Cognitive												
5	1.420	2.169	-0.970	0.025	.792	.373	1.430	2.003	-0.878	-0.062	.721	.480
16	1.960	1.934	-1.433	1.610	.852	.274	1.910	1.808	-1.339	1.310	.856	.268
27	1.860	1.823	-1.526	2.174	.809	.346	1.970	1.659	-1.453	2.055	.828	.314
Motivational												
6	2.000	1.812	-1.260	1.464	.826	.318	1.970	1.850	-1.136	0.700	.767	.411
17	2.040	1.911	-1.582	2.145	.831	.310	2.090	1.752	-1.470	2.304	.852	.275
28	2.030	1.877	-1.469	1.932	.852	.275	2.190	1.709	-1.571	2.744	.856	.267

Supplemental Table 1 Continues

Supplemental Table 1 Continued

Bodily-somatic												
7	1.690	2.050	-0.868	-0.113	.823	.323	1.770	2.017	-0.940	0.135	.814	.337
18	1.820	1.934	-0.983	0.329	.882	.223	1.970	1.797	-1.166	1.120	.831	.309
29	2.050	1.622	-1.454	2.777	.786	.383	2.040	1.677	-1.335	1.947	.813	.339
Motor-behavioral												
8	1.870	1.974	-1.137	0.561	.817	.332	1.930	1.964	-1.156	0.704	.831	.309
19	2.080	1.476	-1.148	1.470	.794	.370	2.080	1.572	-1.133	1.307	.826	.318
30	1.830	1.835	-1.172	0.985	.776	.398	1.820	1.924	-1.271	1.059	.784	.385
Operational												
9	1.900	1.752	-1.429	1.891	.799	.361	1.910	1.719	-1.116	0.914	.842	.292
20	1.970	1.639	-1.270	1.777	.857	.265	1.990	1.642	-1.079	0.973	.846	.284
31	1.920	1.576	-1.211	1.663	.778	.395	1.950	1.618	-1.361	1.971	.782	.388
Communicative												
10	1.990	1.787	-1.222	1.336	.706	.502	2.120	1.607	-1.020	0.882	.670	.551
21	1.600	1.491	-0.642	0.640	.662	.562	1.540	1.576	-0.412	0.021	.691	.523
32	2.340	1.620	-1.298	1.839	.748	.441	2.490	1.513	-1.467	2.845	.640	.591
Social support												
11	2.050	1.379	-1.006	0.928	.839	.296	1.810	1.667	-1.091	0.953	.842	.292
22	1.960	1.434	-0.916	1.120	.785	.384	1.870	1.595	-0.962	1.079	.789	.377
33	2.130	1.551	-1.147	1.462	.818	.331	1.990	1.662	-1.036	0.853	.794	.369

Note. *M* = mean, *SD* = standard deviation, SK = skewness, K = kurtosis, λ = standardized factor loading, δ = standardized residual variance.

Supplemental Table 2

Pearson Product Moment Correlations Between Latent Factors and Reliability Indices

Modality											Sample 1 (*N* = 336)					Sample 2 (*N* = 352)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	α	ω	CR	AVE	α	ω	CR	AVE
(1) Enjoyment	—	.792[§]	.636[§]	.587[#]	.552[#]	.711[§]	.643[§]	.588[#]	.677[§]	.481[#]	.695[§]	.895	.896	.897	.744	.894	.895	.895	.740
(2) Confidence	.780[§]	—	.639[§]	.740[§]	.565[#]	.696[§]	.761[§]	.724[§]	.780[§]	.434[#]	.619[§]	.837	.843	.838	.633	.872	.880	.870	.691
(3) Anxiety	.514[#]	.523[#]	—	.582[#]	.444[#]	.457[#]	.469[#]	.394[*]	.466[#]	.510[#]	.468[#]	.785	.785	.787	.553	.848	.852	.850	.654
(4) Assertiveness	.540[#]	.700[§]	.461[#]	—	.487[#]	.606[§]	.654[§]	.576[#]	.617[§]	.375[*]	.484[#]	.794	.796	.792	.559	.773	.773	.767	.525
(5) Cognitive	.656[§]	.624[§]	.480[#]	.540[#]	—	.745[§]	.552[#]	.523[#]	.597[#]	.424[#]	.548[#]	.855	.856	.858	.669	.841	.843	.845	.646
(6) Motivational	.746[§]	.741[§]	.472[#]	.644[§]	.797[§]	—	.626[§]	.557[#]	.659[§]	.432[#]	.637[§]	.874	.877	.875	.700	.861	.861	.865	.682
(7) Bodily-somatic	.558[#]	.723[§]	.406[#]	.684[§]	.575[#]	.692[§]	—	.796[§]	.809[†]	.405[#]	.568[#]	.861	.875	.870	.691	.856	.861	.860	.671
(8) Motor-behavioral	.538[#]	.694[§]	.349[*]	.609[§]	.592[#]	.665[§]	.801[†]	—	.837[†]	.365[*]	.481[#]	.829	.835	.838	.633	.849	.852	.855	.662
(9) Operational	.627[§]	.737[§]	.432[#]	.655[§]	.694[§]	.736[§]	.782[§]	.799[§]	—	.428[#]	.583[#]	.850	.853	.853	.659	.861	.864	.864	.679
(10) Communicative	.487[#]	.415[#]	.360[*]	.358[*]	.386[*]	.411[#]	.375[*]	.399[*]	.412[#]	—	.398[*]	.746	.752	.748	.499	.704	.709	.706	.445
(11) Social support	.691[§]	.633[§]	.441[#]	.421[#]	.548[#]	.628[§]	.450[#]	.457[#]	.543[#]	.402[#]	—	.853	.855	.855	.663	.848	.850	.850	.654

Note. Sample 1 correlations are below the diagonal and Sample 2 correlations are above; α = Cronbach's alpha values, ω = omega values, CR = composite reliability, AVE = average variance extracted. Correlation [*]low, [#]moderate, [§]moderately high, [†]high.

Supplemental Table 3

Fit Indices for Multi-group Confirmatory Factor Analyses of the PESD-PE

Independent variable	Model	$\chi^2(df)$	χ^2/df	CFI	ΔCFI	TLI	RMSEA (90% CI)	ΔRMSEA	SRMR	ΔSMR	ΔS-B χ^2 (Δ*df*)	*p* value
Study group	Configural	1597.344 (880)	1.815	.936		.923	.049 (.045–.052)		.042			
	Weak measurement	1623.707 (902)	1.800	.935	.001	.924	.048 (.044–.052)	.001	.046	.004	22.900 (22)	.407
	Strong measurement	1664.371 (935)	1.780	.935	.001	.926	.048 (.044–.051)	.001	.047	.005	64.123 (55)	.187
	Strict measurement	1677.388 (957)	1.753	.935	.001	.929	.047 (.043–.050)	.002	.047	.005	76.361 (77)	.499
	Factor variance	1665.793 (934)	1.784	.934	.002	.926	.048 (.044–.051)	.001	.053	.011	65.779 (54)	.131
	Factor covariance	1712.233 (979)	1.749	.934	.002	.929	.047 (.043–.050)	.002	.059	.017	111.822 (99)	.178
Gender, Age, Gender × Age from Study 2	MIMIC Null	996.711 (539)	1.849	.926		.914	049 (.044–.054)		.068			
	MIMIC Saturated	813.435 (440)	1.849	.940		.914	049 (.044–.054)		.038			
	MIMIC Invariant	914.328 (506)	1,807	.934		.918	048 (.043–.053)		.041			

Note. $\chi^2(df)$ = chi-square (degree of freedom), χ^2/df = chi-square/degree of freedom, CFI = comparative fit index, ΔCFI = CFI difference, TLI = Tucker Lewis fit index, RMSEA = root mean square error of approximation, ΔRMSEA = RMSEA difference, SRMR = standardized root mean square residual, ΔSMR = SRMR difference, ΔS-B χ^2 (Δ*df*) = Satorra-Bentler scaled chi-square difference test (degree of freedom difference), MIMIC = multiple indicator, multiple causes model.

