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ORIGINAL PAPER

On the hierarchical and situational multidimensionality of motivation according to self-determination theory: further investigating the specificity hypothesis

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Abstract
Motivational regulations, as conceptualized by Self-Determination Theory (SDT), are fundamental for understanding engagement in diverse contexts. This study examines the structure of these regulations by exploring both their hierarchical and situational multidimensionality, with a focus on testing the Specificity Hypothesis—which posits that motivational regulations vary in situational specificity along the self-determination continuum. Specifically, it suggests that autonomous motivation is more subject-specific than controlled motivation. For instance, students may show high intrinsic motivation in one subject (e.g., mathematics) but lower levels in another (e.g., first language), whereas controlled motivation tends to be more stable across subjects. By investigating how each type of motivational regulation is structured across multiple school subjects and levels of generality, the study aims to address a largely unexplored question in SDT: how the degree of specificity differs across the regulation types and what this implies for the differentiation of motivational experiences. Multiple structural models were evaluated to determine which best capture the distinct characteristics of motivational constructs within academic settings. Two questionnaires were administered to psychology students, measuring general academic motivation and motivation toward five specific courses. Using a bootstrap resampling method, nine structural models were compared, examining both regulation construct and item structure. Results consistently support a hierarchical model with an additional item-related factor, underscoring this structure's superiority across all types of regulation. Findings indicate substantial distinctions in situational motivational measures based on self-determination levels, supporting the Specificity Hypothesis, contributing to the refinement of SDT and establishing a foundation for future motivation research within this theoretical framework.

Keywords Motivational regulations structure · Specificity hypothesis · Multidimensionality · Situational and hierarchical motivation · Bootstrap analyses

Introduction

For Self-Determination Theory (SDT), the issue of the multidimensionality of motivation has long been of paramount importance. Indeed, among the most notable contributions of SDT, the delineation of multiple motivational regulations situated along a continuum of self-determination has represented a major scientific advance in the field of human motivation. Over the past 50 years, the relevance and existence of multiple regulations organized according to a simplex pattern (Howard et al., 2017) have been extensively supported, and the differentiated consequences of these various regulations have validated the theory's central postulates based on the self-determination continuum as a crucial determinant of the affective, cognitive, and behavioral consequences associated with motivation (e.g., Howard et al., 2021; Ng et al., 2012; Vasconcellos et al., 2020). Although this multidimensionality has demonstrated its richness and significance in studying its links with various adaptive and maladaptive variables in the educational context (Howard et al., 2021), it exponentially complicates its investigation

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whenever motivation for different disciplines or different levels of generality is invoked. In contrast to these 50 years of research, this study aims to evaluate the structure of motivational regulations separately, considering the multidimensionality of constructs across various situational measures and hierarchical levels simultaneously. Indeed, considering the multidimensional nature of motivation opens up promising avenues, while raising still largely unexplored questions about how motivational regulations are structured across disciplinary contexts and hierarchical levels (i.e., situational, contextual, and global). To date, most studies have examined motivational regulations within a single motivational profile, often focusing on a single academic subject or a specific level of generality. In contrast, the present study proposes to assess the structure of each motivational regulation separately, across multiple school subjects and levels of generality. This approach aims to rigorously test the Specificity Hypothesis (Chanal & Guay, 2015), which suggests that motivational regulations may vary in their degree of specificity depending on the type of regulation, explaining differences in the differentiation of regulations across various school subjects. Specifically, it posits that autonomous motivation is more subject-specific than controlled motivation. This means that students may exhibit high intrinsic motivation in one subject (i.e., mathematics) but show lower intrinsic motivation in another (i.e., first language), whereas controlled motivation tends to remain more stable across different subjects. By addressing this underexplored issue, the study could contribute to a more nuanced understanding of how motivation is structured and differentiated according to its type and the context in which it is expressed.

Beyond its central aim, this work may also open up several avenues for inquiry from psychometric, theoretical, and practical perspectives. From a methodological standpoint, analyzing each regulation individually could allow for a more precise modeling of their hierarchical and situational structure, while reducing conceptual and statistical ambiguities typically associated with the aggregation of heterogeneous motivational regulations. Furthermore, it may help clarify persistent yet perplexing empirical findings—such as the often weak or inconsistent links between controlled regulations and academic outcomes—by uncovering patterns of specificity that are obscured in traditional measurement methods. On a practical level, differentiating between regulations in this way could ultimately support more targeted motivational interventions, sensitive to the characteristics of each regulation and the specific contexts in which they either emerge or fail to differentiate, depending on their level of specificity at the situational level. At a theoretical level, the findings may enrich existing models, such as Vallerand's Hierarchical Model of Intrinsic and Extrinsic Motivation (HMIEM; Vallerand, 1997), by uncovering structural differences between autonomous and controlled regulations across contexts. Additionally, they may provide a more integrative perspective on students' motivational development across school subjects, shedding light on when and under what conditions specific types of motivation begin to differentiate.

Overall, this work aims to establish a foundation for a more nuanced understanding of motivational differentiation across school subjects. By doing so, it may contribute to advancing theoretical models and guiding educational practices that are better aligned with the contextual and developmental dynamics of student motivation.

Classical differentiation of motivational regulations in SDT

In contrast to other theories of human motivation, SDT not only considers motivation quantitatively but also qualitatively (e.g., Guay et al., 2008), adopting a multidimensional perspective of this construct. This theory acknowledges the existence of several types of motivational regulations, each yielding distinct affective, cognitive, and behavioral consequences (Howard et al., 2021). These various motivational regulations are arranged along a continuum of self-determination (see Fig. 1). The concept of self-determination refers to the degree to which an individual perceives themselves as the initiator of their own behavior (Deci & Ryan, 1985). The more self-determined an individual's motivation, the more inclined they are to engage in behavior voluntarily and spontaneously. Conversely, the less self-determined the motivation, the more the behavior is performed in response to internal or external pressures (Deci & Ryan, 2008).

Intrinsic motivation sits atop the self-determination continuum, representing the most internalized form of motivation. It manifests when an individual engages in an activity for the satisfaction and enjoyment it brings, without being driven by or concerned with external rewards or pressures (Ryan & Deci, 2020). This level of motivation entails a perception of internal locus of causality, where the individual recognizes themselves as the initiator of their actions (Ryan & Deci, 2017). For example, an intrinsically motivated student may complete math homework out of genuine interest in the subject, pleasure in understanding, or satisfaction derived from solving mathematical problems. In contrast, extrinsic motivation arises when an individual engages in an activity for instrumental reasons, guided by external outcomes rather than the intrinsic characteristics of the activity itself (Ryan, 2023). Extrinsic motivation can be subdivided into several regulations, ranging from the least to the most self-determined. External regulation involves behaviors dictated by external contingencies, such as seeking rewards,

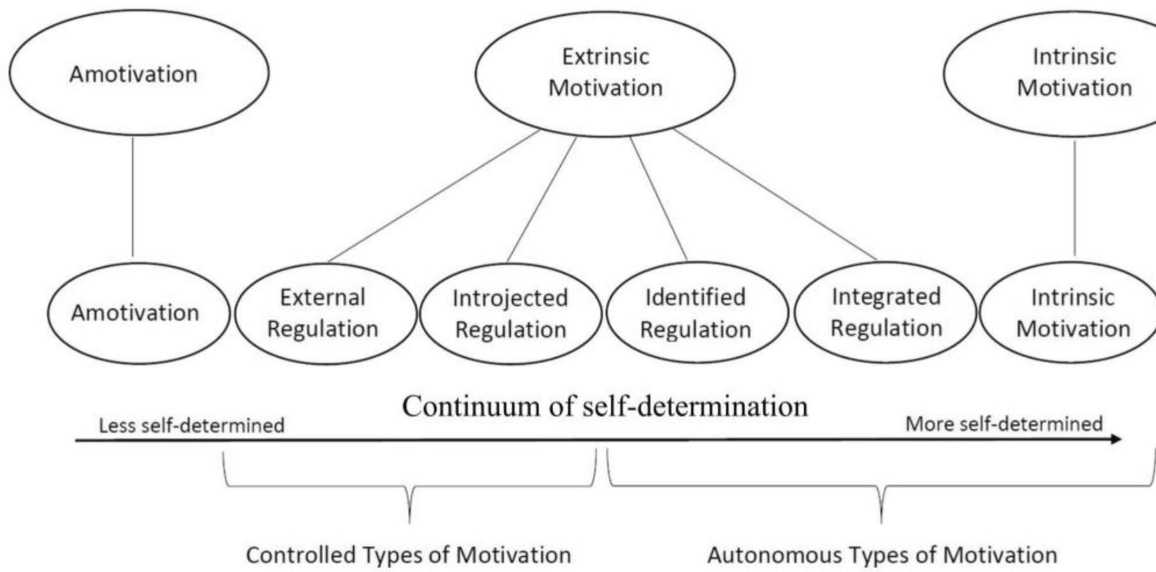

Fig. 1 Representation of Motivation Types on the Self-Determination Continuum. Image adapted from "Testing a Continuum Structure of Self-Determined Motivation: A Meta-Analysis," by J.L. Howard., M. Gagné., & J.S. Bureau, 2017, Psychological Bulletin, 143(12), p. 1347. Copyright 2017 by American Psychological Association.

avoiding punishments, or external constraints (Ryan & Deci, 2017). At this stage, incentives for action are not internalized. Introjected regulation represents an initial level of internalization, where the individual begins to internalize external contingencies while perceiving them as internal pressure (Roth & Assor, 2012). In this regulation, behavior is motivated by internal pressures aimed at maintaining positive self-esteem (Ryan & Deci, 2020). For instance, a student motivated in an introjected manner may work at school to uphold their self-esteem. Identified regulation constitutes the second level of internalization, where the individual acknowledges the value of the behavior by understanding its personal interest, importance, and how it helps achieve an important goal (Ryan, 2023). For example, a student motivated in an identified manner may work at school by recognizing its importance for their future. Finally, integrated regulation[1] represents the most self-determined level of extrinsic motivation. When this regulation is present, the individual has fully integrated the demands and values associated with the behavior into their value system and identity (Ryan & Deci, 2020). In this case, the activity is performed spontaneously, in harmony with the individual's values, goals, and personality, even though the activity is not perceived as intrinsically enjoyable and fun.

A distinction arising from the work of Assor et al. (2009) has brought a novel perspective to introjected regulation by subdividing it into two distinct types: approach (or positive) introjected regulation and avoidance (or negative) introjected regulation. The former aims to maintain or enhance self-esteem, leading, for instance, a student to diligently work to experience personal pride. Conversely, the latter encompasses behaviors aimed at avoiding the loss of self-esteem, prompting a student to complete their assignments to avoid feelings of shame or guilt. This distinction suggests that due to its more negative connotations, avoidance introjected regulation is perceived as less self-determined (autonomous) and more controlled than its approach counterpart (Assor et al., 2009). Sheldon et al. (2017) confirmed and validated this proposition by adopting the terms "positive introjection" and "negative introjection". This duality between approach and avoidance has also been applied to external regulation by Chanal et al. (2019) in their academic motivation scale. Approach external regulation manifests when the student is motivated by positive repercussions such as achieving a good grade or satisfying others, while avoidance external regulation refers to behaviors aimed at avoiding negative consequences such as a poor grade or disappointing the teacher. Furthermore, in the context of physical education, various types of intrinsic motivation have been suggested. In particular, three distinct dimensions have been identified in the literature: stimulation, knowledge, and accomplishment intrinsic motivation (e.g., Carbonneau et al., 2012). Stimulation intrinsic motivation occurs when the individual engages in an activity for the pleasant sensations it provides, such as sensory or aesthetic pleasure. As for knowledge and accomplishment intrinsic motivation, they involve an interest in understanding and learning new things (knowledge intrinsic motivation) or acquiring new skills (accomplishment intrinsic

[1] Integrated regulation was not measured in the present study due to the consensus regarding the challenges associated with assessing integrated motivation (e.g., Sheldon et al., 2017).

motivation). These dimensions of intrinsic motivation have yielded distinct results in the academic context (Chanal et al., 2019).

