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It is autonomous, not controlled motivation that counts: Linear and curvilinear relations of autonomous and controlled motivation to school grades

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ABSTRACT

Can controlled motivation contribute to desired educational outcomes such as academic achievement over and above autonomous motivation? No, According to Self-Determination Theory. Yet, some recent findings have shown that controlled motivation may not fully undermine motivated behavior when autonomous motivation remains high. In this study, we tested this possibility through two different samples of more than 3000 Turkish adolescent students. Through polynomial regression and response surface analyses we found only slim evidence that high controlled motivation can predict higher grades. Instead, a consistent finding that emerged was that higher grades were expected when high levels of autonomous motivation coincided with low levels of controlled motivation rather than high levels of controlled motivation. These findings highlight the usefulness of polynomial regressions and response surface analyses to examine pertinent questions which challenge the view that controlled motivation may not be as much detrimental as self-determination theory claims to be.

1. Introduction

Do students succeed academically if they study for multiple reasons? Do they get higher grades at school only when they enjoy and value learning? Or do they also need to psychologically press themselves or being pressed by others? These practical questions haunt many parents, teachers, and education policy makers; and sometimes, researchers too (Gillet, Morin, & Reeve, 2017; Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). Given that striving for learning within the formal classroom-based education context cannot always be fun or challenging and that students may have difficulty to foresee the value of everyday schoolwork, many people might be tempted to question whether strategies employing some psychological pressure such as self-worth appeals, rewards promises, or punishment threats could keep students on track. Empirical research that relies on Self-Determination Theory (SDT; Ryan & Deci, 2017) has consistently shown that such psychological pressures barely predict desired outcomes (Hagger & Chatzisarantis, 2016; Koestner, Otis, Powers, Pelletier, & Gagnon, 2008). Instead, what seems to be conducive to desired outcomes is autonomous motivation, which refers to activities that are undertaken because they are fun, interesting, challenging, or personally important. In contrast to autonomous motivation, controlled motivation refers to activities that are carried out due to psychological pressures to maintain contingent self-worth, to get a promised reward, or to avoid some negative consequences. Notably, some recent studies (Malmberg, Pakarinen, Vasalampi, & Nurmi, 2015; Phillips & Johnson, 2018) have shown that controlled motivation could be less detrimental than it was thought to be when it coincides with autonomous motivation.

Using polynomial regression analyses Phillips and Johnson (2018) have found that autonomous motivation related to more physical exercise activity when controlled motivation surpassed a minimum level. Such a finding challenges one of the key tenets of SDT, according to which it is quality of motivation (i.e., high autonomous combined with low controlled motivation) that does matter. Can thus autonomous motivation combined with at least some moderate levels of controlled motivation yield better outcomes? This is a viable possibility that has remained largely untested, given that previous research has routinely disregarded the likely curvilinear relations of autonomous and

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controlled motivation to motivational correlates as it relied mainly on typical analytical approaches such as variable-centered (e.g., linear regression) and person-centered (e.g., cluster) analyses. In this two-sample study we aimed to revisit this issue. By employing polynomial regression analysis and the resultant response surface analysis, we sought to examine the linear and curvilinear relations of autonomous and controlled motivation to school grades, one of the most highly appreciated educational outcome and indicator of academic achievement.

1.1. Autonomous and controlled motivation at school

Autonomous and controlled motivation refer to a set of qualitatively different reasons for which students may become, remain, or cease engage in various activities, including schoolwork (Ryan & Deci, 2017). Autonomous motivation refers to behaviors that students endorse out of their own will; behaviors that students carry out because they find them interesting, fun, or challenging (intrinsic motivation), or because they consider such behaviors as part of their own identity (integrated regulation), or because they consider them meaningful and personally important (identified regulation). Autonomous motivation, especially identified regulation and interest as an integral part of intrinsic motivation, corresponds conceptually to the intrinsic value of the Expectancy by Value Model (Atkinson, 1964; Eccles & Wigfield, 2002). Both SDT and the Expectancy by Value Model assume that the more students are autonomous motivated (according to SDT) or the more they consider an activity as inherently valuable (according to the Expectancy by Value theory), the more they benefit.

On the contrary, controlled motivation reflects behaviors that students feel obliged to undertake out of some internal or external psychological pressures; behaviors that students perform to boost their self-esteem, or to avoid feelings of guilt and shame (introjected regulation); or behaviors that they endorse to attain contingent rewards or avoid negative implications (external regulation).

Autonomous motivation leads to more desired outcomes because when autonomously motivated people feel free to pursue their interests and carry out tasks and activities that attract, delight, and satisfy them. Under such conditions, students have an internal locus of causality and become more functional and productive because they can better activate their inner resources (Ryan & Deci, 2017). However, when controlled motivated, students are forced to act due to some pressures that may come either from outside (e.g., punishment threats or reward promises) or inside (e.g., ego-threats or self-worth concerns). In such instances, students are expected not to genuinely endorse the activities they carry out and hence not to recruit their full potential. Consequently, when controlled motivated, students are expected to exhibit a less adaptive mode of functioning (Vansteenkiste, Niemiec, & Soenens, 2010).