Supplemental Table 4

Confirmatory Factor Analysis Fit Indices and Reliability Values from Study 2

Instrument	Factor	$\chi^2(df)$	χ^2/df	CFI	TLI	RMSEA (90% CI)	SRMR	α	ω	CR	AVE
PACES[1]		236.027 (101)	2.337	.951	.941	.062 (.051–.072)	.050				
	Pleasant experience (9 items)							.941	.941	.941	.640
	Unpleasant experience (7 items)							.866	.878	.868	.495
TIMCPEQ[2]		37.719 (33)	1.143	.996	.994	.020 (.000–.046)	.031				
	Mastery climate (6 items)							.883	.885	.886	.570
	Performance climate (4 items)							.794	.796	.770	.461
BPN-PE		146.775 (51)	2.878	.955	.942	.073 (.059–.087)	.075				
	Competence (4 items)							.891	.897	.811	.690
	Autonomy (4 items)							.876	.882	.818	.665
	Relatedness (4 items)							.885	.890	.872	.677

Note. PACES = Physical Activity Enjoyment Scale, TIMCPEQ = Teacher-Initiated Motivational Climate in Physical Education Questionnaire, BPN-PE = Basic Psychological Needs in Physical Education Scale, $\chi^2(df)$ = chi-square (degrees of freedom), CFI = comparative fit index, TLI = Tucker Lewis fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, α = Cronbach's alpha values, ω = omega values, CR = composite reliability, AVE = average variance extracted. [1]Two correlated errors on the Pleasant experience scale and two correlated errors on the Unpleasant experience scale. [2]Two correlated errors on the Performance climate scale.

Supplemental Table 5

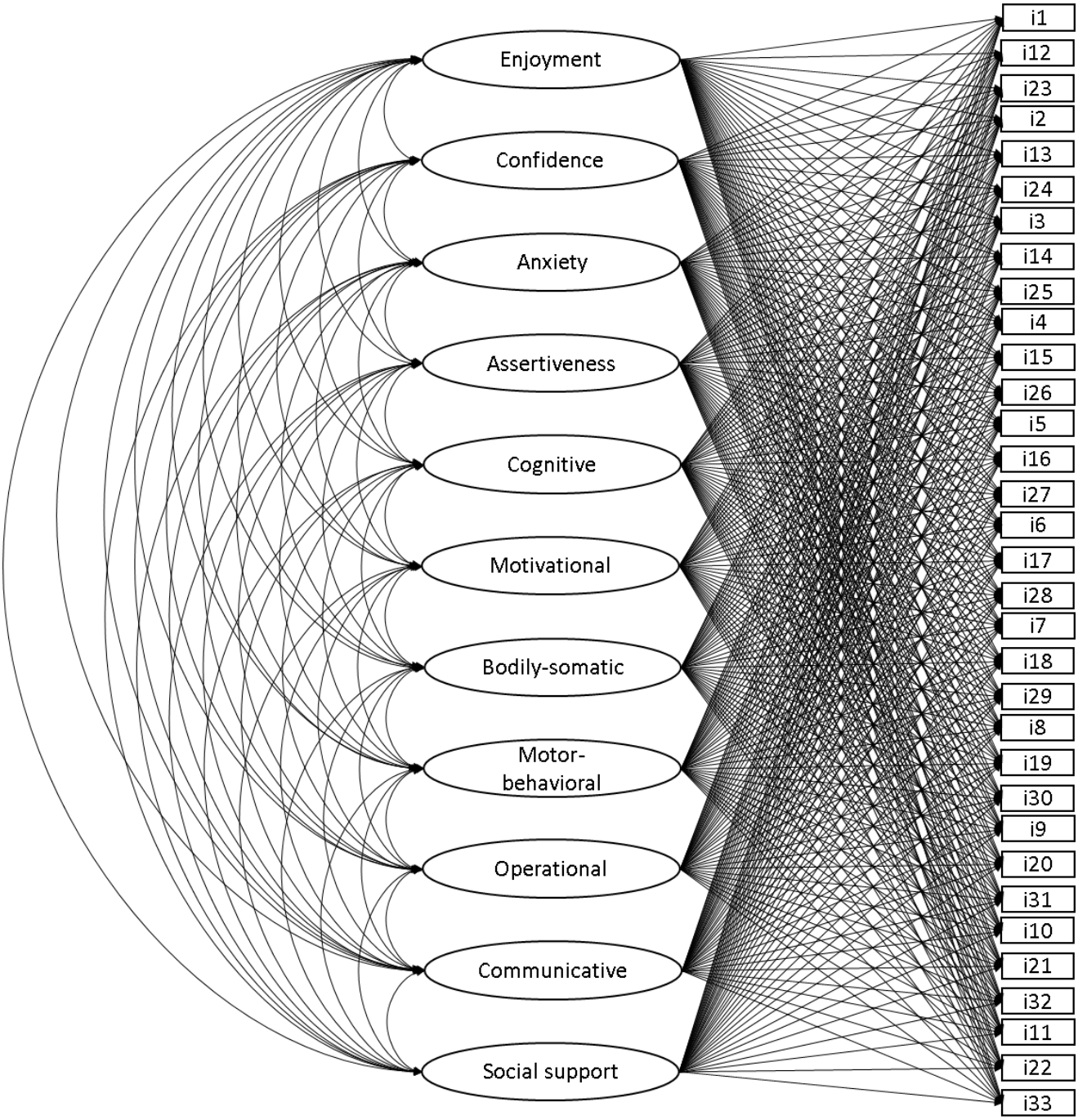
Latent Variable Correlations Between the PESD-PE Modalities and Measures from Study 2

Modality	PACES		TIMCPEQ		BPN-PE		
	Pleasant	Unpleasant	Mastery	Performance	Competence	Autonomy	Relatedness
Enjoyment	.720†	-.572§	.325*	-.285*	.602†	.532§	.463§
Confidence	.580§	-.413§	.155	-.170	.752†	.371*	.308*
Anxiety	.411§	-.266*	.099	-.077	.475§	.302*	.248*
Assertiveness	.608†	-.418§	.218*	-.168	.677†	.373*	.334*
Cognitive	.491§	-.445§	.274*	-.121	.456§	.415§	.337*
Motivational	.758†	-.629†	.382*	-.208*	.516§	.595§	.399*
Bodily-somatic	.603†	-.334*	.157	-.085	.724†	.376*	.356*
Motor-behavioral	.531§	-.283*	.135	-.133	.773†	.341*	.295*
Operational	.558§	-.372*	.192	-.213*	.747†	.365*	.330*
Communicative	.541§	-.372*	.282*	-.179	.451§	.364*	.568§
Social support	.584§	-.519§	.391*	-.313*	.494§	.499§	.559§

Note. PACES = Physical Activity Enjoyment Scale, TIMCPEQ = Teacher-Initiated Motivational Climate in Physical Education Questionnaire, BPN-PE = Basic Psychological Needs in Physical Education Scale. Correlation *low, §moderate, †moderately high.