A new perspective on motivational regulations differentiation

The study by Guay et al. (2010) was the first to integrate the analysis of differentiation between academic subjects with motivational regulations described by SDT. Their objective was to examine intrinsic, identified, and controlled motivation (combined introjected and external) towards mathematics, reading, and writing among students aged 6 to 9 years. To assess the effect of between-subject differentiation, researchers calculated correlations between the three academic subjects for each motivational regulation. The study results revealed between-subject differentiation was more pronounced when motivations were more self-determined. The average correlations between motivations for different subjects were weaker for intrinsic motivation ($r=0.36$) compared to identified regulation ($r=0.76$), which, in turn, was lower than for controlled motivation ($r=0.86$). These findings suggest that students exhibit more significant motivational variations between different academic subjects for the most self-determined motivational regulations. In other words, students may demonstrate distinct levels of intrinsic motivation between academic subjects, with, for example, high intrinsic motivation for reading but lower levels for writing, or vice versa. Conversely, since controlled motivation is less differentiated between academic subjects, students tend to exhibit similar levels of this type of motivation across all disciplines. These results, although unexpected, provide crucial insights, as theoretically, according to SDT, there is no a priori indication that the magnitude of between-subject differentiation of motivations should differ depending on the level of self-determination of regulation types.

The Specificity Hypothesis, developed to elucidate why differentiation between academic subjects is more pronounced for the most self-determined motivational regulations, was pioneered by Chanal and Guay (2015). They addressed the multidimensionality of motivations across academic subjects by concurrently adopting a hierarchical perspective, drawing on research related to self-concept (Marsh et al., 2019), and building upon the premises of Vallerand's Hierarchical Model of Intrinsic and Extrinsic Motivation (HMIEM; Vallerand, 1997). Their approach involved scrutinizing various motivational regulations as described by SDT, both at the contextual level (i.e., motivation towards school as a whole) and at the situational level (i.e., motivation towards different academic school-subjects). The Specificity Hypothesis posits that autonomous regulations would exhibit greater differentiation between academic subjects than controlled motivations, owing to their heightened specificity to the disciplines in which they are appraised. Specifically, autonomous regulations would manifest a more pronounced differentiation between academic subjects because the underlying regulatory processes would be more closely intertwined with the characteristics unique to each discipline, unlike controlled regulations (Chanal & Guay, 2015).

To validate their hypothesis, the researchers chose to apply the Correlated Trait-Correlated Minus One (CTCM-1) model, as advocated by Brunner et al. (2010) in the context of academic self-concept. According to Brunner et al. (2010), the CTCM-1 model is particularly suitable for accounting for the multidimensional and hierarchical nature of constructs, allowing for the consideration of inherent specificity to constructs, differentiation between different domains, and organizing these elements in a hierarchical perspective with, at the top of the model, a global and contextual construction comparable to postulated theoretical definitions (Brunner et al., 2010). The self-concept, whose multidimensional and hierarchical nature has been clearly established (e.g., Marsh & Craven, 2006; Marsh et al., 2017), has thus been modeled with a CTCM-1 model in several studies (e.g., Arens et al., 2021; Brunner et al., 2010; Schmidt et al., 2017). Chanal and Guay (2015) were the first to use this model to model SDT motivational regulations in the academic context. The CTCM-1 model allowed them to decompose the variance of items common at the contextual level (i.e., school) from that attributable solely to the situational level (i.e., towards the academic subject in which motivation is measured) for each of the measured motivational regulations. Specifically, with this modeling, the regulation considered at the contextual level (towards school in general) is regarded as a single trait, while measures taken in different academic subjects are considered deviations from this global trait (see Fig. 2).

The results obtained by Chanal and Guay (2015) confirmed the Specificity Hypothesis. Indeed, in the study involving elementary school students, the proportion of variance attributable solely to the situational level was, on average, higher for autonomous motivations (0.64 and 0.55, respectively, for intrinsic motivation and identified regulation) than for controlled motivations (0.18 and 0.08, respectively, for introjected and external regulations). These findings were corroborated by the study with secondary school students, indicating that the proportion of variance of items solely attributable to the situational level was higher for autonomous motivations than for controlled ones. Chanal and Paumier (2020) replicated these results regarding the Specificity Hypothesis in a new study involving 579 secondary school students for additional motivational regulations (i.e., intrinsic stimulation, intrinsic achievement, introjected

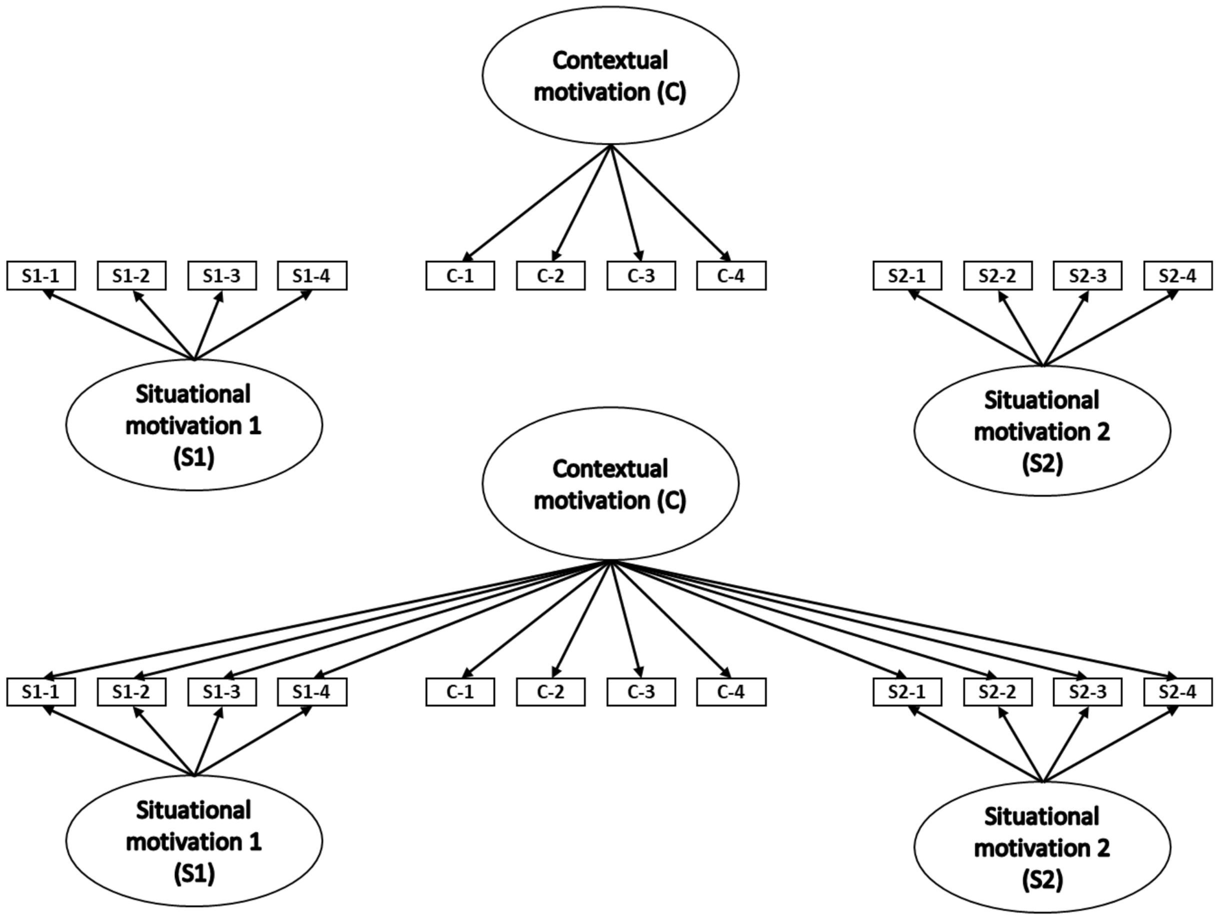

Fig. 2 Graphical Representation of CFA (Top) and CTCM-1 (Bottom) Modeling. S1 and S2 = school subjects 1 and 2; C = contextual; S1-1 to S1-4 = items for school subject 1; S2-1 to S2-4 = items for school subject 2; C1 to C4 = items for contextual level

approach, introjected avoidance, external approach, external avoidance).

Our study

The primary aim of this study is, first, to evaluate the multidimensional and hierarchical structure of the different regulations outlined by SDT, and then to rigorously and robustly test the Specificity Hypothesis. We hypothesize that a hierarchical modeling approach will optimally represent the data across all types of motivational regulations described by SDT. Specifically, we predict that CTCM-1 models will offer the best model-data fits compared to classical models (i.e., confirmatory factor analysis models; CFA), demonstrating their suitability for capturing the multidimensional and hierarchical organization of motivational regulations, as previously shown with self-concept (Brunner et al., 2009, 2010). In a second phase, we aimed to examine the specificity of motivational regulations at the situational level across different academic subjects, consistent with the Specificity Hypothesis. We sought to verify that these regulations vary in specificity according to their position on the continuum of self-determination, as indicated by previous work (Chanal & Guay, 2015; Chanal & Paumier, 2020). Consistent with these findings, we anticipate variability in specificity across regulations depending on their level of self-determination. Specifically, we hypothesize that the proportion of variance explained at the situational level will be higher for autonomous motivations, such that the degree of specificity (i.e., the percentage of variance explained by specificity) increases along the continuum of self-determination, with more self-determined forms of regulation showing greater specificity, and less self-determined forms showing lesser specificity.

Methods

Participants and procedure

This study was conducted with first-year Bachelor students in psychology at the University of Geneva. Data were collected from two distinct samples. The first sample consisted of 314 students (17.83% males; $M_{\text{Age}}=21.71$, $SD_{\text{Age}}=4.7$) enrolled in the first year of the Bachelor's program in psychology during the first semester of the academic year 2017–2018. The second sample comprised 275 students (23.65% males; $M_{\text{Age}}=20.57$, $SD_{\text{Age}}=4.4$) enrolled in the first year of the Bachelor's program in psychology at the University of Geneva during the first semester of the academic year 2020–2021. Questionnaires for both samples were administered online using the Qualtrics platform (http://qualtrics.com). Participants provided informed consent to participate in the study, and their data were anonymized. The study received approval from the ethics committee of the Faculty of Psychology at the University of Geneva.