Numerous empirical studies have indicated that compared to controlled motivation, autonomous motivation relates to a host of desired outcomes, including higher levels of physical activity among exercisers (Owen, Smith, Lubans, Ng, & Lonsdale, 2014), work engagement and well-being among employees (Slemp, Kern, Patrick, & Ryan, 2018), and grades among students (Richardson, Abraham, & Bond, 2012). In contrast, controlled motivation has been found either to unrelate to similar desired outcomes or to relate negatively to positive outcomes, such as school satisfaction and high grades (Li, Deng, Wang, & Tang, 2018) and positively to negative outcomes such as basic psychological needs frustration (Bartholomew et al., 2018), procrastination (Mouratidis, Michou, Aelterman, Haerens, & Vansteenkiste, 2018), or school dropout (Jeno, Danielsen, & Raaheim, 2018). The reason for this mixed pattern could be attributed to the fact that controlled motivation may energize students yet in less optimal way (Vansteenkiste, Zhou, Lens, & Soenens, 2005). Therefore, there might be instances where controlled motivation may predict more effort exertion (Malmberg & Martin, 2019), but not the kind of effort that characterizes high quality engagement that required extensive use of deep-learning strategies (Michou, Vansteenkiste, Mouratidis, & Lens, 2014).

In support of the claim that autonomous motivation leads to better outcomes, including school performance, comes from a neurophysiological study which showed that autonomous motivation facilitates self-regulatory functioning through more effective neuro-affective responsiveness (Legault & Inzlicht, 2013). The ever-growing empirical research has provided ample evidence to a key proposition of SDT that high quality of motivation (i.e., high autonomous motivation relative to controlled one) does count (Deci & Ryan, 2000; Vansteenkiste et al., 2010).

Although arguing that autonomous motivation outweighs controlled motivation cannot be easily refuted, a pertinent question is whether controlled motivation could complement autonomous motivation to yield even better outcomes. For instance, does a student with moderate levels of autonomous motivation and low levels of controlled motivation benefit more than a student who is moderately motivated by both autonomous and controlled reasons? Accordingly, what happens if moderate or even high levels of controlled motivation co-exist with autonomous motivation? A recent study in which polynomial regression analysis was employed revealed that moderate levels of controlled motivation that were combined with high levels of autonomous motivation predicted higher physical activity among young adults (Phillips & Johnson, 2018). Specifically, Phillips and Johnson (2018) recruited three different samples of university students and asked them to indicate through online surveys the degree to which they engage in exercise for autonomous and controlled reasons. The dependent variable was physical activity, as assessed either through self-reports or accelerometers. Across all three samples, higher levels of physical activity were observed when autonomous motivation and controlled motivation were both increased. This finding suggests that controlled motivation might not undermine motivated behavior providing that autonomous motivation is also ardently endorsed.

Along similar lines, a three-sample study (Brunet, Gunnell, Gaudreau, & Sabiston, 2015) in which polynomial regression analyses were also employed showed that higher levels of certain indices of well-being (such as joy and hope) were predicted when there was a congruence between high levels of autonomous and controlled motivation. Yet, it should be noted that higher levels of some other well-being indices (such as positive affect and life satisfaction) were positively predicted when there was an incongruence between autonomous and controlled motivation. That is, when autonomous motivation scores increased, and controlled motivation decreased. Relevant to the focus of the present study, Brunet et al. (2015) found inconsistent results regarding school grades. Specifically, higher grades were positively predicted only by incongruence between autonomous and controlled motivation in one sample, a finding that conforms to SDT. Yet, in another sample, higher grades were predicted not only by incongruence but also by congruence between autonomous and controlled motivation, a finding which deviates from the basic premises of SDT.

Similar results implying that controlled motivation may not be as harmful as long as they coincide with autonomous motivation have been occasionally reported by studies that have used profile (i.e., person-centered) analysis. For instance, Van den Berghe, Vansteenkiste, Cardon, Kirk, and Haerens (2014) found no significant differences in a series of correlates such as effective teaching, personal accomplishment, and emotional exhaustion between teachers with a profile of high autonomous motivation and low controlled motivation and teachers with a profile of high autonomous motivation and high controlled motivation. Profile analyses have also pointed out that students high in both autonomous and controlled motivation barely did differ from students being high only in autonomous motivation in outcomes such as cognitive processing, meta-cognitive strategy use, and effort regulation (Vansteenkiste et al., 2009). Likewise, no differences were reported in another study in outcomes such as positive affect, interest, and effort between students with moderate levels of autonomous motivation and low levels of controlled motivation and students with moderate levels of both autonomous and controlled motivation (Gillet et al., 2017). Relevant to the present discussion, inconsistent results have been found regarding graded performance. Whereas Vansteenkiste et al. (2009) found that students high in autonomous and low in controlled motivation outperformed in grades students high in both autonomous and controlled motivation, other studies have failed to find similar differences (Gillet et al., 2017; Ratelle, Guay, Vallerand, Larose, & Senécal, 2007). These results suggest that controlled motivation might be innocuous when it is combined with autonomous motivation.