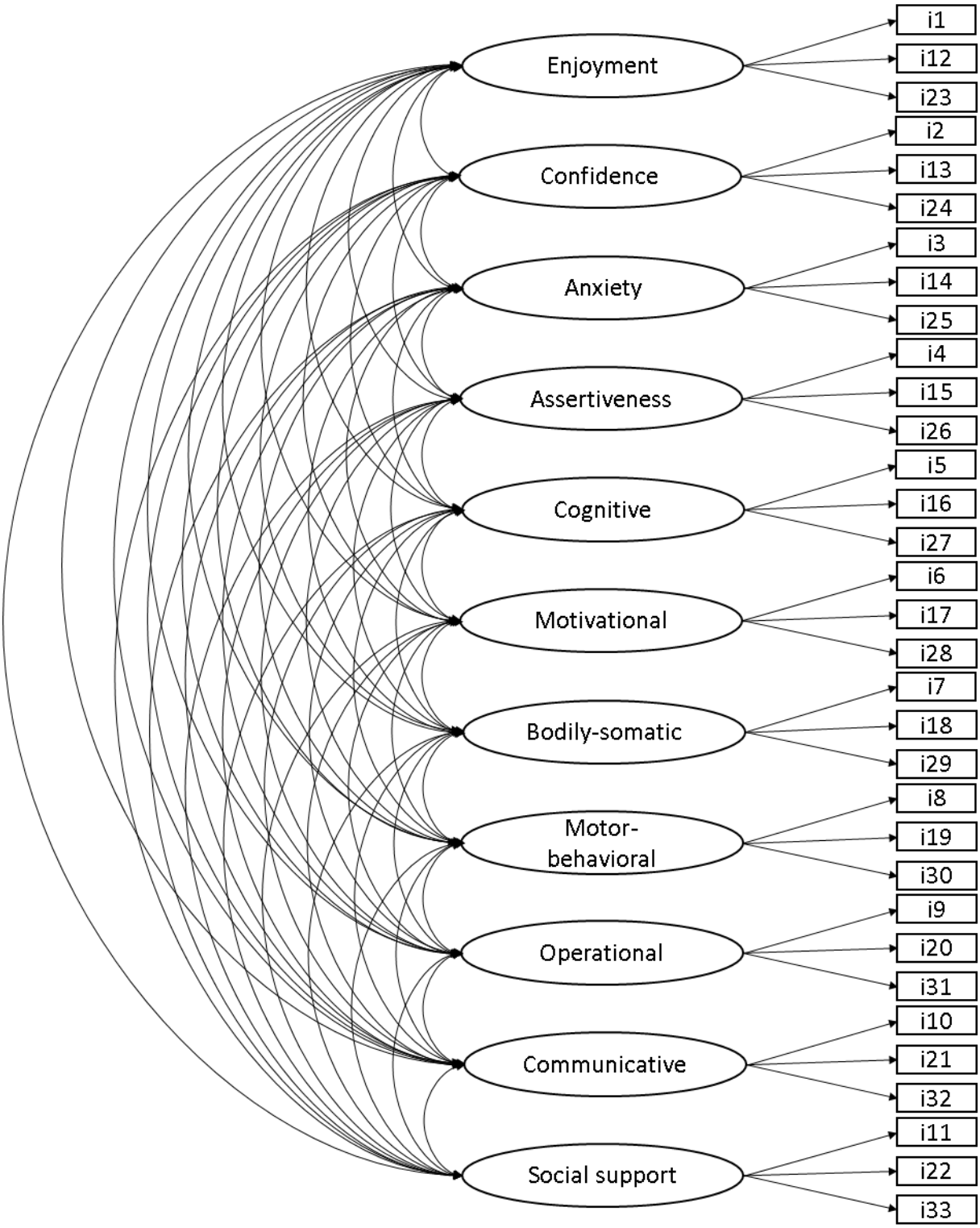
Supplemental Figure 1a

First-Order Factor Model, Exploratory Form



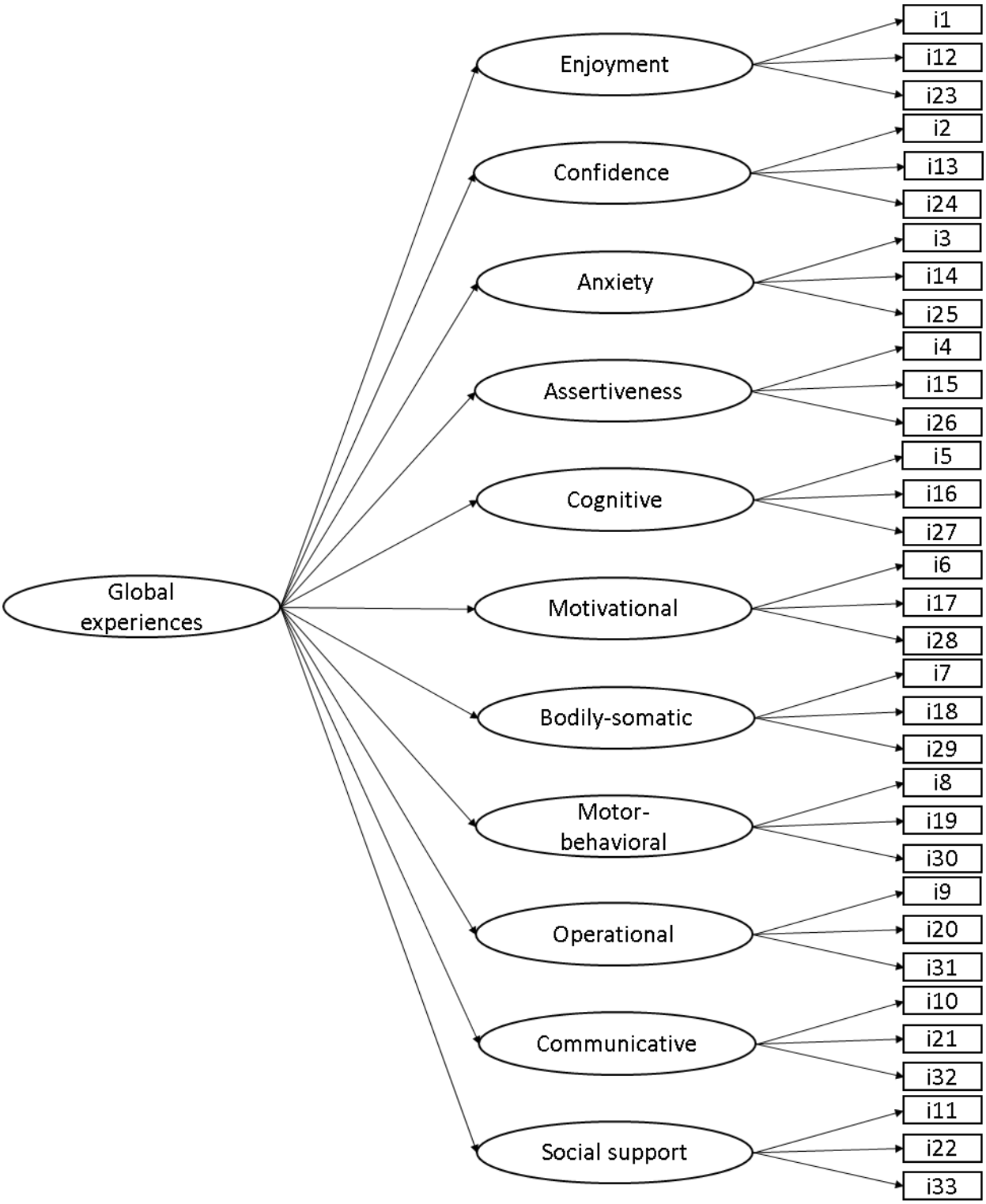
Supplemental Figure 1b

First-Order Factor Model, Confirmatory Form



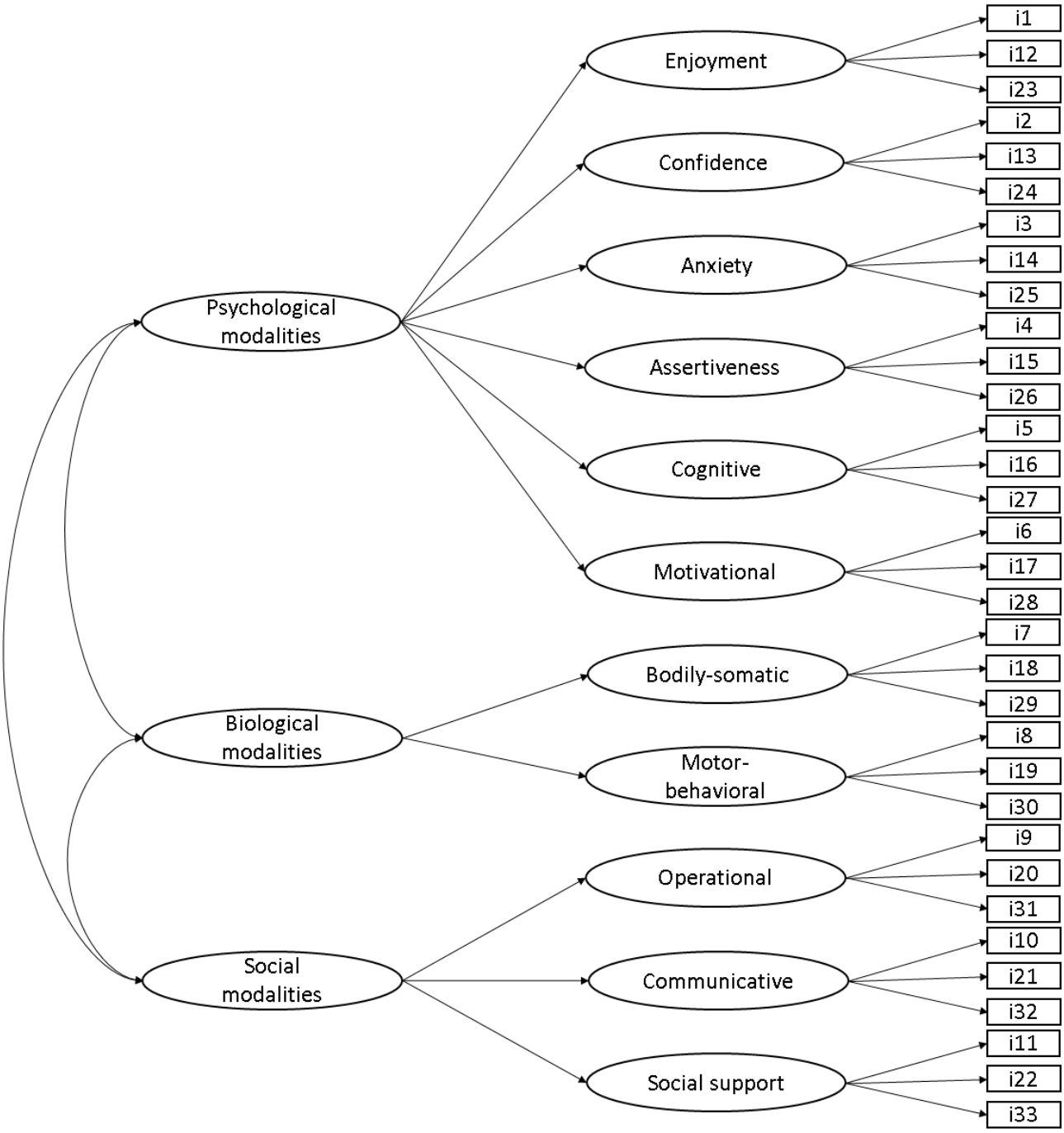
Supplemental Figure 2

Second-Order Factor Model



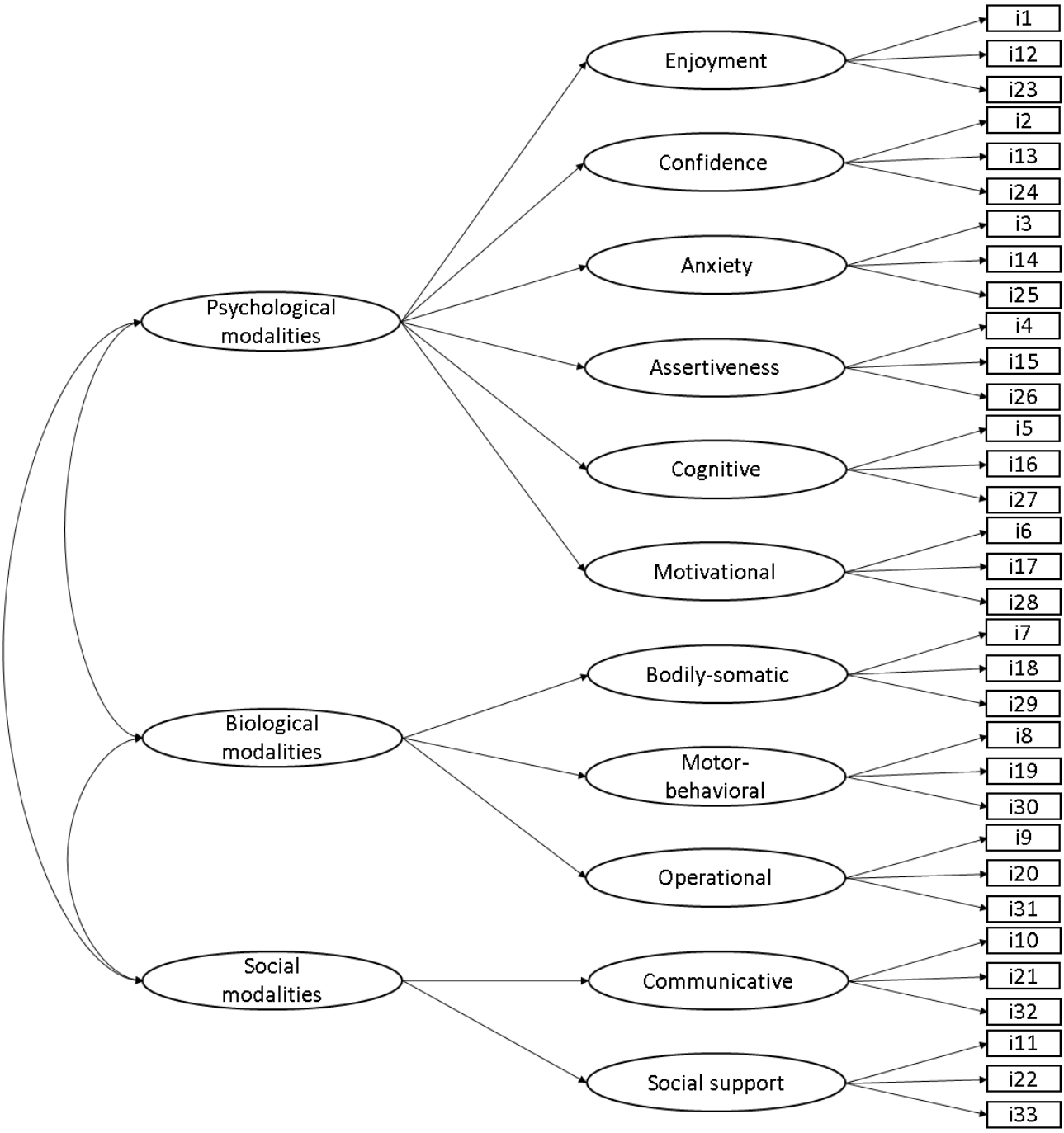
Supplemental Figure 3a

Three-second-Order Factor Model



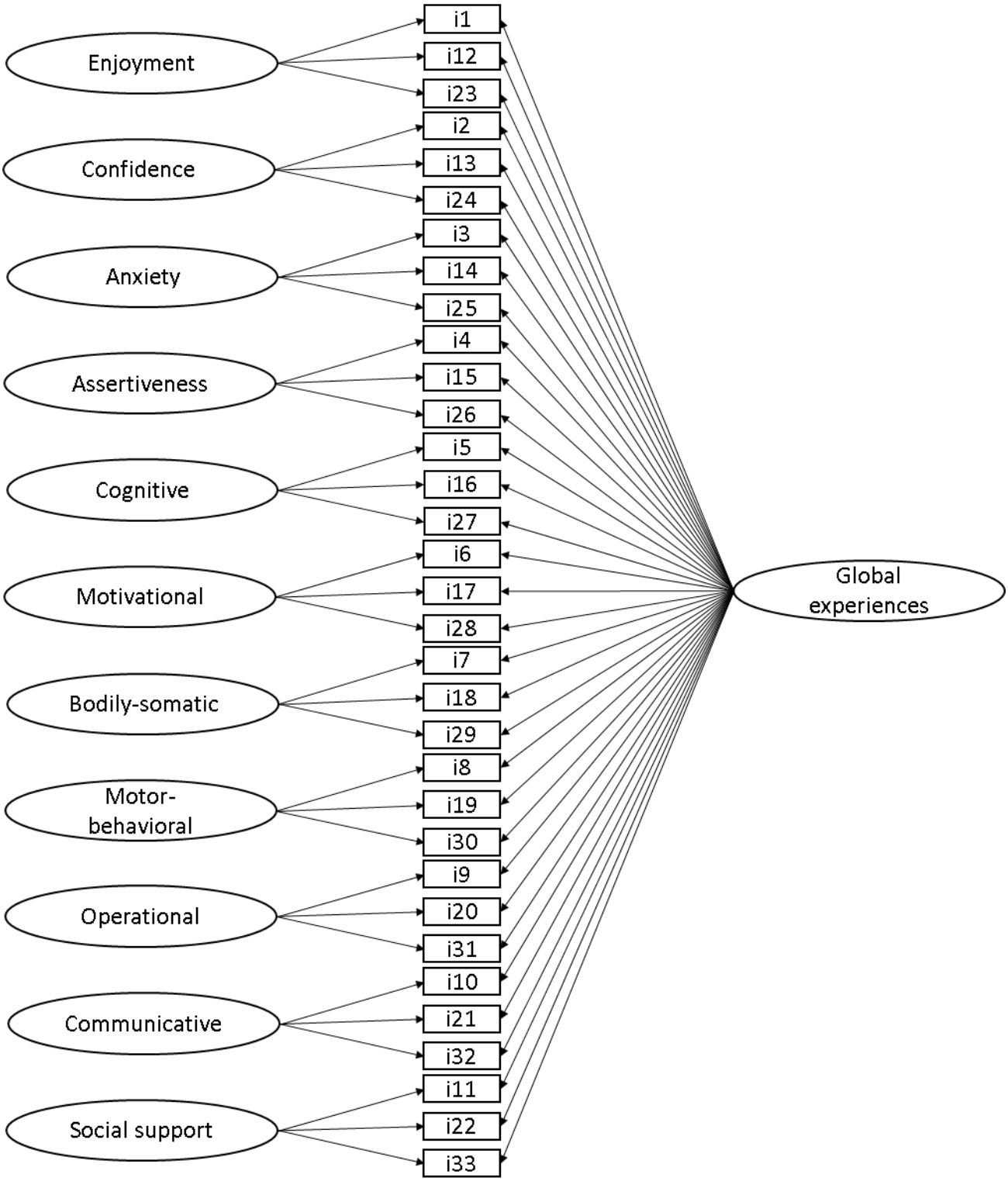