Measures

Students' motivation was assessed using two motivational questionnaires. The first administered questionnaire developed by Chanal et al. (2019), measures seven motivational regulations: intrinsic motivation for stimulation, intrinsic motivation for achievement, identified regulation, approach introjected regulation, avoidance introjected regulation, approach external regulation, and avoidance external regulation. Each subscale is assessed with 4 items, except for approach external regulation, which includes 5 items (see online Appendix A for the complete list of items). Participants were required to indicate the frequency with which each statement corresponded to the reasons why they attended the courses on a 7-point Likert scale ranging from 1 = "never" to 7 = "all the time". This questionnaire was adapted to measure these seven motivational regulations towards psychology studies (contextual level) and towards five courses (situation level) taken in the first year of the Bachelor's program (i.e., introduction to clinical psychology, introduction to methodology and data analysis, social psychology, cognitive development psychology, motivation and learning). This questionnaire was administered only to participants from the first sample.

The second motivational questionnaire was developed by Sheldon et al. (2017). This questionnaire consists of 5 subscales, each measuring one of the five motivational regulations, assessed with 4 items each: intrinsic motivation, identified regulation, positive introjected regulation, negative introjected regulation, and external regulation (see online Appendix A for the complete list of items). Similarly, participants were required to indicate the frequency with which each statement corresponded to the reasons why they attended the courses on a 7-point Likert scale ranging from 1 = "never" to 7 = "all the time". The questionnaire was adapted to measure the five motivational regulations towards psychology studies (contextual level) and towards five specific courses (situation level) taken in the first year of the Bachelor's program (i.e., introduction to clinical psychology, introduction to methodology and data analysis, social psychology, cognitive development psychology, motivation and learning). This questionnaire was administered to participants from both samples.

We utilized two different questionnaires to incorporate multi-dimensional scales and varied items (see online Appendix A), which enabled us to replicate our findings and confirm that our results were not solely dependent on a specific questionnaire or set of scales.

Statistical procedure

Structural equation models

We performed several modelings of the academic motivation structure for each regulation. Our initial approach involved assessing whether a hierarchical organization of constructs, as envisaged in CTCM-1 models in other contexts (Brunner et al., 2010), applied to all motivational regulations postulated by SDT. We therefore compared classical models (i.e., confirmatory factor analysis models, CFA) without shared variance between measures at different levels with CTCM-1 models (with correlated or uncorrelated dimensions). Three distinct structures were examined (i.e., Fig. 3, line 1) within the framework of structural equation models. The first model (CFA, a) did not consider any linkage between situational measures and the contextual level, while the other two models (CTCM) did account for these linkages. The CTCM models were evaluated by considering the correlation between situational measures (i.e., school subjects) as either absent (CTCM, b) or present (CTCM_C, c).

Given that the regulations are measured multiple times across different subjects, the items are presented repeatedly to the same respondent, with only the measurement context differing. For example, an item related to introjected regulation linked to guilt is presented to the same respondent once for clinical psychology, once for social psychology, and once for psychology studies. Since the various items of the different regulations were presented multiple times across different subjects, we also modeled several method factors related to the items (i.e., correlated uniquenesses CU and item-specific factors IS). Once again, three distinct structures regarding the relationships between items were

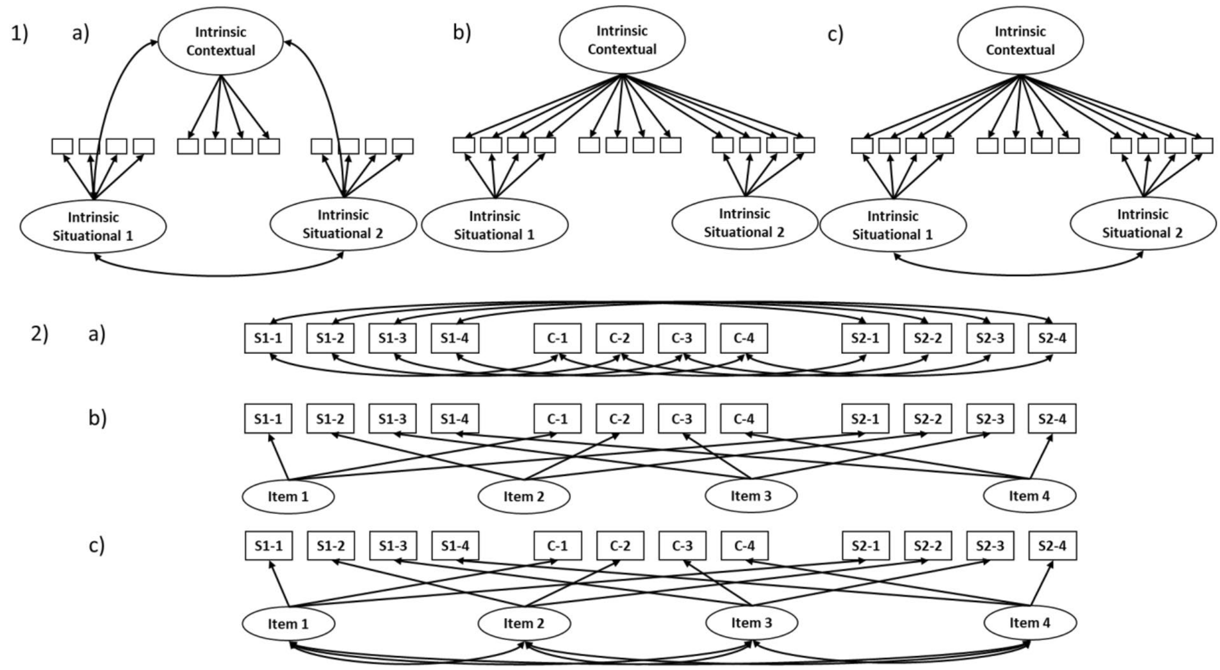

Fig. 3 Graphical Representation of Structure and Item Modeling. (1) = Representation of structure modeling of intrinsic motivation: Confirmatory Factor Analysis (CFA, a), Correlated Trait-Correlated Method Minus One Model uncorrelated (CTCM, b), Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor (CTCM_C, c); (2) = Representation of item variance modeling: Correlated-Uniqueness (CU, a), Item Specific factor uncorrelated (IS,b); Item Specific factor Correlated (IS_C, c)

examined (Fig. 3, lines 2). The first structure considered a simple correlation between items (CU, a), while the other two involved a factorial structure among items, with factors either uncorrelated (IS, b) or correlated (IS_C, c) with each other. By combining the three hierarchical structures (CFA, CTCM, and CTCM_C) with the three method factors (CU, IS and ISC), we examined a total of nine distinct models. These nine models were implemented to examine the seven motivational regulations (i.e., intrinsic stimulation, intrinsic accomplishment, identified, introjected approach introjected introjected avoidance, approach external, avoidance external) from Chanal et al.'s (2019) questionnaire, as well as the five motivational regulations (i.e., intrinsic, identified, positive introjection, negative introjection, external) from Sheldon et al.'s (2017) questionnaire.

Bootstrap resampling

To assess the psychometric characteristics of these different models and to provide precise guidance to researchers in the field, we employed bootstrap resampling analyses. Parametric bootstrap resampling with replacement was applied to each of the original datasets to generate 5000 bootstrapped datasets of the same size as the initial sample. Analyses based on the questionnaire by Chanal et al. (2019) were exclusively performed on the data from the first sample, while those based on the questionnaire by Sheldon et al. (2017) were conducted by combining data from both samples (N = 589, with a proportion of 20.74% males; $M_{\text{Age}} = 21.14$, $SD_{\text{Age}} = 4.55$). Statistical analyses were conducted using R software (version 3.6.1). The Lavaan package 0.6–7 (Rosseel, 2012) was employed for modeling the structures and obtaining fit indices. In summary, this led to the creation of 315,000 models (9 models for 7 regulations for 5000 samples) for the data from Chanal et al.'s (2019) questionnaire and 225,000 models (9 models for 5 regulations for 5000 samples) for the data from Sheldon et al.'s (2017) motivation questionnaire.

Convergence and model acceptance across regulations and structures

In a first step, we investigated the convergence and acceptance rates of the models according to the different proposed structures. The convergence rate reflects the frequency at which the model converged among the 5,000 resamples used. The model acceptance rate indicates the percentage of times the model fit indices met the classic fit thresholds commonly used in the literature, among the models that converged. This analysis not only identifies the model with the best psychometric properties among the proposals but also assesses whether different regulations exhibit distinct convergence and acceptance characteristics depending on the models, which amounts to evaluating whether the psychometric qualities of the models can vary depending on the level of self-determination of the regulations.

To evaluate the acceptance rate of a model, the quality of fit to the data of the tested models was measured using the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA). These two indices share a common metric while providing complementary information, with the CFI informing about the model's fit to the data regarding the structural part, whereas the RMSEA provides indications of the residual part (Xia & Yang, 2019). It is worth noting that these indices establish acceptability thresholds to determine if a model exhibits adequate, acceptable, or poor fit to the data. They can also be interpreted in terms of absolute fit value. In line with the recommendations of Hu and Bentler (1999), a model demonstrates acceptable fit if it displays a CFI$\geq$0.90 and an RMSEA$\leq$0.08 (lenient thresholds), and optimal fit if it achieves a CFI$\geq$0.95 and an RMSEA$\leq$0.05 (strict thresholds).

Model selection

In a second step, we delved into the preferential choice among the nine proposed models for each of the regulations derived from the different questionnaires. To determine the probability of selecting a winning model, we assessed the fit of these models using two distinct indices, namely the Akaike Information Criterion (AIC; Akaike, 1973) and the Bayesian Information Criterion (BIC; Schwarz, 1978). These two indices, measuring comparative fit, only make sense when used to compare different models (Kenny et al., 2015). Lower values of these indices indicate better fit to the data. They balance adequacy and complexity, penalizing lack of parsimony based on the number of model parameters. The AIC applies a linear penalty of two for each estimated parameter, while the BIC applies a more severe penalty to model complexity, increasing exponentially as complexity grows (Vrieze, 2012).

The comparative analysis of the models was based on the estimation of the relative weights of AIC (AICw) and SaBIC (SaBICw) for each model, following the method proposed by Wagenmakers and Farrell (2004). First, for each resampled dataset where the nine measurement models converged without warnings or errors, we calculated the difference in fit, ΔAIC and ΔSaBIC, between the best-fitting model (indicated by the lowest AIC and SaBIC values) and the other models. Thus, the best-fitting model always has a ΔAIC (or ΔSaBIC) equal to 0, while the other models display a ΔAIC (or ΔSaBIC) greater than 0. Then, the AICw and SaBICw were calculated for each model using the equations provided by Wagenmakers and Farrell (2004). This approach allows estimating the probability that each of the nine models is the best given the data and the tested candidate models.

Variance decomposition

In a third and final step, we decomposed the shared variance of the items according to the winning model for the different regulations considered in the two questionnaires, thus validating or refuting the Specificity Hypothesis.

Results

In this manuscript, we present only the results from the Chanal et al. (2019) questionnaire for the sake of clarity. The findings from the Sheldon questionnaire will be included in the supplementary material, as they largely exhibit the same patterns. This approach streamlines the presentation and enhance the readability of the main text.

Model convergence across regulations

Table 1 presents the model convergence percentages among the 5000 resamples, based on the statistical model and regulation. Figure 4 depicts the mean convergence rates for the 9 models, distributed across regulations.

The results reveal that the mean convergence rate of the 9 models is not uniform across the considered regulation. Indeed, the convergence rate is approximately 40% at the intrinsic motivation level, around 80% at the identified regulation level, before decreasing for the introjected regulation, and showing lower convergence for the external regulations. These results suggest, in general, that model convergence varies depending on motivational regulations. However, Table 1 highlights the significant variability in results for different models based on the considered structures.