Given these findings, the notion that controlled motivation along with autonomous motivation might not undermine, if not enhance, academic-related behaviors deserves further testing. Examining the combined effects of autonomous and controlled motivation might have gone unnoticed because the bulk of previous studies have mainly focused on the independent linear relations (and, rather infrequently, on the interdependent relations) of autonomous and controlled motivation to correlates of interest. The combined effects of autonomous and controlled motivation might have remained uncovered because of disregarding testing linear and curvilinear relations, as the recent study of Phillips and Johnson (2018) suggests.

1.2. Linear and curvilinear relations among motivational constructs

An assumption made by most researchers when they examine the relations of autonomous and controlled motivation to motivational correlates through regression analyses is that they linearly relate to one another. For instance, typical regression models examine whether as autonomous motivation increases, a motivational correlate will also increase (or decrease) at the same rate (linear relation). Yet, it is possible that as autonomous motivation increases the motivational correlate also increases (or decreases) but not necessarily at the same rate (monotonic relation). Simply put, a monotonic relation does not necessarily mean a linear relation (Edwards, 2008). Yet, it is this linear relation assumption – a stronger and in many instances an inaccurate assumption compared to the monotonic one - that most of SDT scholars implicitly endorse when they test their hypotheses through linear regressions without testing for any likely curvilinear relations. To the best of our knowledge, only two out of approximately five hundred studies - that of Brunet et al. (2015) and Phillips and Johnson (2018) - have examined the linear, curvilinear, and interactive relations of autonomous and controlled motivation to motivational outcomes through polynomial regressions. This is unfortunate because we can get a more refined picture if we consider next to linear the curvilinear relations of autonomous and controlled motivation to relevant outcomes.

Including autonomous and controlled motivation not only as linear but also as curvilinear predictors enable us to predict more accurately at what levels of autonomous motivation or controlled motivation, a motivational correlate will be even higher (or lower). For instance, are desired educational outcomes such as school grades even higher when autonomous motivation surpasses certain levels? Or, is it this more likely to happen when controlled motivation remains below a certain point? Accordingly, do students have lower grades when their controlled motivation surpasses moderate levels and autonomous motivation falls below moderate ones? Such questions can be better addressed when we jointly examine linear and curvilinear relations of autonomous and controlled motivation.

From a methodological and statistical point of view, testing the null hypothesis that the curvilinear effects are indeed statistically nonsignificant is required even in cases where only a linear relation is expected. Showing that the curvilinear effects are nonsignificant could therefore provide evidence for a linear relation. There is one further reason that warrants testing curvilinear relations. As Edwards (2008) has pointed out, testing for interactions between two predictors without considering their curvilinear relations to an outcome might lead to inflated Type I errors. In that case, a statistically significant interaction between the two predictors (e.g., autonomous and controlled motivation) might emerge, without knowing however whether this is a true effect or whether such statistically significant interaction is driven by the curvilinear relations of one or both predictors to the outcome.

Setting aside statistical reasoning, examining jointly linear and curvilinear relations of autonomous and controlled motivation to motivational correlates enables scholars to address meaningful research questions that have been inadequately addressed so far. The most obvious one refers to the question of whether indeed incongruence between autonomous and controlled motivation predict desired motivational correlates. This is a key assumption for SDT (Ryan & Deci, 2017), which argues that high autonomous combined with low controlled motivation could yield more adaptive outcomes than high autonomous combined with high controlled motivation. However, some recent research findings (Brunet et al., 2015; Phillips & Johnson, 2018) seem to cast some doubt to this key proposition.

Incongruence effects between autonomous and controlled motivation may exist, yet in a more nuanced manner. Perhaps higher levels of desired outcomes are predicted by a pattern of incongruence in which autonomous motivation scores increase at a different rate than controlled motivation scores decrease. For instance, a positive motivational outcome might be even higher when autonomous motivation increases by one unit and controlled motivation might decrease by less (or more) than one unit. This could also be a viable hypothesis that could be attributed to various psychometric factors, such as reliability of measures (due to systematic or random measurement error), and item discrimination index – the difficulty for a respondent to fully agree or disagree with certain statement (Roberts, Donoghue, & Laughlin, 2000). For example, it might be more difficult for a respondent to fully agree with the statement that one undertakes an activity to avoid feelings of guilt; accordingly, it might be equally difficult to fully disagree with the statement that one carries out an activity because she or he enjoys it. In such cases, the discrimination index will be higher and therefore an incongruence pattern between autonomous and controlled motivation may take place within certain boundaries.

It should be emphasized that no accurate prediction of the strength and the pattern of linear and curvilinear relations of the predictors (and their interaction) to grades could be made given that a different combination of these relations may yield a similar pattern of results, when these are inspected through response surface analysis. For instance, two models might yield different strength of relations of their linear and nonlinear predictors to an outcome but still yield a very similar picture regarding the nature of relation between the predictors and a dependent variable along the line of congruence or incongruence.