Supplemental Figure 3b

Modified Three-second-Order Factor Model



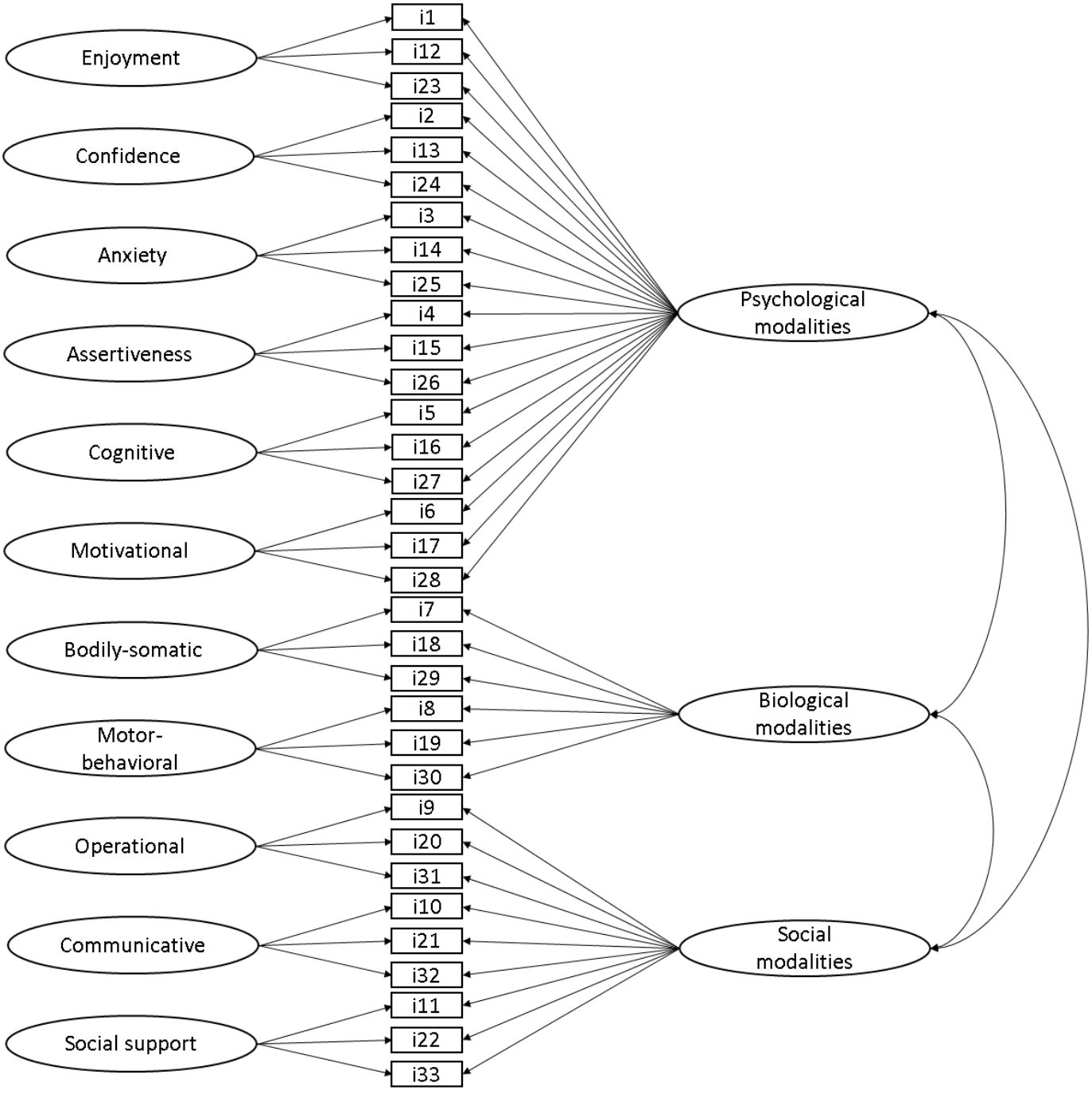
Supplemental Figure 4

Nested-factor Model



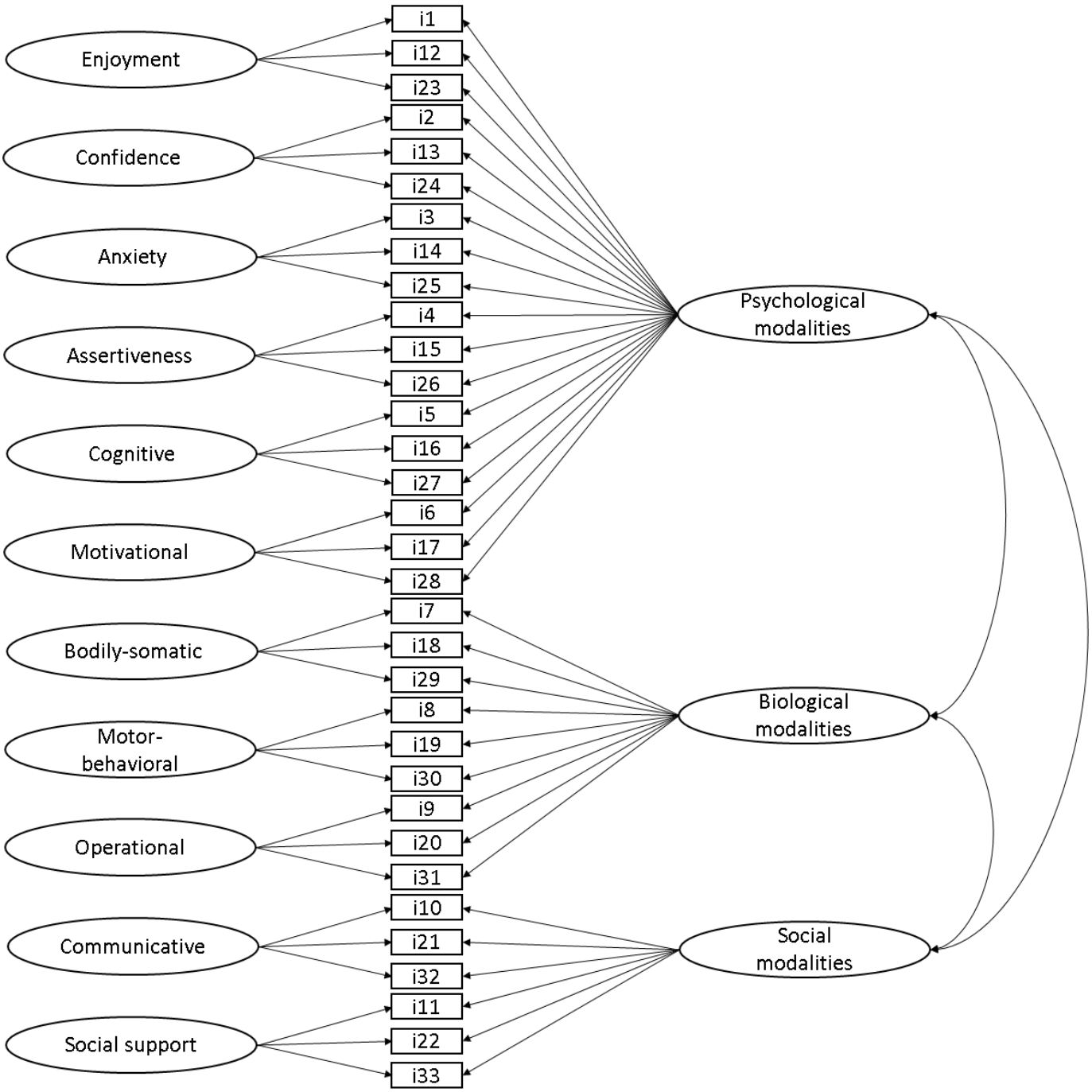
Supplemental Figure 5a

Nested Three-factor Model



Supplemental Figure 5b

Modified Nested Three-factor Model



Appendix 1

Psychobiosocial Experiences in Physical Education (PESD-PE)

Below you can find adjectives (descriptors) or sentences that people usually use to describe how they feel about their experience in physical education. For each row there are two opposing descriptors. Read them carefully and for each row choose one descriptor, ***one only*** (e.g., the descript on the left or the one on the right), which best reflects ***how you usually feel during physical education classes***. Then mark the intensity of the descriptor on the scale ranging from 1 (***a little***) to 4 (***very much***). If none of the descriptors in a row reflect how you feel in your experience during physical education classes, check the middle box 0 (***neither… nor***). There are no right or wrong answers. Please, make sure to complete all rows.

Example:
"I feel quite satisfied with myself". In this case you check box 2 on the right side.

Unsatisfied	4	3	2	1	0	1	~~2~~	3	4	Satisfied

On the other hand, if for you it is true: "I feel much dissatisfied with myself", then you have to check box 3 on the left side.