The results obtained with Sheldon's questionnaire are similar to those reported. For more detailed information, see Table S1, and Figure S1 in the online supplement.

Model convergence across structures

The results regarding model convergence across different structures considered (CFA, CTCM, and CTCM_C), as well as the various methods used for item variances (CU, IS, ISC), are presented in Table 2 and depicted in Fig. 5. Concerning the different structures, CFA models exhibit higher convergence rates (50.01%) compared to CTCM_C (45.20%) and CTCM (39.06%) models. Regarding the various methods used for item variance, the results show that, for both questionnaires, the CU structure displays the highest

Table 1 Percent of models that converged among 5000 bootstrapped data sets, according to statistical model and regulation

	Converged models (%)		
Models stucture	CFA		
Items structure	CU	IS	ISC
Intrinsic Stimulation	100	3.96	24.96
Intrisic Achievement	99.84	43.60	31.36
Identified	99.36	55.68	87.12
Introjected Approach	99.72	57.44	38.42
Introjected Avoidance	97.82	87	37.30
External Approach	5.22	42.24	21.68
External Avoidance	2.44	8.76	6.34
Models stucture	CTCM		
Items structure	CU	IS	ISC
Intrinsic Stimulation	100	5.18	32.68
Intrinsic Achievement	99.78	51.80	40.62
Identified	97.80	54.72	85.18
Introjected Approach	89.78	51.16	57.34
Introjected Avoidance	21.92	13.36	13.62
External Approach	1.74	0.92	2.66
External Avoidance	0	0	0
Models stucture	CTCM_C		
Items structure	CU	IS	ISC
Intrinsic Stimulation	100	5.18	26.64
Intrinsic Achievement	99.72	47	37.44
Identified	95.04	47.22	81.68
Introjected Approach	70.44	42.50	45.30
Introjected Avoidance	80.40	70.98	24.40
External Approach	10.64	17.14	20.38
External Avoidance	1.44	9.86	15.90

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

convergence rate (65.39%), surpassing ISC (37.81%) and IS (34.08%).

In summary, in terms of model convergence, it appears that CFA and CTCM_C structures do not significantly differ on a global scale. However, concerning the methods used at the item level, the CU method exhibits the highest convergence rate. These results are consistent, given that the CU method is less demanding in terms of estimation compared to IS methods.

The results obtained with Sheldon's questionnaire are similar to those reported. For more detailed information, see Table S2, and Figure S2 in the online supplement.

Model acceptance across regulations

Among the converged models, we examined the percentage of models fitting the data well according to lenient criteria (CFI≥0.90 or RMSEA≤0.08), indicating acceptable fits, or according to strict criteria (CFI≥0.95 or RMSEA≤0.05), indicating excellent fits to the data. Tables 3 (CFI) and 4 (RMSEA) present the percentages of models exceeding these thresholds for each model, depending on the different regulations. Figures 6 and 7 illustrate the averages of these proportions for CFI and RMSEA according to lenient criteria.

Figures 6A and 7A depict the mean acceptance rates for the 9 models, distributed across the different regulations. The results show that the mean acceptance rate of the 9 models is not uniform across the considered regulations, also depending on the CFI and the RMSEA. Specifically, in the case of CFI, the acceptance rate ranges from 80 and 100% for intrinsic motivation through to introjected avoidance regulation, with lower acceptance shown for both external regulations. For the RMSEA, the acceptance rates are significantly lower, with all values below 40%, except for the introjected approach regulation. These results suggest that, in general, model acceptance varies depending on the type

Fig. 4 Average Rate of Convergence of the 9 Models for Each Regulation

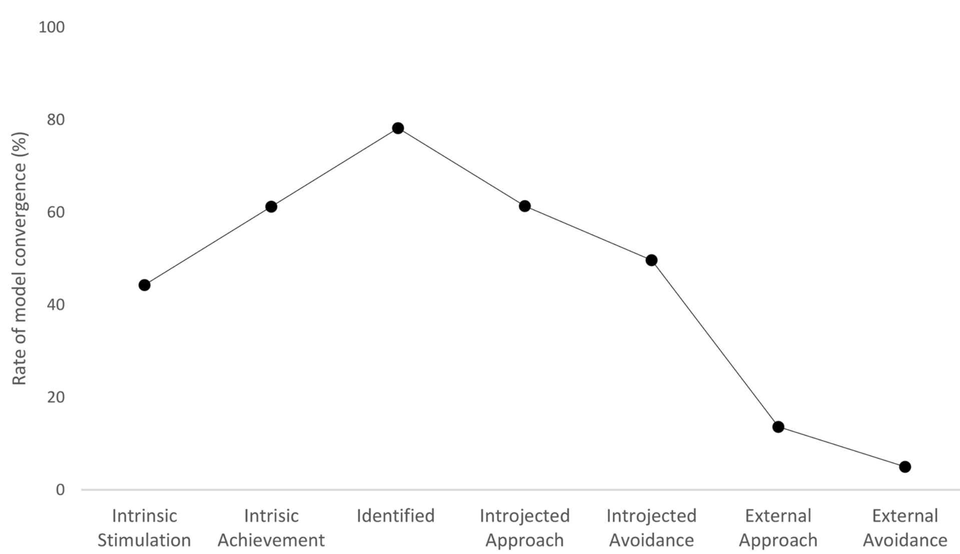

Table 2 Average rate of model convergence by items and models structure for each regulation

Converged Models (%)							
Items structure	CFA	CTCM	CTCM_C	Models structure	CU	IS	ISC
Intrinsic Stimulation	42.97	45.95	43.94	Intrinsic Stimulation	100.00	4.77	28.09
Intrinsic Achievement	58.27	64.07	61.39	Intrinsic Achievement	99.78	47.47	36.47
Identified	80.72	79.23	74.65	Identified	97.40	52.54	84.66
Introjected Approach	65.19	66.09	52.75	Introjected Approach	86.65	50.37	47.02
Introjected Avoidance	74.04	16.30	58.59	Introjected Avoidance	66.71	57.11	25.11
External Approach	23.05	1.77	16.05	External Approach	5.87	20.10	14.91
External Avoidance	5.85	0.00	9.07	External Avoidance	1.29	6.21	7.41
Mean	50.01	39.06	45.20	Mean	65.39	34.08	37.81

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

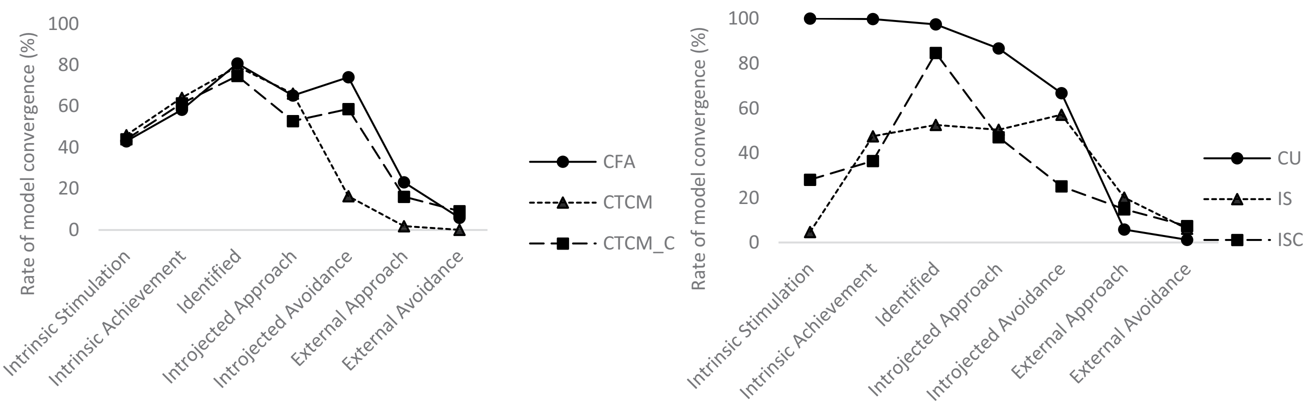

Fig. 5 Average Rate of Model Convergence by Models and Items Structure for Each Regulation. CFA=Confirmatory Factor Analysis; CTCM=Correlated Trait-Correlated Method Minus One Model; CTCM_C=Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor; CU=Correlated-Uniqueness; IS=Item Specific; ISC=Item Specific Correlated

of motivational regulation and the criteria used. However, Tables 3 and 4 highlight the significant variability in results for different models based on the structures considered.

The results obtained with Sheldon's questionnaire are similar to those reported. For more detailed information, see Tables S3 and S4, and Figures S3 and S4 in the online supplement.

Model acceptance across structures

Results regarding model acceptance, based on the different academic structures considered (CFA, CTCM, and CTCM_C), as well as the different methods used for item variances (CU, IS, ISC), are presented in Tables 5 and 6.

Comparative Fit Index (CFI). The results are presented in Table 5 and represented in Fig. 6B and C. CTCM_C models demonstrated superior performance, surpassing both CFA and CTCM models, for lenient criteria (81.47% vs. 76.74% and 70.20%) and strict criteria (21.41% vs. 13.18% and 9.97%).

Acceptance rates for the different methods used, ISC models (85.45%) outperformed CU (74.15%) and IS (68.81%) models for lenient criteria. For strict criteria, CU (19.75) and ISC (18.87%) models were preferred over IS models (5.94%).

The results obtained with Sheldon's questionnaire are similar to those reported. For more detailed information, see Table S5, and Figures S3B and S3C in the online supplement.

Root mean square error of approximation (RMSEA)

The results are presented in Table 6 and represented in Fig. 7B and C. The results showed that acceptance rates favored CFA and CTCM_C models (27.14% and 29.87%), compared to CTCM models (18.68%) under lenient criteria. Acceptance rates for the different methods used for item variances favored ISC method (40.11%) over IS (16.99%) and CU methods (18.59%) under lenient criteria.

The results obtained with Sheldon's questionnaire are a bit different to those reported, as acceptance rates under lenient criteria are higher in average (92% overall) and favored CTCM_C models (98.29%) over CFA (96.29%) and CTCM models (81.55%). For more detailed information, see Tables S6, and Figures S4B and S4C in the online supplement.