1.3. The present study

In this study, we aimed to investigate through polynomial regression analyses the linear and curvilinear relations of autonomous and controlled motivation as well as their interaction to school grades. We focused on school grades as a motivational outcome for two reasons. First, because school grades reflect academic achievement which is highly appreciated by the society. Secondly, because grades reflect a relatively more objective educational outcome than other self-reported behavioral outcomes (e.g., academic effort). In doing so, we tried to minimize common method bias that occurs when both the predictors and the outcome are assessed by the same informants (Podsakoff, MacKenzie, & Podsakoff, 2012). We were particularly interested in scrutinizing whether autonomous motivation combined with controlled motivation does matter more. Specifically, we aimed to investigate to what extent autonomous and controlled motivation predict grades linearly and curvilinearly, and if so within what specific range of scores this prediction may take place. To attain our aims, we recruited two samples of Turkish adolescent students attending the 10th grade (high school; Sample 1) and the 6th to 8th grade (middle school; Sample 2) and examined to what extent autonomous and controlled motivation would predict their grades six months (Sample 1) and two months (Sample 2) later. In that way we investigated whether the linear and curvilinear relations of autonomous and controlled motivation to grades would apply to both middle and high school students.

Although quality of motivation can be defined in various ways, depending on the theoretical framework such as the achievement goal viewpoint (Murayama & Elliot, 2019), implicit theories of ability (Yeager & Dweck, 2012), or expectancies, values and control beliefs perspective (Wigfield, Turci, Cambria, & Eccles, 2019), we relied on SDT and the empirical findings supporting the notion that it is quality of motivation (i.e., high autonomous motivation and low controlled motivation) which matters for positive outcomes to formulate the following four hypotheses. First, we expected that autonomous motivation would positively relate to grades (Hypothesis 1). Second, despite the recent, yet limited and somewhat contradictory findings (cf. Brunet et al., 2015; Phillips & Johnson, 2018) showing that controlled motivation may be less harmful when autonomous motivation exceeds a certain level, we expected that it would not be congruence (Hypothesis 2a), but incongruence (Hypothesis 2b), between autonomous and controlled motivation that would mainly predict higher academic grades. Third, we anticipated that controlled motivation would fail to predict higher grades, either when autonomous motivation would be low (Hypothesis 3a) or high (Hypothesis 3b). Hypothesis 3a directly addressed the question of whether controlled motivation could act as a compensatory mechanism in that it can predict some positive results in the absence of autonomous motivation. In contrast, we hypothesized that autonomous motivation would predict higher grades, when controlled motivation would be low (Hypothesis 4a) rather than when it would be high (Hypothesis 4b). A graphical representation of these hypotheses is depicted in Fig. 1.

2. Method

2.1. Procedures

Sample 1 was coming from a study that was a part of a three-year longitudinal project with high school students, funded by the Scientific and Technological Research Council of Turkey. Sample 2 was coming from a separate, independent study with middle school students. Both studies were approved by the corresponding Ethical Committees. Consent forms for both samples were obtained from students' parents as well as from the host principals. A team of research assistants visited the schools and during 1-h class sessions they delivered a battery of questionnaires that included, among others, measures tapping into quality of motivation. The research assistants ensured the students that there were no right, or wrong answers and their responses would remain confidential. Participants were also acknowledged that they could withdraw from the study at any point without any implications.

2.2. Participants

The initial pool of participants in Sample 1 included 3598 Turkish high school students from the 10th grade (M_{age} = 15.52 years, SD = 0.38; 41.1% males) of public schools located in Ankara, Turkey. All the students attended public schools in the district of Ankara. The retained sample after data cleaning (e.g., after inconsistent responses and or unexpected values) consisted of 3094 students who provided information regarding their autonomous or controlled motivation at the beginning of school year (T1). From that sample however we had information from 1618 (52.3%) students regarding their grades at the end of school year (T2). Supplemental analyses showed that the retained group did differ from the group from which we had missing information.