Unsatisfied	4	~~3~~	2	1	0	1	2	3	4	Satisfied

		Very much	Much	Moderate	A little	neither… nor	A little	Moderate	Much	Very much	
1	Unhappy	4	3	2	1	0	1	2	3	4	Happy
2	Incapable	4	3	2	1	0	1	2	3	4	Capable
3	Worried in a harmful way	4	3	2	1	0	1	2	3	4	Worried in a helpful way
4	Submissive	4	3	2	1	0	1	2	3	4	Fighting spirit
5	Distracted	4	3	2	1	0	1	2	3	4	Alert
6	Unmotivated	4	3	2	1	0	1	2	3	4	Motivated
7	Physically weak	4	3	2	1	0	1	2	3	4	Physically vigorous
8	Uncoordinated in my movements	4	3	2	1	0	1	2	3	4	Coordinated in my movements
9	Ineffective in my performance	4	3	2	1	0	1	2	3	4	Effective in my performance
10	Being communicative is harmful	4	3	2	1	0	1	2	3	4	Being communicative is useful

11	I feel ignored	4	3	2	1	0	1	2	3	4	I feel considered
12	Sad	4	3	2	1	0	1	2	3	4	Joyful
13	Insecure	4	3	2	1	0	1	2	3	4	Secure
14	Mentally tense in a harmful way	4	3	2	1	0	1	2	3	4	Mentally tense in a helpful way
15	Fragile	4	3	2	1	0	1	2	3	4	Gritty
16	Unfocused	4	3	2	1	0	1	2	3	4	Focused
17	Disengaged	4	3	2	1	0	1	2	3	4	Engaged
18	Physically fatigued	4	3	2	1	0	1	2	3	4	Full of energy
19	Lethargic in my movements	4	3	2	1	0	1	2	3	4	Dynamic in my movements
20	Unskillful in my performance	4	3	2	1	0	1	2	3	4	Skillful in my performance
21	Being expansive is harmful	4	3	2	1	0	1	2	3	4	Being expansive is useful
22	I feel neglected	4	3	2	1	0	1	2	3	4	I feel supported

		Very much	Much	Moderate	A little	neither… nor	A little	Moderate	Much	Very much	
23	Dejected	4	3	2	1	0	1	2	3	4	Cheerful
24	Uncertain	4	3	2	1	0	1	2	3	4	Certain
25	Nervous in a harmful way	4	3	2	1	0	1	2	3	4	Nervous in a helpful way
26	Surrendered	4	3	2	1	0	1	2	3	4	Combative
27	Inattentive	4	3	2	1	0	1	2	3	4	Attentive
28	Uninterested	4	3	2	1	0	1	2	3	4	Interested
29	Physically drowsy	4	3	2	1	0	1	2	3	4	Physically charged
30	Clumsy in my movements	4	3	2	1	0	1	2	3	4	Smooth in my movements
31	Inconsistent in my performance	4	3	2	1	0	1	2	3	4	Consistent in my performance
32	Being sociable is harmful	4	3	2	1	0	1	2	3	4	Being sociable is useful
33	I feel rejected	4	3	2	1	0	1	2	3	4	I feel accepted

Scoring

Scores on the dysfunctional side (i.e., left side) are transformed into negative scores. Thus, the score of an item could range from –4 to 4, and the total score of each modality could range from –12 to 12. It is also possible to calculate a total score by adding the scores of the individual items. The total score could range from –132 to 132.

Mean scores of each modality:

Enjoyment = (1 + 12 + 23)/3
Confidence = (2 + 13 + 24)/3
Anxiety = (3 + 14 + 25)/3
Assertiveness = (4 + 15 + 26)/3
Cognitive = (5 + 16 + 27)/3
Motivation = (6 + 17 + 28)/3
Bodily-somatic = (7 + 18 + 29)/3
Motor-behavioral = (8 + 19 + 30)/3
Operational = (9 + 20 + 31)/3
Communicative = (10 + 21 + 32)/3
Social support = (11 + 22 + 33)/3

Note: The English version here presented is a translation of the Italian version (see last page) and has not been validated.

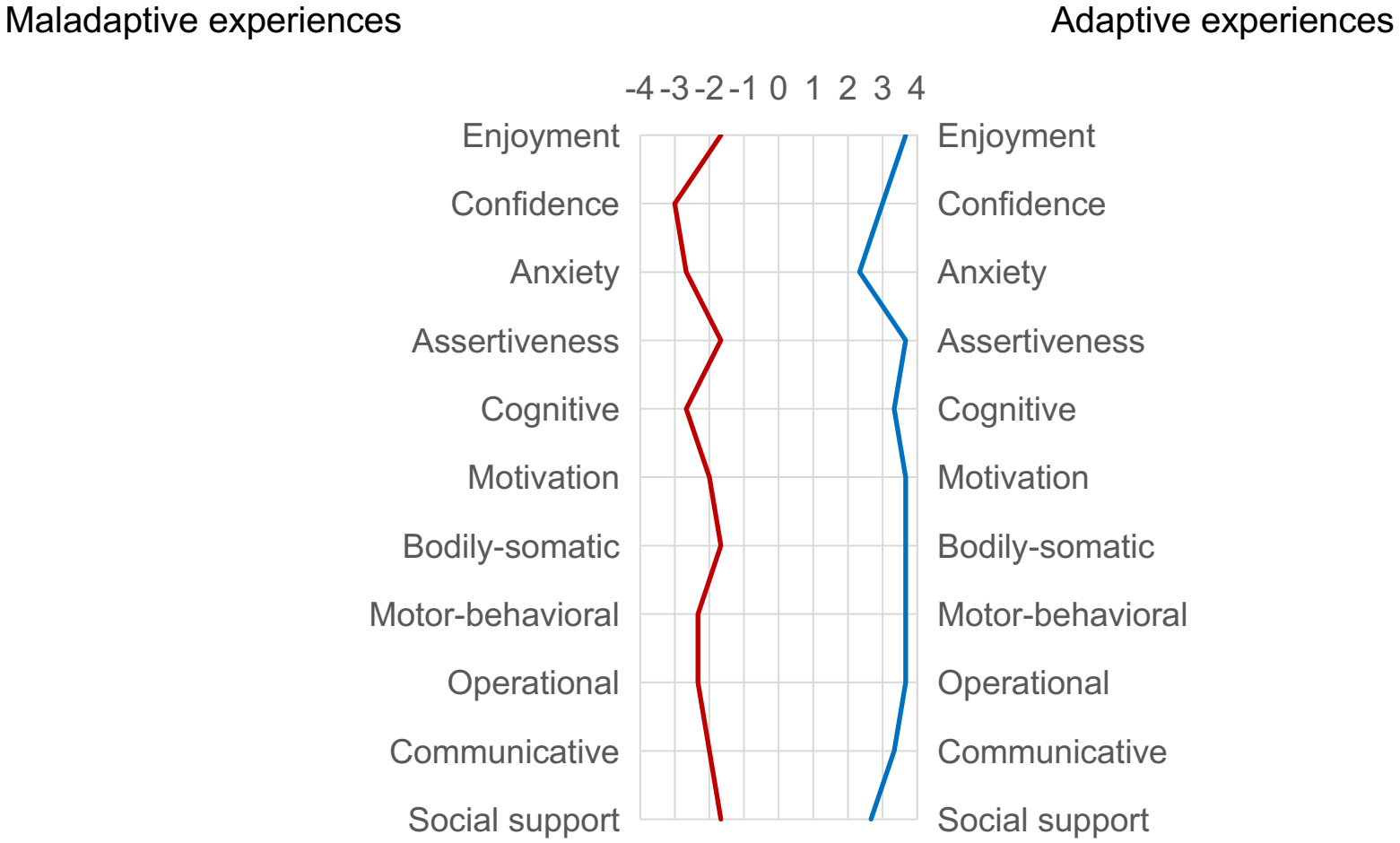
Complete Psychobiosocial Profile of two Students