Table 3 Percent of models that meet CFI lenient and strict criteria among converged models according to statistical model and regulation

	CFI ≥.90 (%)			CFI ≥.95 (%)		
Models structure	CFA					
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	100	100	100	58.42	24.75	47.68
Intrinsic Achievement	67.07	45.96	97	0	0	2.93
Identified	99.86	97.81	99.75	11.21	1.54	10.31
Introjected Approach	100	98.57	99.95	62.31	11.49	32.07
Introjected Avoidance	98.18	72.14	100	0.67	0	11.42
External Approach	0	0	30.07	0	0	0
External Avoidance	73.77	34.25	97.16	0	0	1.89
Models structure	CTCM					
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	100	100	100	52.96	23.17	50.06
Intrinsic Achievement	65.48	64.30	97.93	0	0	3.79
Identified	99.49	99.20	99.30	3.48	0.40	4.27
Introjected Approach	99.91	100	99.93	32.99	4.26	27.97
Introjected Avoidance	94.53	89.52	99.12	0	0	6.02
External Approach	0	0.12	20.30	0	0	0
External Avoidance	0	45.03	0	0	0	0
Models structure	CTCM_C					
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	100	100	100	79.12	23.17	71.85
Intrinsic Achievement	85.26	64.30	99.73	0.24	0	13.84
Identified	99.96	99.20	99.85	24.01	3.77	20.10
Introjected Approach	100	100	100	86.12	32.24	64.64
Introjected Avoidance	99.95	89.52	100	3.13	0	23.36
External Approach	0	0.12	55.74	0	0	0
External Avoidance	73.61	45.03	98.62	0	0	4.03

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

Model selection

The results of model selection among the nine models are presented in Table 7. Only samples where all nine tested models converged were considered. It is important to note that no convergence for all nine models was observed for the approach external and avoidance external regulations. This result is notably explained by the zero convergence rate of CTCM models for avoidance external regulation, and the low convergence of these same models for approach external regulation (1.74%, 0.92%, and 2.66% for CU, IS, and ISC methods). Intrinsic stimulation and introjected avoidance regulations showed a low number of convergent samples (N = 23 and N = 67), representing 0.46% and 1.34% of all simulated samples, respectively. This low percentage of samples where all nine models converged is explained by the low convergence rate of models using the IS method (6.80%, 5.34%, and 5.90%, respectively, for CFA, CTCM, and CTCM_C models) for intrinsic motivation to stimulation, and by the low convergence rates of CTCM models for introjected avoidance regulation (21.92%, 13.36%, and 13.62%, respectively, for CU, IS, and ISC). In contrast, introjected approach, intrinsic motivation to achievement, and identified regulation displayed relatively higher percentages (3.94%, 7.72%, and 29%).

Among the nine models compared in our analyses, only two models were declared winners based on the AICw and SaBICw criteria used to evaluate the probabilities of each model being a winner: the CTCM_C_ISC model (9 times out of 10) and the CFA_ISC model (1 time out of 10). No other model was declared a winner according to either of the two selected criteria, although several models appeared with non-zero probabilities of being a winner (e.g., CTCM_C_CU for intrinsic motivation to stimulation and introjected approach regulation, respectively). Furthermore, considering the average model fit indices (CFI_Mean and RMSEA_Mean), the CTCM_C_ISC model obtained the best average according to the index 3 times out of 5 for CFI (with the CTCM_C_CU model having the best average the other two times) and 5 times out of 5 for RMSEA.

The results obtained with Sheldon's questionnaire are quite similar to those reported. For more detailed information, see Table S7. Among the nine models compared in our analyses, only two models were declared winners: the

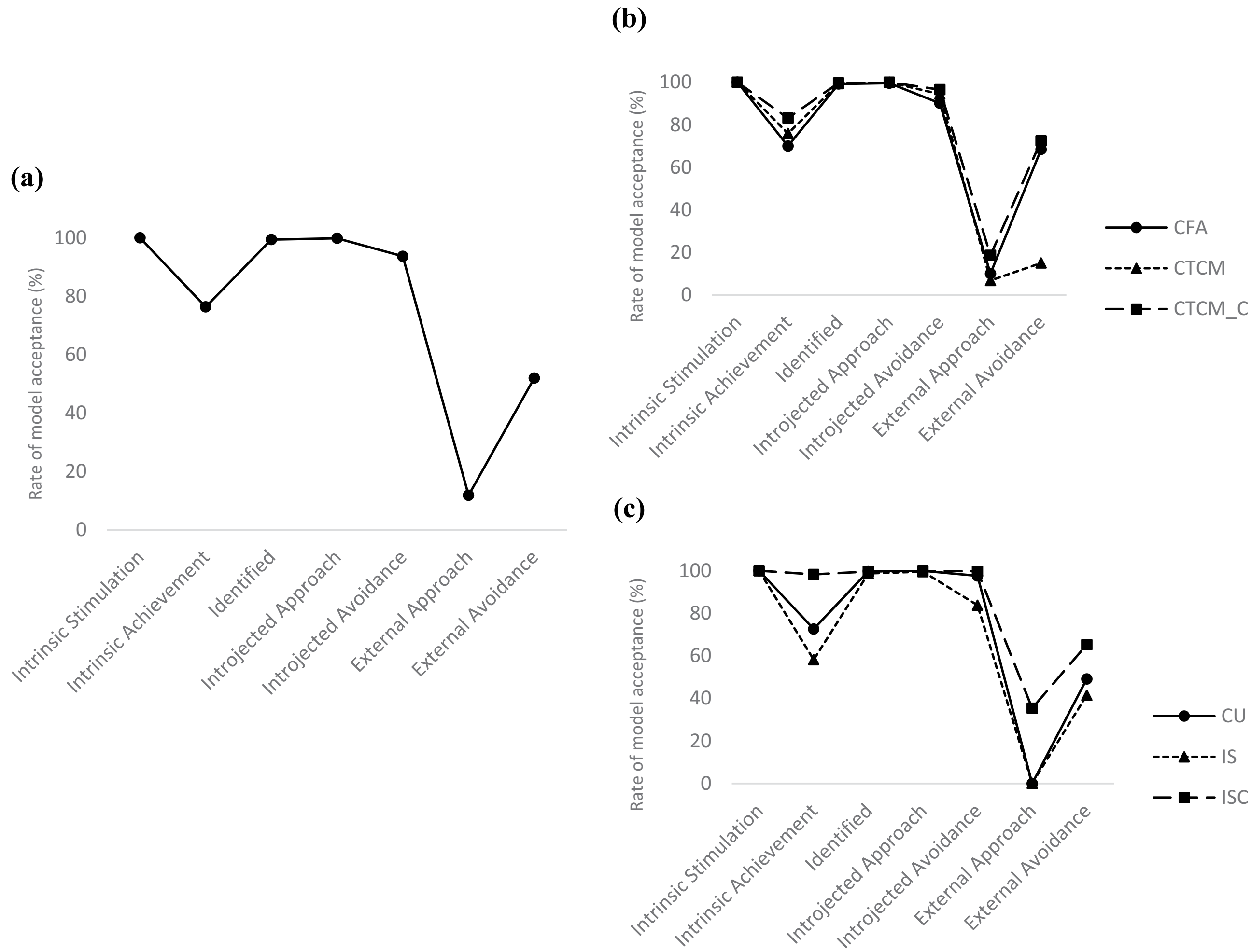

Fig. 6 Average Rate of Models That Meet CFI Lenient Criteria. **a** By regulations; **b** by models structure; **c** by items structure; *CFA* Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness; *IS* Item Specific, *ISC* Item Specific Correlated

CTCM_C_ISC model (8 times out of 10) and the CTCM_CU model (2 times out of 10).

Variance decomposition

The results of the variance decomposition of the winning model (i.e., CTCM_C_ISC) are presented in Table 8. All models that converged for each regulation were included in the analysis to ensure that the estimates were derived from the maximum number of valid models available.

The results show that the explained variance related to academic subjects increases along the continuum (from external avoidance regulation 0.22 to intrinsic motivation 0.57) when considering absolute variance (0.22, 0.13, 0.11, 0.16, 38. 0.38 and 0.57), as well as when considering the percentage of total variance explained by the different latent factors (29%, 19%, 15%, 24%, 53%, 51%, and 70%). These findings indicate that more self-determined forms of regulation display higher specificity. Furthermore, the variance related to the item method decreases along the continuum (0.50, 0.52, 0.52, 0.39, 0.19, 0.22, and 0.09), along with the percentage of explained variance (65%, 74%, 74%, 57%, 25%, 30%, and 11%). Considering the variance decomposition according to autonomous and controlled motivations on average, the results show that the variance specific to academic subjects and the percentage of explained variance are high (0.44, and 58%) while those related to items are low (0.17, and 22%) for autonomous motivations. Regarding controlled motivations, the results show the opposite effect. Specifically, the results indicate that the variance specific to academic subjects and the percentage of explained variance are low (0.16, and 22%) while those related to items are high (0.48, and 68%).

In summary, the results regarding the variance decomposition are consistent with the hypotheses formulated regarding the different degrees of specificity along the continuum

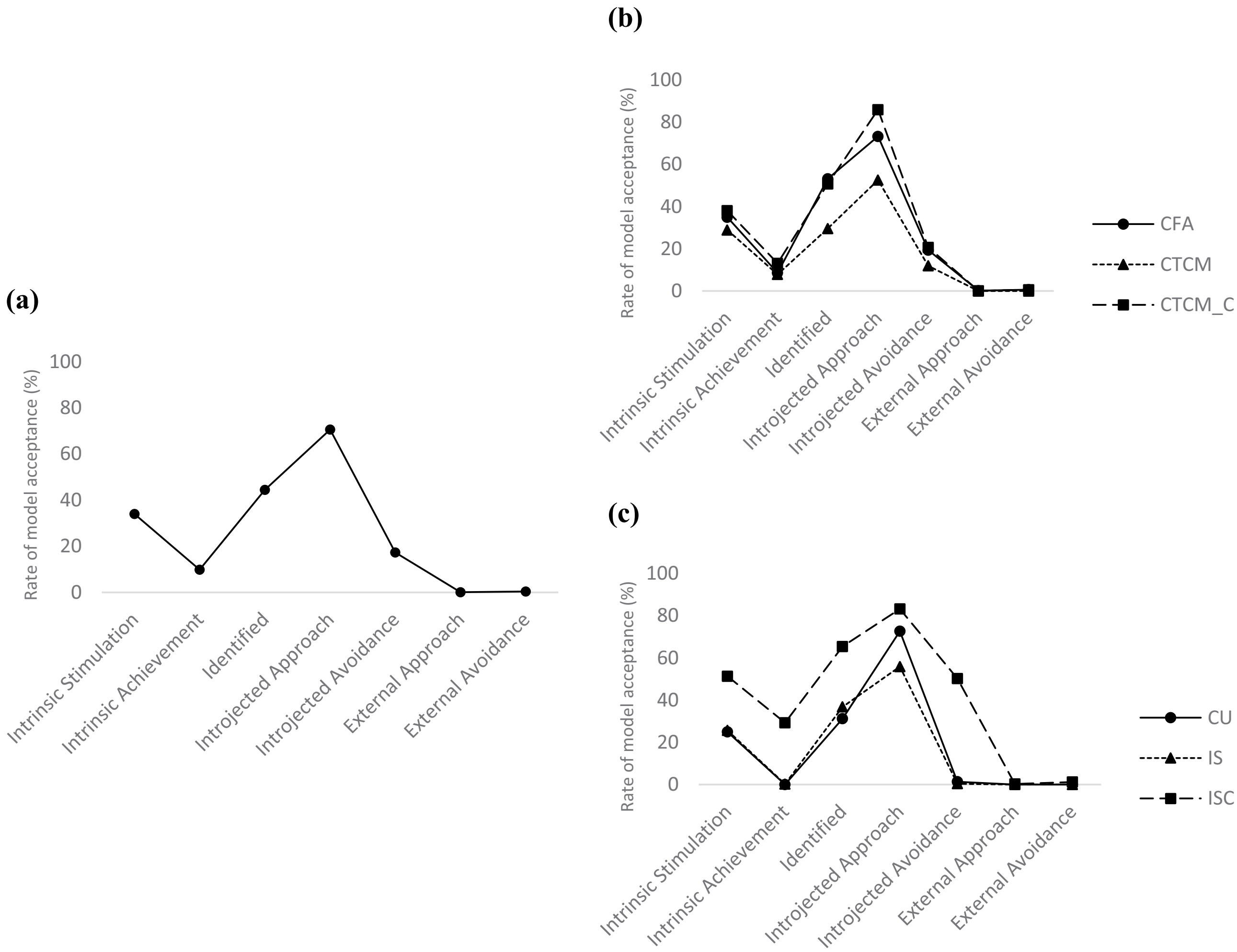

Fig. 7 Average Rate of Models That Meet RMSEA Lenient Criteria. **a** By regulations; **b** by models structure; **c** by items structure; *CFA* Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

of self-determination, namely that the portion of variance of items corresponding to the specific measurement of motivation in different subjects increases along the continuum of self-determination in accordance with the Specificity Hypothesis.