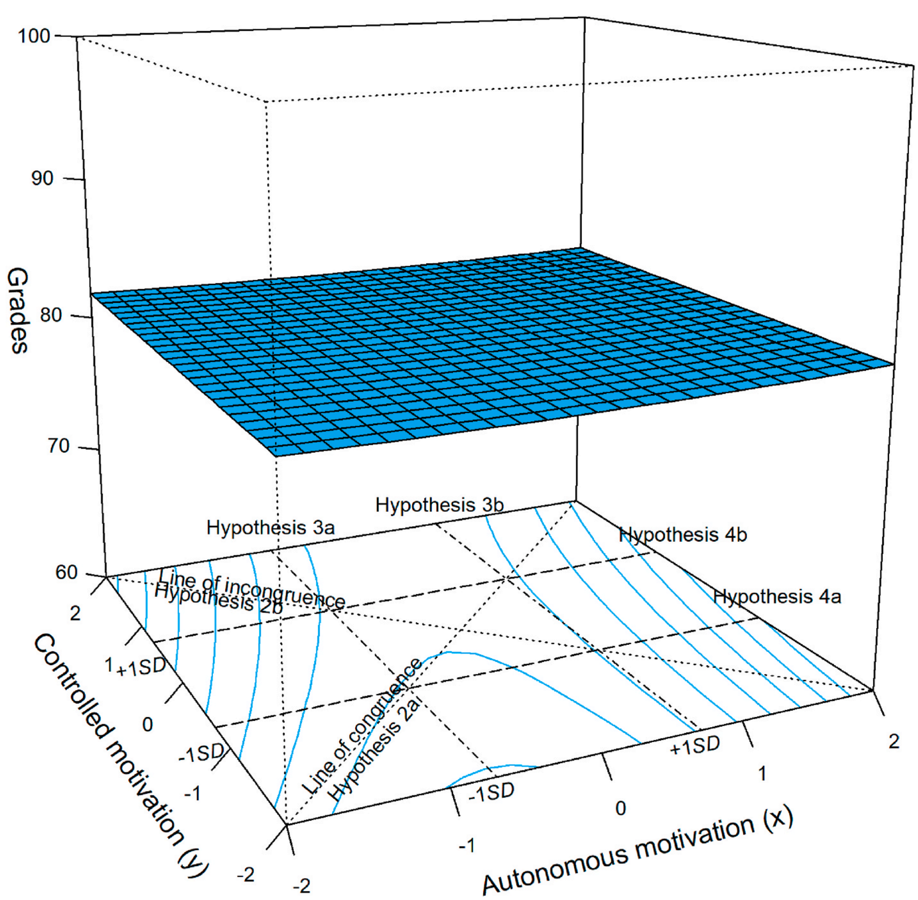

Fig. 1. A representation of the hypotheses as examined through response surface analysis In the X–Y plane, the dotted line running diagonally from the near corner to the far corner represents the line of congruence between autonomous and controlled motivation (Hypothesis 2a); the dotted line running diagonally left to right represents the line of incongruence between autonomous and controlled motivation (Hypothesis 2b).
The two dot-dashed lines running parallel to controlled motivation test the hypotheses whether controlled motivation would predict grades, regardless whether autonomous motivation would be low (Hypothesis 3a) or high (Hypothesis 3b). The two long-dashed lines running parallel to autonomous motivation test the hypotheses whether autonomous motivation would predict grades, regardless whether controlled motivation would be low (Hypothesis 4a) or high (Hypothesis 4b).

Specifically, Little's MCAR test was found to be marginally significant, $\chi^2_{[8]} = 46.83$, $p < .001$) and independent-sample *t*-tests indicated that the retained group did differ in autonomous motivation ($t_{[3,066]} = 5.53$, $p < .001$). Inspection of the means showed that, compared to the dropouts, the retained group reported higher levels of autonomous motivation of moderately low size (Cohen's $ES = 0.32$). Although, we assumed that these differences would not significantly distort the expected pattern of relations had we had complete information from the full sample, we decided to impute the missing data using the expectation-maximization (EM) algorithm. However, the data without the imputation of missing scores are also available as supplementary material.

Sample 2 involved 257 Turkish middle school students from 6th to 8th grade from a private school located in Ankara, Turkey ($M_{age} = 12.09$ years, $SD = 0.99$; 45.9% males; 3.9% did not report their gender). In particular, 102 students were attending the 6th grade, 77 students the 7th grade, and 78 the 8th grade. The students from both samples were coming from families with average and average-to-high socio-economic background.

2.3. Measures

For both Samples 1 and 2 the measures were translated from English to Turkish by a team of researchers who were native Turkish speakers and fluent in English. A back translation from Turkish to English was made by a native English speaker who was fluent in Turkish. In cases of discrepancies, the items were discussed by the translators until attaining mutual consent (Hambleton & De Jong, 2003).

2.3.1. Autonomous and controlled motivation

For Sample 1, a Turkish version of the Self-Regulated Questionnaire (Ryan & Connell, 1989) was used to assess students' quality of motivation. Specifically, students reported the reasons for which they tried to do well either in mathematics or in Turkish language. We focused on these two subject matters as they are considered among the core subjects that determine Turkish students' access to higher education. The students answered on a 6-point Likert-type scale (1 = *Strongly disagree*; 6 = *Strongly agree*) to what extent they were trying to do well in school because they were considering school work (a) interesting and enjoyable (i.e., intrinsic motivation; 4 items; e.g., "Because it is fun."); (b) personally important (i.e., identified regulation; 4 items; e.g., "Because it's important to me to do my homework."). Also, they indicated whether they were striving to do well at school (c) to avoid feelings of guilt and shame or to attain contingent self-worth (i.e., introjected regulation; 4 items; e.g., "Because I will feel bad about myself if I don't do it.") or (d) to attain a promised reward or to avoid some negative consequences (i.e., external regulation; 4 items; e.g., "Because I will get in trouble if I don't."). A CFA of a higher-order model where (a) autonomous motivation latent factor was defined by intrinsic and identified regulation latent factors after imposing equality constraints); (b) controlled motivation latent factor was defined by introjected and external regulation (after imposing equality constraints); (c) the four first-order latent factors were defined through their respective items; (d) identified and introjected regulation first-order latent factors were allowed to covary; and (e) the errors of two intrinsic items were allowed to covary and an external regulation item was allowed to (negatively) cross-load to intrinsic motivation latent factor yielded the following fit: $S\text{-}B\chi^2$ (97; $N = 2758$) = 1090.94, $p < .001$, CFI = 0.914, SRMR = 0.064, RMSEA = 0.061 (90% CI: 0.058, 0.064). Although not optimal, these indices were deemed reasonably acceptable, according to the cutoff criteria proposed by Hu and Bentler (1999).