	Maladaptive experiences	Very much	Much	Moderate	A little	neither… nor	A little	Moderate	Much	Very much	Adaptive experiences
1	Unhappy			X						X	Happy
12	Sad				X				X		Joyful
23	Dejected			X						X	Cheerful
2	Incapable			X						X	Capable
13	Insecure		X					X			Secure
24	Uncertain	X							X		Certain
3	Worried in a harmful way		X				X				Worried in a helpful way
14	Mentally tense in a harmful way			X					X		Mentally tense in a helpful way
25	Nervous in a harmful way		X						X		Nervous in a helpful way
4	Submissive				X					X	Fighting spirit
15	Fragile			X					X		Gritty
26	Surrendered			X						X	Combative
5	Distracted		X						X		Alert
16	Unfocused		X							X	Focused
27	Inattentive			X					X		Attentive
6	Unmotivated		X							X	Motivated
17	Disengaged			X					X		Engaged
28	Uninterested				X					X	Interested
7	Physically weak			X						X	Physically vigorous
18	Physically fatigued				X					X	Full of energy
29	Physically drowsy			X					X		Physically charged
8	Uncoordinated in my movements		X							X	Coordinated in my movements

19	Lethargic in my movements			X						X	Dynamic in my movements
30	Clumsy in my movements			X					X		Smooth in my movements
9	Ineffective in my performance		X						X		Effective in my performance
20	Unskillful in my performance			X						X	Skillful in my performance
31	Inconsistent in my performance			X						X	Consistent in my performance
10	Being communicative is harmful			X						X	Being communicative is useful
21	Being expansive is harmful		X						X		Being expansive is useful
32	Being sociable is harmful				X				X		Being sociable is useful
11	I feel ignored			X					X		I feel considered
22	I feel neglected			X				X			I feel supported
33	I feel rejected				X				X		I feel accepted

Note. A Maladaptive Profile of a Student is Displayed on the Left Side (in red) and an Adaptive Profile of Another Student is Displayed on the Right Side (in blue).

Aggregated Psychobiosocial Profile of two Students



Note. A Maladaptive Profile of a Student is Displayed on the Left Side (in red) and an Adaptive Profile of Another Student is Displayed on the Right Side (in blue).

Esperienze Psicobiosociali in Educazione fisica (PESD-PE)

Di seguito sono riportati aggettivi o frasi che le persone di solito usano per descrivere come si sentono in relazione alle attività motorie. Per ogni riga vi sono due descrittori opposti. Leggili attentamente e per ciascuna riga scegli uno dei due, ***uno solo*** (quello nella parte sinistra oppure quello nella parte destra), che riflette ***come ti senti di solito durante le lezioni di scienze motorie***; indicane poi l'***intensità*** con una X sulla scala che va da 1 (***poco***) a 4 (***moltissimo***). Se in una riga nessuno dei due descrittori è presente nella tua esperienza durante le lezioni di scienze motorie, segna la casella centrale 0 (***né…né***). Non ci sono risposte giuste o sbagliate. Per favore, accertati di rispondere a tutte le descrizioni.

Esempio:
"Mi sento abbastanza soddisfatto di me stesso". In tal caso devi contrassegnare la casella 2 nella parte destra.

Insoddisfatto	4	3	2	1	0	1	X 2	3	4	Soddisfatto

Se invece per te è vero: "Mi sento molto insoddisfatto di me stesso", in tal caso devi contrassegnare la casella 3 nella parte sinistra.

Insoddisfatto	4	X 3	2	1	0	1	2	3	4	Soddisfatto

		Moltissimo	Molto	Abbastanza	Poco	Né…né	Poco	Abbastanza	Molto	Moltissimo	
1	Infelice	4	3	2	1	0	1	2	3	4	Felice
2	Incapace	4	3	2	1	0	1	2	3	4	Capace
3	Preoccupato in modo dannoso	4	3	2	1	0	1	2	3	4	Preoccupato in modo utile
4	Remissivo	4	3	2	1	0	1	2	3	4	Combattivo
5	Distratto	4	3	2	1	0	1	2	3	4	Vigile
6	Demotivato	4	3	2	1	0	1	2	3	4	Motivato
7	Fisicamente affaticato	4	3	2	1	0	1	2	3	4	Pieno di energia
8	Fiacco nei movimenti	4	3	2	1	0	1	2	3	4	Attivo nei movimenti
9	Inefficace nella mia prestazione	4	3	2	1	0	1	2	3	4	Efficace nella mia prestazione
10	Essere comunicativo mi danneggia	4	3	2	1	0	1	2	3	4	Essere comunicativo mi è utile

11	Mi sento ignorato	4	3	2	1	0	1	2	3	4	Mi sento considerato
12	Triste	4	3	2	1	0	1	2	3	4	Gioioso
13	Insicuro	4	3	2	1	0	1	2	3	4	Sicuro
14	Mentalmente teso in modo dannoso	4	3	2	1	0	1	2	3	4	Mentalmente teso in modo utile
15	Fragile	4	3	2	1	0	1	2	3	4	Grintoso
16	Deconcentrato	4	3	2	1	0	1	2	3	4	Concentrato
17	Disimpegnato	4	3	2	1	0	1	2	3	4	Coinvolto
18	Fisicamente scarico	4	3	2	1	0	1	2	3	4	Fisicamente carico
19	Inerte nei movimenti	4	3	2	1	0	1	2	3	4	Dinamico nei movimenti
20	Scadente nella mia prestazione	4	3	2	1	0	1	2	3	4	Abile nella mia prestazione
21	Essere espansivo mi danneggia	4	3	2	1	0	1	2	3	4	Essere espansivo mi è utile
22	Mi sento trascurato	4	3	2	1	0	1	2	3	4	Mi sento supportato

		Moltissimo	Molto	Abbastanza	Poco	Né…né	Poco	Abbastanza	Molto	Moltissimo	
23	Avvilito	4	3	2	1	0	1	2	3	4	Allegro
24	Incerto	4	3	2	1	0	1	2	3	4	Certo
25	Nervoso in modo dannoso	4	3	2	1	0	1	2	3	4	Nervoso in modo utile
26	Arrendevole	4	3	2	1	0	1	2	3	4	Agguerrito
27	Disattento	4	3	2	1	0	1	2	3	4	Attento
28	Disinteressato	4	3	2	1	0	1	2	3	4	Interessato
29	Fisicamente non reattivo	4	3	2	1	0	1	2	3	4	Fisicamente reattivo
30	Goffo nei movimenti	4	3	2	1	0	1	2	3	4	Fluido nei movimenti
31	Instabile nella mia prestazione	4	3	2	1	0	1	2	3	4	Stabile nella mia prestazione
32	Essere socievole mi danneggia	4	3	2	1	0	1	2	3	4	Essere socievole mi è utile
33	Mi sento rifiutato	4	3	2	1	0	1	2	3	4	Mi sento accettato