The results obtained with Sheldon's questionnaire are similar to those reported. For more detailed information, see Table S8 in the online supplement.

Discussion

This study aimed to test and evaluate the hierarchical and multidimensional structure of the different regulations of self-determined motivation, thus robustly and systematically replicating the results regarding the Specificity Hypothesis (Chanal & Guay, 2015). The ambition of this work was therefore to demonstrate that the level of specificity of different motivational regulations regarding measures taken at the situational level (i.e., in school subjects in our case) depends on the type of regulation considered. To achieve this, a study was conducted with university students, evaluating different types of motivational regulations, considering the different regulations measured in different situations and at a contextual level simultaneously to situational level. Nine distinct modeling approaches were developed for each type of regulation, considering different hierarchical structures and methods related to items shared variance. Psychometric evaluation of these models was conducted using resampling analyses. Our hypotheses were that all motivational regulations from SDT would exhibit a hierarchical and multidimensional structure, and that autonomous motivations would be more specifically associated with situational measures of school subjects as hypothesized by the Specificity Hypothesis.

Table 4 Percent of models that meet RMSEA lenient and strict criteria among converged models according to statistical model and regulation

	RMSEA ≤.08 (%)			RMSEA ≤.05 (%)		
Models structure	CFA					
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	25.58	29.80	49.44	0	0	0
Intrinsic Achievement	0	0.23	25.51	0	0	0
Identified	39.25	46.34	73.76	0	0	0
Introjected Approach	80.79	58.57	80.32	0	0	0
Introjected Avoidance	2	0.62	55.44	0	0	0
External Approach	0	0	0.46	0	0	0
External Avoidance	0	0	1.89	0	0	0
Models structure	CTCM					
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	17.02	23.55	46.14	0	0	0
Intrinsic Achievement	0	0	23.54	0	0	0
Identified	15.79	21.42	51.44	0	0	0
Introjected Approach	47.85	33.27	76.49	0	0	0
Introjected Avoidance	0.09	0	35.68	0	0	0
External Approach	0	0	0	0	0	0
External Avoidance	0	0	0	0	0	0
Models structure	CTCM_C					
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	32.26	23.55	58.26	0	0	0
Intrinsic Achievement	0.10	0.47	38.78	0	0	0
Identified	38.53	42.57	70.91	0	0	0
Introjected Approach	89.21	75.76	92.67	0.06	0	0
Introjected Avoidance	1.94	0.54	59.51	0	0	0
External Approach	0	0	0.39	0	0	0
External Avoidance	0	0	1.76	0	0	0

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

Table 5 Rate of model acceptance for CFI lenient and strict criteria among converged models according to statistical model and regulation

	CFI ≥.90 (%)			CFI ≥.95 (%)		
Models structure	CFA	CTCM	CTCM_C	CFA	CTCM	CTCM_C
Intrinsic Stimulation	100	100	100	43.62	42.06	58.05
Intrinsic Achievement	70.01	75.90	83.10	0.98	1.26	4.69
Identified	99.14	99.33	99.67	7.69	2.72	15.96
Introjected Approach	99.51	99.95	100	35.29	21.74	61
Introjected Avoidance	90.11	94.39	96.49	4.03	2.01	8.83
External Approach	10.02	6.81	18.62	0	0	0
External Avoidance	68.39	15.01	72.42	0.63	0	1.34
Mean	76.74	70.20	81.47	13.18	9.97	21.41
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	100	100	100	63.50	23.70	56.53
Intrinsic Achievement	72.60	58.19	98.22	0.08	0	6.85
Identified	99.77	98.74	99.63	12.90	1.9	11.56
Introjected Approach	99.97	99.52	99.96	60.47	16	41.56
Introjected Avoidance	97.55	83.73	99.71	1.27	0	13.60
External Approach	0	0.08	35.37	0	0	0
External Avoidance	49.13	41.44	65.26	0	0	1.97
Mean	74.15	68.81	85.45	19.75	5.94	18.87

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

Table 6 Rate of model acceptance for RMSEA lenient and strict criteria among converged models according to statistical model and regulation

	RMSEA ≤.08 (%)			RMSEA ≤.05 (%)		
Models structure	CFA	CTCM	CTCM_C	CFA	CTCM	CTCM_C
Intrinsic Stimulation	34.94	28.90	38.02	0	0	0
Intrinsic Achievement	8.58	7.85	13.12	0	0	0
Identified	53.12	.26.55	50.67	0	0	0
Introjected Approach	73.23	52.54	85.88	0	0	0.02
Introjected Avoidance	19.35	11.92	20.66	0	0	0
External Approach	0.15	0	0.13	0	0	0
External Avoidance	0.63	0	0.59	0	0	0
Mean	27.14	18.68	29.87	0	0	0
Items structure	CU	IS	ISC	CU	IS	ISC
Intrinsic Stimulation	24.95	25.63	51.28	0	0	0
Intrinsic Achievement	0.03	0.23	29.28	0	0	0
Identified	31.19	36.78	65.37	0	0	0
Introjected Approach	72.62	55.87	83.16	0.02	0	0
Introjected Avoidance	1.34	0.39	50.21	0	0	0
External Approach	0	0	0.28	0	0	0
External Avoidance	0	0	1.22	0	0	0
Mean	18.59	16.99	40.11	0	0	0

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

Examination of results concerning model acceptance showed that CFA and CTCM_C structures exhibited the best outcomes, and depending on the criteria used for adjustment indices, the CTCM_C structure slightly outperformed models with a CFA structure. Additionally, the ISC method seemingly demonstrated its superiority in terms of acceptance compared to the CU method. When all models were compared across the various proposed motivational regulations, the results indicated the superiority of only two models among the nine: the CTCM_C_CU and CTCM_C_ISC models. Finally, the results confirmed that the explained variance at the situational level increased along the continuum, while the variance explained by the items decreased simultaneously.

Hierarchical and multidimensional structure of motivational regulations

Overall, if the CTCM_C structure outperforms the CFA structure, it concretely signifies that the hierarchical vision of the academic structure of different motivational regulations is relevant and that measuring motivation at the contextual level should also be considered in studies investigating the effects of motivation at the situational level. These initial findings have significant practical implications for SDT researchers interested in academic motivation, as well as for the issue of the level of measurement to be undertaken when focusing on a particular domain where multiple measurements at different levels or with multiple situational tasks are conducted (e.g., work, organizations, sports, health). This result implies that when researchers measure multiple hierarchical levels of motivation within the same study, they should also prioritize this modeling. Additionally, the results show that while the ISC method exhibits better adjustments than other methods, it is penalized by lower convergence rates. Thus, overall, the recommendation we can make to researchers conducting studies involving measurements of motivational regulations in several academic subjects or across multiple domains simultaneously with the same tool is to consider the ISC method as a priority, but if model convergence is not feasible, the CU method is a completely acceptable compromise given its qualities in terms of adjustment with higher convergence rates than the ISC method. We understand the practical challenges that these conclusions may pose for researchers. Indeed, systematically measuring motivation at a higher hierarchical level, particularly among certain populations (e.g., children), or in light of common constraints such as limited access to participants, time restrictions for data collection, or the length of instruments, can be problematic. Our findings suggest that prioritizing the measurement of autonomous regulations would be particularly relevant due to their greater variability related to situational specificity. Furthermore, the results regarding the importance of the level of item variance captured for controlled motivations indicate that the choice of items for these regulations is crucial. Specifically, the variance of items for controlled regulations is more explained by the item factor than by the specific regulation factor. This means that the links between controlled regulations and outcomes at the situational level are more complex to apprehend, given the distribution of variance between the

Table 7 Average rate of models selected according to indices

	Model	CFI_mean	RMSEA_mean	AICw_Mean	SaBICw_Mean
Intrinsic Stimulation *K* Samples—All Models Converged N = 23	CFA_CU	0.951	0.085	0	0
	CFA_IS	0.942	0.084	0	0
	CFA_ISC	0.950	0.079	0.008	0.094
	CTCM_CU	0.949	0.088	0	0
	CTCM_IS	0.941	0.086	0	0
	CTCM_ISC	0.950	0.080	0.089	0.110
	CTCM_C_CU	**0.956**	0.084	0.211	0.091
	CTCM_C_IS	0.941	0.086	0	0
	CTCM_C_ISC	0.955	**0.078**	**0.692**	**0.704**
Intrinsic Achievement *K* Samples—All Models Converged N = 386	CFA_CU	0.908	0.104	0	0
	CFA_IS	0.900	0.099	0	0
	CFA_ISC	0.931	0.083	0.021	0.060
	CTCM_CU	0.907	0.106	0	0
	CTCM_IS	0.898	0.101	0	0
	CTCM_ISC	0.932	0.084	0.014	0.024
	CTCM_C_CU	0.917	0.103	0	0
	CTCM_C_IS	0.908	0.098	0	0
	CTCM_C_ISC	**0.939**	**0.081**	**0.965**	**0.916**
Identified *K* Samples—All Models Converged N = 1450	CFA_CU	0.938	0.081	0.049	0.041
	CFA_IS	0.928	0.080	0	0.003
	CFA_ISC	0.938	0.075	0.309	**0.543**
	CTCM_CU	0.933	0.086	0	0
	CTCM_IS	0.922	0.084	0	0
	CTCM_ISC	0.933	0.079	0.006	0.013
	CTCM_C_CU	0.943	0.081	0.155	0.055
	CTCM_C_IS	0.932	0.081	0.001	0.003
	CTCM_C_ISC	**0.942**	**0.076**	**0.479**	0.343
Introjected Approach *K* Samples—All Models Converged N = 197	CFA_CU	0.958	0.069	0.119	0.147
	CFA_IS	0.940	0.075	0	0
	CFA_ISC	0.948	0.071	0.044	0.115
	CTCM_CU	0.948	0.078	0	0
	CTCM_IS	0.931	0.082	0	0
	CTCM_ISC	0.947	0.073	0.005	0.006
	CTCM_C_CU	**0.963**	0.068	0.413	0.197
	CTCM_C_IS	0.948	0.073	0.001	0.002
	CTCM_C_ISC	0.957	**0.067**	**0.417**	**0.532**
Introjected Avoidance *K* Samples—All Models Converged N = 67	CFA_CU	0.931	0.090	0	0
	CFA_IS	0.911	0.093	0	0
	CFA_ISC	0.938	0.079	0.215	0.367
	CTCM_CU	0.921	0.098	0	0
	CTCM_IS	0.900	0.100	0	0
	CTCM_ISC	0.934	0.082	0.006	0.013
	CTCM_C_CU	0.937	0.090	0.012	0
	CTCM_C_IS	0.917	0.094	0	0
	CTCM_C_ISC	**0.944**	**0.078**	**0.766**	**0.620**

CFA Confirmatory Factor Analysis, *CTCM* Correlated Trait-Correlated Method Minus One Model, *CTCM_C* Correlated Trait-Correlated Method Minus One Model with Correlated Specific Factor, *CU* Correlated-Uniqueness, *IS* Item Specific, *ISC* Item Specific Correlated