In line with SDT, which theorizes that intrinsic motivation and identified regulation reflect autonomous motivation and that introjection and external regulation represent controlled motivation, we used the standardized item loadings to compute a score for intrinsic and identified regulation and a composite score for autonomous motivation, after taking into account the standardized loadings of the two first-order latent factors that defined the higher-order latent factor of autonomous motivation. We did the same to compute controlled motivation by using the standardized loading of introjected and external regulation.

For Sample 2, the students answered to four sets of four 5-point Likert type items 1 = *Strongly disagree*; 5 = *Strongly agree*) as suggested by Sheldon, Osin, Gordeeva, Suchkov, and Sychev (2017). This instrument, not available at the time of data collection in Sample 1, is considered an improved version of Ryan and Connel's scale (1989). It is purported to assess intrinsic motivation (e.g., "I study because it is fun"), identified regulation (e.g., "I study because it is meaningful"), introjected negative regulation (e.g., "I study because I would feel guilty if I didn't") and external regulation (e.g., "I study because others will get mad if I don't") in a specific subject matter. A CFA with a four-latent factor model yielded acceptable fit: $S\text{-}B\chi^2$ (98; $N = 234$) = 181.73, $p < .001$, CFI = 0.943, SRMR = 0.080, RMSEA = 0.060 (90% CI: 0.048, 0.072)[1]. Similar to Sample 1, we computed a score for autonomous motivation by aggregating the intrinsic and identified motivation latent factors (as estimated through the loadings of the respective items) and we did the same for controlled motivation through the aggregation of introjected and external regulation latent factors (again, as estimated through the loading of the respective items). The fact that the items in Sample 1 and 2 were presented, respectively, on a 6-point and 5-point anchors pose no serious threat to the validity of the obtained results, given that no gross differences are expected when a scale is presented in either of these two formats (see Leung, 2011).

2.3.2. Grades

Students' end-of-school-year grades to the respective grade subject matter were obtained from students' follow-up reports six months later in Sample 1. In Sample 2 students' grades of the first semester of the academic year concerning the subject matter for which motivation had been assessed were collected from the school records two months later. The range of grades in secondary school in Turkey is between 0 and 100, with scores higher than 85 being characterized as "very good", scores between 65 and 84.99 being characterized as "Good", 50 and 64.99 as "Average" and less than 50 as "Fail".

2.4. Plan of analyses

After clearing the data, we imputed the missing values for both Sample 1 ($n = 1476$ 47.7% of the retained sample) and Sample 2 ($n = 13$, 5.1%), using the norm package (Novo & Schafer, 2015). Specifically, we followed the recommendations being made by Graham (2009) and by Schafer and Graham (2002; see also Graham, Olchowski, & Gilreath, 2007) and we used autonomous and controlled motivation (after centering them around their midscale), their two-way interaction, and their squared scores as predictors of grades for 1000 imputed datasets (each of which was simulated 500 times).[1] The code for the imputation routine is available as supplementary material.

After checking for the presence of univariate or multivariate outliers, we compared three regression models to properly address our research questions. In the first model, we regressed grades on autonomous and controlled motivation (first-order model); in the second step we included their interaction (interaction model), whereas in the third model we added the two predictors squared (polynomial model). The polynomial regression model would be meaningful providing that the polynomial model would be (statistically) significantly different (in terms of *F*-change value), from either the first-order model or the interaction model. To properly set up the polynomial model and render

[1] The same analyses without imputing the missing data yielded similar results and are available as supplementary material. Wherever the present analyses differ from the analyses with listwise deletion, a footnote will note this difference.

its solution comparable to the respective solution from the first-order and the interaction model, we centered the scores of autonomous and controlled motivation around their respective scale midpoints. Centering is especially needed when a hypothesis of congruence or incongruence between two predictors is tested. It should be noted however that centering around the scale midpoint (rather than around the mean) is preferable for polynomial regression with response surface analysis (Atwater, Waldman, Ostroff, Robie, & Johnson, 2005; Cohen, Nahum-Shani, & Doveh, 2010; Shanock, Baran, Gentry, Pattison, & Heggestad, 2010). This is because, centering around the midscale does not imply that the two scores of the two predictors deviate from their respective means by the same amount, an oftentimes unrealistic assumption that is being made when scores are centered at the mean (Barranti, Carlson, & Côté, 2017).