Bold values indicate models selected

situational level and the item-specific variance concerned. For example, in a previous study investigating the Specificity Hypothesis that decomposed item variance based on the subject and items, Chanal and Paumier (2020) demonstrated that 1) controlled items were linked to students' grades independently of situational regulation, 2) these links were more numerous for controlled motivations than for autonomous ones, and 3) some items within the same regulations could have opposing links with outcomes. Specifically, and interestingly for the academic context, items related to grades (to get good grades or to avoid bad grades) were positively associated with grades, whereas all other items, along with external approach and avoidance regulations, were negatively linked to grades across the various academic subjects considered. This result may explain why the links between external regulation and outcomes have been found to be

Table 8 Variance and percent of the variance due to contextual, specific and item levels of the winning model (i.e., CTCM_C_ISC)

Regulation (Models considered)	Contextual Variance	Specific Variance	Items Variance	% Contextual	% Specificity	% Items
Intrinsic Stimuation (N=1332)	0.16	0.57	0.09	19	70	11
Intrinsic Achievement (N=1872)	0.14	0.38	0.22	19	51	30
Identified (N=4084)	0.16	0.38	0.19	22	53	25
Introjected Approach (N=2265)	0.13	0.16	0.39	19	24	57
Introjected Avoidance (N=1220)	0.08	0.11	0.52	11	15	74
External Approach (N=1019)	0.05	0.13	0.52	7	19	74
External Avoidance (N=795)	0.05	0.22	0.50	6	29	65
Autonomous_Mean	0.15	0.44	0.17	20	58	22
Controlled_Mean	0.08	0.16	0.48	11	22	68

poorly related in the meta-analysis by Howard et al. (2021) and also why results sometimes diverge between studies across different contexts, as the items are not homogeneous across the various scales used in different fields of SDT.

Other elements within the results of our study seem to reinforce the idea that measuring certain regulations at the situational level appears to be problematic. Indeed, the results revealed substantial variations in the convergence and acceptance of the constructed models depending on the motivational regulations. Regarding model convergence rates across regulations, a distinct pattern emerged along the continuum of self-determination. This pattern suggests overall lower convergence, both for intrinsic motivation and external regulations. Indeed, concerning intrinsic motivation, the low overall convergence can be attributed to the low convergence rates of models associated with IS and ISC item-related methods (4.77% and 28.09%), whereas models using the CU method converged at 100%. Analysis of results concerning model acceptance for intrinsic motivation (Figs. 6C and 7C) indicates that when the model converges, adjustments are satisfactory. However, for the external approach and avoidance regulations, convergence rates are lower than for other regulations, regardless of the item-related method considered (5.87%, 20.10%, 14.91%, and 1.29%, 6.21%, 7.41%, respectively for CU, IS, and ISC for external approach and avoidance), and model acceptance is also low, regardless of the item-related method considered (Figs. 6C and 7C).

Two distinct explanations for these results can be provided depending on the regulation in question. Regarding intrinsic motivation, the variance explained by intrinsic regulation items in models considering the ISC method is very low (see Table 8). Thus, the main reason for the low convergence rates observed for these methods likely stems from the model's difficulty in capturing this low variance for this regulation. The very good psychometric results obtained for the CU method indicate that the construct is sufficiently captured by the model without requiring an additional method factor to capture the common variance among items. For external regulations, acceptance rates are very low for all methods, including the CU method. This result therefore seems to indicate that the lower convergence and acceptance rates recorded for these regulations depend rather on the lesser quality of construct validity of the regulations in question. This result may seem surprising in light of the numerous studies that exist regarding the validation of questionnaires in the academic context on which the questionnaires used in this article were constructed. However, it should be remembered that during the validation of these scales, the different regulations studied were evaluated jointly (i.e., simultaneously with the other regulations in the same subject or at the situational level considered) and were not evaluated individually at the situational or contextual level. Also, the better indices or results obtained for the most autonomous regulations scales may have masked the lower performances or results obtained for the more controlled regulations scales. Upon careful examination of validation studies conducted on measurement tools issued from SDT literature in various domains, we find evidence that Cronbach's alphas reported often exhibit lower values for subscales measuring controlled regulations compared to those measuring autonomous regulations. For instance, the two questionnaires used in our study had been validated and demonstrated satisfactory fit indices for their measurement models when considering all the motivational regulations within a single model (see Chanal et al., 2019; Sheldon et al., 2017). However, a closer inspection of Cronbach's alphas for the different regulations shows lower levels displayed along the self-determination continuum (Sheldon et al., 2017). The mean averages of alphas across the 4 samples were 0.88 for intrinsic motivation, 0.81 for identified regulation, 0.74 for positive introjection, 0.82 for negative introjection and 0.71 for external regulation, demonstrating lower alphas for controlled regulations scales with the exception of negative introjection. For Chanal et al.'s (2019) questionnaire, a recent study conducted with secondary school students (Paumier & Chanal, 2023) displayed alphas across four different school-subjects and toward school in general measurements that were comprised between 0.81 and 0.94 for intrinsic motivation for stimulation, 0.81 and 0.88 for intrinsic motivation for accomplishment, 0.77 to 0.87 for identified regulation, 0.72 to 0.81 for introjected approach regulation, 0.62 to 0.73 for introjected avoidance regulation, 0.64 to 0.69 for external approach regulation and 0.66 to 0.75 for external avoidance regulation, reproducing the same evidence. Considering each of the motivational regulations separately, as we do in this article, is virtually unheard in the tradition of SDT researchers. Evaluating and validating the structure of regulations taken separately rather than simultaneously, as done in this study, provide a different approach and perspective regarding the validation of the psychometric quality of our instruments and the understanding of the validation of the constructs concerned, which have probably been neglected during questionnaire validations conducted in the literature. This work thus paves the way for a new way of considering the understanding and measurement of different motivational regulations not only in academic works but also for other intervention domains of SDT.

The specificity hypothesis

One of the implications of this new approach lies in the question of specificity of measurements according to the different considered regulations. Indeed, recent research on the differentiation of regulations along the continuum of self-determination suggests that the variance specific to academic subjects might be more significant for autonomous regulations than for controlled regulations (Chanal & Guay, 2015; Chanal & Paumier, 2020; Paumier & Chanal, 2022, 2023). Although some articles have put forward results in this direction, various modelings, questionnaires, and regulations have been considered, necessitating robust evidence before being able to assert the truth and solidity of this Specificity Hypothesis. These elements are crucial for envisioning in-depth research on the links between different academic subjects, as well as their implications on outcomes such as academic performance or subject-specific emotions, but also in the perspective of a better understanding of the emergence and differentiation of different motivational regulations during development.

The analysis of variance decomposition carried out for all regulations relies on a substantial number of samples (between 795 and 4084 samples). This procedure ensures robust results to support our conclusions. Our findings demonstrate significant variations in the proportion of variance explained by academic subjects. Indeed, autonomous motivations reveal a higher proportion of variance specific to academic subjects than controlled motivations, thus validating the postulates of the Specificity Hypothesis. Our results support the existence of a pattern of increasing specificity to academic subjects along the continuum of self-determination. As regulations become less self-determined, they are less specific. This result supports the postulates of the Specificity Hypothesis, which consider that the development of specificity would be linked to individuals' self-development (Chanal & Guay, 2015; Paumier & Chanal, 2022, 2023). The hierarchical and multidimensional self-concept model has been widely supported in the literature, and works in the academic context have supported the model of a hierarchical and multidimensional self that develops during schooling (e.g., Arens et al., 2021; Marsh et al., 2017). A recent study focusing on the relationship between self-concept and academic performance among secondary school students has provided indirect insights into this issue. Paumier and Chanal (2023) investigated the mediating role of autonomous and controlled regulations in the relationship between self-concept and academic outcomes. Their findings revealed a differentiated mediation effect of motivational regulations, showing that the influence of self-concept on academic achievement was mediated by autonomous regulations, but not by controlled regulations.

Furthermore, the results demonstrate that the proportion of variance associated with the items used is more substantial for controlled regulations than for autonomous regulations, indicating a pattern of item-specificity opposite to that of subject-specificity. However, it is important to emphasize that these mechanisms are independent and not related, and thus, this result is not a corollary of the results concerning the Specificity Hypothesis. Additionally, this implies that our results clearly demonstrate that other factors and mechanisms are involved in participants' responses to proposed items measuring situational responses regarding the least self-determined regulations. What this result reveals as problematic for SDT researchers is that a significant portion of the variance in items related to controlled regulations is accounted for by a dimension that does not pertain to the specific situation being measured. The immediate and practical implication for researchers working with SDT is that they should be cautious when using item aggregation methods that do not account for measurement error and shared item variance, such as factor analyses. Additionally, the use of single items to measure a specific context should be avoided with the currently available tools. Beyond this practical implication, the result highlights the potentially distinct characteristics of autonomous and controlled regulations. Indeed, the findings may suggest that controlled regulations are more stable (i.e., trait-like) and less variable than autonomous regulations (i.e., state-like). The theoretical implications for SDT, particularly for Vallerand's HMIEM model, are significant. The social factors–needs–motivation–outcomes causal chain does not distinguish between regulation types based on their hierarchical level, meaning the social factors influencing motivational regulations at the situational level are assumed to be situational, not contextual or global. Our results suggest that different levels of factors may influence autonomous versus controlled regulations. For autonomous regulations, typical situational factors (e.g., need-supportive or need-thwarting climates, psychological need satisfaction or frustration) may be at play, whereas controlled regulations could be affected by factors operating at a more global level, such as SDT's causal orientations or classical personality traits from the Big Five framework.

Finally, considering the observed differences in variance decomposition according to the different motivational regulations, one might have expected to observe several different winning models for the different regulations. This congruence of results demonstrates that considering the hierarchical dimension and the item-specific variance dimension is necessary to properly adjust to the data in the considered sample, which concerns young adults. However, these results based on a sample of young adults could be influenced by the fact that the differentiation of constructs along the continuum of self-determination has been fully realized in this population for whom their self-concept has matured. Indeed, the available results on testing the Specificity Hypothesis are limited, and it is essential to note that these results were obtained in samples of different age groups (e.g., primary and secondary students), showing that the older the samples, the greater the specificity. For example, Chanal and Guay (2015) found in two samples of primary and secondary students' different level of specificity according to sample age (from 64 to 76% for intrinsic motivation, 55% to 74% for identified regulation, from 18 to 26% for introjected regulation and from 8 to 28% for external regulation). The plausible hypothesis of a developmental approach to differentiation between different academic subjects for different types of regulation will require thorough exploration. Two different perspectives are conceivable regarding this question. The first concerns the different levels of specificity for each regulation, which could be increasingly large as the self develops. In other words, as specificity is greater for the most autonomous motivations, one could also postulate that specificity levels would be greater according to the age of the students, considering that the self-concept develops over the various experienced school experiences but also due to individuals' biological maturation over development (e.g., Marsh & Ayotte, 2003). A second perspective would be to consider that the academic differentiation structure could be different according to the age of the students and notably for the most controlled regulations. Indeed, we know that it is during the period between 5 and 8 years old that the self-concept begins to differentiate in students (Marsh et al., 2019), and therefore, we can imagine that at this age, there is a greater chance that autonomous motivations present this same developmental pattern, but one could question the same finding for controlled regulations. Indeed, the results of available studies (Guay et al., 2010) show that students have a lot of difficulty distinguishing controlled regulations in different academic subjects, and thus it would be interesting to replicate the type of analyses conducted in this article to understand which factor structure is most appropriate among different academic subjects according to regulations at different stages of development. Considering the differences in specificity observed along the continuum, one could envisage that the differentiation of autonomous motivations occurs earlier than that of controlled motivations.

Limitations and future directions

This study is not without its limitations. One notable limitation is the weak model fit indices obtained, particularly in relation to the RMSEA strong criterion. This may suggest potential psychometric weaknesses in the instrument used. However, it is important to consider that the available sample size for this questionnaire likely contributed to this result. In fact, results obtained with the Sheldon questionnaire on a larger sample (see supplementary materials) show better model fit indices, while remaining largely consistent with those presented in this manuscript. This suggests that the sample size may have played a critical role in the lower fit indices reported here. Nevertheless, this limitation offers a useful avenue for further investigation into our tools. A more detailed analysis of item variance structure, particularly for controlled regulations, could help identify which items are more or less aligned with the regulation targeted. For example, Chanal and Paumier (2020) demonstrated that both approach and avoidance external regulation items related to grades were positively associated with academic outcomes across various subjects, whereas other items within these dimensions showed negative associations with the same outcomes.

A second limitation of this study is that most research on the Specificity Hypothesis to date has been conducted within academic settings. While these findings provide valuable insights into the structure of student motivation, their generalizability to other contexts remains untested. We encourage researchers within SDT across different fields to explore the implications of our findings in other domains and with diverse populations, including individuals of varying ages and backgrounds. Broadening the scope of this research will not only validate the current results but also extend the theoretical framework of SDT to new and unexplored areas.

A future research direction should also consider the implications of modeling all motivational regulations within the same domain simultaneously. Specifically, it would be beneficial to examine the entire motivational continuum together and explore how the Specificity Hypothesis affects the simplex pattern, which has long been a cornerstone of SDT research. In addition, recent modeling techniques such as Exploratory Structural Equation Modeling (ESEM) and its bifactor variant (B-ESEM) could provide further insights into testing the SDT continuum. The challenge will be to account for all regulations concurrently, while also addressing the general factor of self-determined motivation, as specified in these models. Addressing this challenge will require a large sample size to meet the computational and technical demands of such complex analyses. This may necessitate a collaborative effort among SDT researchers, akin to the Psychological Science Accelerator SDT Collaboration that successfully conducted a large-scale study on motivating social distancing during the COVID-19 pandemic (e.g., Psychological Science Accelerator Self-Determination Theory Collaboration et al., 2022).

Finally, another potential future direction would be to propose and test an updated version of Vallerand's HMIEM, based on the results and studies conducted. Indeed, there seems to be a growing need to adjust both the model and its underlying assumptions to integrate findings that support the Specificity Hypothesis. This revision could provide a more accurate and nuanced understanding of motivational dynamics across different levels of analysis.

Conclusion

In conclusion, this study sheds crucial light on the hierarchical and multidimensional structure of motivational regulations described by SDT in an academic context. The results confirm that all regulations benefit from considering existing structural hierarchies, and they also underscore the robustness of the Specificity Hypothesis, highlighting an increase in the specificity levels of regulations along the self-determination continuum. Furthermore, they demonstrate that the sources of variability concerning the items used are also variable according to the level of self-determination of the regulations. These findings emphasize the importance of considering different levels of measurement whenever possible for regulations, not only viewing the multidimensionality of SDT regulations from the perspective of one activity but also recognizing that the impact of items used to measure different regulations varies according to the type of regulation considered.

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Data availablity The data that support the findings of this study are available from the corresponding author, JC, upon reasonable request.

Declarations

Conflict of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Akaike, H. (1973). Information Theory and an Extension of the Maximum Likelihood Principle. In B. N. Petrov & F. Csaki (Éds.), *International Symposium on Information Theory* (p. 267-281). Akadémiai Kiadó

Arens, A. K., Jansen, M., Preckel, F., Schmidt, I., & Brunner, M. (2021). The structure of academic self-concept: A methodological review and empirical illustration of central models. *Review of Educational Research,91*(1), 34–72. https://doi.org/10.3102/0034654320972186

Assor, A., Vansteenkiste, M., & Kaplan, A. (2009). Identified versus introjected approach and introjected avoidance motivations in school and in sports: The limited benefits of self-worth strivings. *Journal of Educational Psychology,101*(2), 482–497. https://doi.org/10.1037/a0014236

Brunner, M., Keller, U., Dierendonck, C., Reichert, M., Ugen, S., Fischbach, A., & Martin, R. (2010). The structure of academic self-concepts revisited: The nested Marsh/Shavelson model. *Journal of Educational Psychology,102*(4), 964–981. https://doi.org/10.1037/a0019644

Brunner, M., Keller, U., Hornung, C., Reichert, M., & Martin, R. (2009). The cross-cultural generalizability of a new structural model of academic self-concepts. *Learning and Individual Differences,19*(4), 387–403. https://doi.org/10.1016/j.lindif.2008.11.008

Carbonneau, N., Vallerand, R. J., & Lafrenière, M. K. (2012). Toward a tripartite model of intrinsic motivation. *Journal of Personality,80*(5), 1147–1178. https://doi.org/10.1111/j.1467-6494.2011.00757.x

Chanal, J., Cheval, B., Courvoisier, D. S., & Paumier, D. (2019). Developmental relations between motivation types and physical activity in elementary school children. *Psychology of Sport and Exercise,43*, 233–242. https://doi.org/10.1016/j.psychsport.2019.03.006

Chanal, J., & Guay, F. (2015). Are autonomous and controlled motivations school-subjects-specific? *PLoS ONE,10*(8), 1–21. https://doi.org/10.1371/journal.pone.0134660

Chanal, J., & Paumier, D. (2020). The school-subject-specificity hypothesis: Implication in the relationship with grades. *PLoS ONE,15*(4), 4. https://doi.org/10.1371/journal.pone.0230103

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Springer.

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology/psychologie Canadienne,49*(3), 182–185. https://doi.org/10.1037/a0012801

Guay, F., Chanal, J., Ratelle, C. F., Marsh, H. W., Larose, S., & Boivin, M. (2010). Intrinsic, identified, and controlled types of motivation for school subjects in young elementary school children. *British Journal of Educational Psychology,80*(4), 4. https://doi.org/10.1348/000709910X499084

Guay, F., Ratelle, C. F., & Chanal, J. (2008). Optimal learning in optimal contexts: The role of self-determination in education. *Canadian Psychology/psychologie Canadienne,49*(3), 233–240. https://doi.org/10.1037/a0012758

Howard, J. L., Bureau, J., Guay, F., Chong, J. X. Y., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*. https://doi.org/10.1177/1745691620966789

Howard, J. L., Gagné, M., & Bureau, J. S. (2017). Testing a continuum structure of self-determined motivation: A meta-analysis. *Psychological Bulletin,143*(12), 1346–1377. https://doi.org/10.1037/bul0000125

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal,6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociological Methods & Research,44*(3), 486–507. https://doi.org/10.1177/0049124114543236

Marsh, H. W., & Ayotte, V. (2003). Do multiple dimensions of self-concept become more differentiated with age? The differential distinctiveness hypothesis. *Journal of Educational Psychology,95*(4), 687–706. https://doi.org/10.1037/0022-0663.95.4.687

Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multidimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science,1*(2), 133–163. https://doi.org/10.1111/j.1745-6916.2006.00010.x

Marsh, H. W., Martin, A. J., Yeung, A., & Craven, R. (2017). Competence self-perceptions. In A. J. Elliot, C. S. Dweck, & D. S. Yeager (Eds.), *Handbook of competence and motivation: Theory and application* (pp. 85–115). The Guilford Press.

Marsh, H. W., Seaton, M., Dicke, T., Parker, P. D., & Horwood, M. S. (2019). The centrality of academic self-concept to motivation and learning. In K. A. Renninger & S. E. Hidi (Eds.), *The cambridge handbook of motivation and learning* (pp. 36–62). Cambridge University Press.

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science,7*(4), 325–340. https://doi.org/10.1177/1745691612447309

Paumier, D., & Chanal, J. (2022). The antecedents and consequences of autonomous and controlled motivation: Domain specificity and motivational sequence at the situational level. *Frontiers in Psychology,13*, Article 987582. https://doi.org/10.3389/fpsyg.2022.987582

Paumier, D., & Chanal, J. (2023). The differentiated mediation effect of academic autonomous and controlled motivation in the relation between self-concept and achievement. *Learning and Motivation,83*, 1–15. https://doi.org/10.1016/j.lmot.2023.101918

Psychological Science Accelerator Self-Determination Theory Collaboration, Legate, N., Nguyen, T., Weinstein, N., Moller, A., Legault, L., Vally, Z., Tajchman, Z., Zsido, A. N., Zrimsek, M., Chen, Z., Ziano, I., Gialitaki, Z., Ceary, C. D., Jang, Y., Lin, Y., Kunisato, Y., Yamada, Y., Xiao, Q., & Primbs, M. A. (2022). A global experiment on motivating social distancing during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences,119*(22), e2111091119. https://doi.org/10.1073/pnas.2111091119

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*. https://doi.org/10.18637/jss.v048.i02

Roth, G., & Assor, A. (2012). The costs of parental pressure to express emotions: Conditional regard and autonomy support as predictors of emotion regulation and intimacy ⋆. *Journal of Adolescence,35*(4), 799–808. https://doi.org/10.1016/j.adolescence.2011.11.005

Ryan, R. M. (2023). *The Oxford handbook of self-determination theory*. Oxford University Press.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology,61*, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Schmidt, I., Brunner, M., Keller, L., Scherrer, V., Wollschläger, R., Baudson, T. G., & Preckel, F. (2017). Profile formation of academic self-concept in elementary school students in grades 1 to 4. *PLoS ONE,12*(5), Article e0177854. https://doi.org/10.1371/journal.pone.0177854

Schwarz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics*. https://doi.org/10.1214/aos/1176344136

Sheldon, K. M., Osin, E. N., Gordeeva, T. O., Suchkov, D. D., & Sychev, O. A. (2017). Evaluating the dimensionality of self-determination theory's relative autonomy continuum. *Personality and Social Psychology Bulletin,43*(9), 1215–1238. https://doi.org/10.1177/0146167217711915

Vallerand, R. J. (1997). Toward a hierarchical model of intrinsic and extrinsic motivation. In M. P. Zanna (Ed.), *Advances in experimental social psychology.* Academic Press.

Vasconcellos, D., Parker, P. D., Hilland, T., Cinelli, R., Owen, K. B., Kapsal, N., Lee, J., Antczak, D., Ntoumanis, N., Ryan, R. M., & Lonsdale, C. (2020). Self-determination theory applied to physical education: A systematic review and meta-analysis. *Journal of Educational Psychology,112*(7), 1444–1469. https://doi.org/10.1037/edu0000420

Vrieze, S. I. (2012). Model selection and psychological theory: A discussion of the differences between the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). *Psychological Methods,17*(2), 228–243. https://doi.org/10.1037/a0027127

Wagenmakers, E.-J., & Farrell, S. (2004). AIC model selection using Akaike weights. *Psychonomic Bulletin & Review,11*(1), 192–196. https://doi.org/10.3758/BF03206482

Xia, Y., & Yang, Y. (2019). RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods. *Behavior Research Methods,51*(1), 409–428. https://doi.org/10.3758/s13428-018-1055-2