Providing that the polynomial regression model statistically differs in terms of *F*-change value from the first-order and/or the interaction model, the resultant response surface analysis can meaningfully interpret the linear and curvilinear relations between the predictors and the outcome to address our hypotheses. There are five pieces of information from the derived response surface analysis which are of interest in the present study because they address our four hypotheses. The first one, concerns the *line of congruence* ($x = y$), which tests whether autonomous (x) and controlled motivation (y) may synergistically function to predict academic performance. The slope of line of congruence, α_1, represents the sum of the two first-order predictors (i.e., α_1 = autonomous motivation + controlled motivation), whereas the curvature, α_2, represents the sum of autonomous by controlled motivation interaction with the 2 s-order predictors (i.e., α_2 = autonomous X controlled motivation + autonomous motivation, squared + controlled motivation, squared). The null hypothesis, which corresponds to our Hypothesis 2a, assumes that the surface over the line of congruence is flat. This means that the slope α_1 and the curvature α_2 (or their net effect when they are jointly considered) will be zero.

The second key feature concerns the *line of incongruence* ($x = -y$) which examines whether higher levels of autonomous motivation combined with lower levels of controlled motivation (or vice versa) predict higher grades (Hypothesis 2b). The slope of line of incongruence, α_3, represents the differences of the two first-order predictors (i.e., α_3 = autonomous motivation - controlled motivation), whereas the curvature, α_4, represents the difference of autonomous motivation squared predictor from the sum of controlled motivation squared with autonomous by controlled motivation interaction predictor (i.e., α_4 = autonomous motivation, squared – [autonomous X controlled motivation + controlled motivation, squared]). Given Hypothesis 2b, we expected that the surface over the line of incongruence would be ascending and thus that either the slope α_3 or the curvature α_4 (or their net effect when jointly considered) would predict higher grades when higher and higher scores of autonomous motivation would coincide with lower and lower scores of controlled motivation.

The third piece of information concerns the surface along the line that runs parallel to controlled motivation at 1 *SD* below and 1 *SD* above the midpoint of autonomous motivation. The surface along these lines directly addresses Hypothesis 3 - whether controlled motivation can compensate for the absence of autonomous motivation or can further boost the positive relations of it to grades. It concerns the relation of controlled motivation to grades when autonomous motivation is relatively low or high, respectively. Given our hypotheses, we expected that the surface along these lines would be flat, which means that the linear and curvilinear relation of controlled motivation (or their net effect when jointly considered) to grades would be zero.

The fourth piece of information concerns the surface along the lines that run parallel to autonomous motivation at 1 *SD* below and 1 *SD* above the midpoint of controlled motivation. Examining the surface along these lines addresses our Hypothesis 4 according to which autonomous motivation does predict higher grades, especially when controlled motivation is low (i.e., 1 *SD* below the midpoint). We expected that the linear and curvilinear relation of autonomous motivation, or their net effect when jointly considered, would predict higher grades, especially when controlled motivation would be low.

An additional, yet peripheral, piece of information that can help us understand the nature of the inter-relation among autonomous motivation, controlled motivation, and grades refers to the location of the *stationary point*, which represents the point in the surface where the slope of the estimated surface is null at all directions. Knowing where the stationary point is and whether from that point grades decrease (for concave, or dome-shaped surfaces) or increase (for convex, or bowl-shaped surfaces) as a function of higher autonomous motivation and lower controlled motivation (or vice versa) can inform us about the nature of interdependencies between autonomous and controlled motivation in the prediction of grades. To examine our hypotheses in a robust way, we bootstrapped with 10,000 samples the estimates from the polynomial regression model to get the 95% confidence interval for the slopes and curvatures along the lines of congruence and incongruence and the lines that run parallel to autonomous and controlled motivation at moderately high (+1 *SD* above the midscale), moderate (at the midscale), and moderately low (−1 *SD* below the midscale) levels of controlled and autonomous motivation, respectively.

To summarize, we examined the degree to which the slope and curvature of the following lines would be statistically significant: The lines of congruence ($x = y$) and incongruence ($x = -y$) between autonomous and controlled motivation and the lines at low, moderately low, moderate, moderately high, and high levels of autonomous and controlled motivation. Testing the slopes and curvatures of each of these lines addresses through different angles our hypotheses and research questions. For instance, a statistically significant and positive slope and curvature along the line of incongruence would provide support to incongruence hypothesis (i.e., Hypothesis 2b). Accordingly, statistically significant slope and curvature along the lines that run parallel to autonomous motivation would provide evidence that autonomous motivation plays a role in the prediction of higher grades; showing that the slope and curvature or their combination is even more marked when controlled motivation is low rather than when it is high would provide further evidence of the undermining role of controlled motivation in the prediction of grades. In contrast, statistically nonsignificant slope and curvature (or their combination) along the lines that run parallel to controlled motivation would provide evidence that controlled motivation cannot predict higher grades, regardless whether autonomous motivation is low or high.

3. Results

Descriptive statistics, internal consistencies, and bivariate correlations of the measured variables of both samples are shown in Table 1. As can be noticed, the correlation between autonomous motivation and controlled motivation was positive and statistically significant for the first sample but not for the second one. Further, grades related positively to autonomous motivation and negatively to controlled motivation in both samples.

3.1. Sample 1

3.1.1. Regression analysis

The estimates for the first-order, interaction, and full polynomial regression models are shown in Table 2 (left column, upper panel). In line with SDT (Ryan & Deci, 2017), Hypothesis 1, and the few studies that have examined the relation of autonomous and controlled motivation to academic achievement (Guay, Ratelle, Roy, & Litalien, 2010), end-of-school-year grades in either mathematics or Turkish language subject matter were predicted positively by T1 autonomous motivation and negatively by T1 controlled motivation. Interestingly, although the model with the interaction term did not statistically differ from the first-order model (see left column, middle panel in Table 2) the full

Table 1
Means, standard deviations, cronbach alphas, and bivariate correlations of the measured variables for sample 1 (lower diagonal; first set of coefficients) and sample 2 (upper diagonal; second set of coefficients).

Variables	1	2	3	4	5	6	7
1. Intrinsic motivation	–	.78**	.06	-.15*	.96**	-.05	.25**
2. Identified regulation	.65**	–	.13**	-.10	.92**	.02	.24**
3. Introjected regulation	.33**	.46**	–	.63**	.09	.91**	-.10
4. External regulation	.00	-.01	.40**	–	-.13	.90**	-.24**
5. Autonomous motivation	.92**	.89**	.43**	-.01	–	-.02	.26**
6. Controlled motivation	.22**	.31**	.88**	.78**	.29**	–	-.19**
7. Grades	.09**	.06**	-.06**	-.08**	.08**	-.08**	–
Cronbach Alpha	.81/.88	.83/.80	.69/.77	.65/.74	.88/.90	.79/.84	–
Omega	.79/.89	.76/.81	.80/.79	.61/.73	.85/.92	.76/.84	–
M	2.51/3.10	2.87/2.88	3.04/1.99	2.02/1.57	2.51/2.99	2.03/1.78	74.29/89.28
SD	0.77/0.89	0.69/0.64	0.84/0.71	0.62/0.68	0.62/0.72	0.49/0.63	14.31/10.24
Skewness	−0.40/0.87	−0.67/0.97	−0.64/0.16	−0.02/0.50	−0.47/-0.89	−0.43/0.36	−0.20/-1.24
Observed range	0.58–4.61/ 0.82–4.40	0.64–4.36/ 0.73–3.64	0.58–4.67/ 0.69–3.43	0.56–3.75/ 0.64–3.24	0.58–3.97/ 0.77–3.88	0.46–3.33/ 0.67–3.34	40.0–100/ 47.0–100

Note. $^{*}p < .05$. $^{**}p < .01$.

Table 2
End-of-school-year Grades as a Function of Autonomous and Controlled Motivation, their Interaction and Quadratic Slopes.

Predictors	Grades					
	Sample 1			Sample 2		
First-order Model	*B*	(*SE*)	β	*B*	(*SE*)	β
Intercept	74.13	(0.28)	–	85.65	(0.82)	–
Autonomous motivation	2.66**	(0.43)	.12	4.62**	(0.83)	.33
Controlled motivation	−3.41**	(0.54)	-.12	−3.09**	(0.93)	-.19
F change	(2, 3091) = 30.41**			(2, 251) = 20.81**		
Adjusted R^2	.02			.14		
Interaction Model	*B*	(*SE*)	β	*B*	(*SE*)	β
Intercept	74.03	(0.28)	–	86.03	(0.85)	–
Autonomous motivation	2.58**	(0.43)	.11	4.14**	(0.88)	.29
Controlled motivation	−3.70**	(0.56)	-.13	−1.42	(1.36)	-.09
Autonomous x Controlled	1.36†	(0.72)	.04	−2.23	(1.33)	-.15
F change	(1, 3090) = 3.50†			(1, 250) = 2.80		
Adjusted R^2	.02			.14		
Full Polynomial Model	*B*	(*SE*)	β	*B*	(*SE*)	β
Intercept	72.61	(0.37)	–	85.18	(1.02)	–
Autonomous motivation	2.27**	(0.44)	.10	2.68*	(1.11)	.19
Controlled motivation	−3.42**	(0.56)	-.12	−1.60	(1.42)	-.10
Autonomous x Controlled	−0.51	(0.79)	-.01	−2.14	(1.34)	-.14
Autonomous, squared	1.95**	(0.52)	.07	2.09*	(0.95)	.17
Controlled, squared	3.15**	(0.77)	.08	−0.30	(1.27)	-.01
F change	(2, 3088) = 16.83**			(2, 248) = 2.40		
Adjusted R^2	.03			.15		

Note. $^{\dagger}p = .06$. $^{*}p < .05$ $^{**}p < .01$. $^{\dagger}p \leq .06$.

polynomial regression model in which autonomous and controlled motivation were also entered as squared predictors in the equation did significantly differ from the interaction model (see Table 2, left column, lower panel). In that model both the linear and curvilinear relations of autonomous motivation to grades were positive and statistically significant. This finding suggests an accelerating rate of increase in grades when autonomous motivation was higher and higher. In contrast to autonomous motivation, the pattern of relation of controlled motivation to grades was more complicated, as the linear predictor was negative and the curvilinear was positive. To ease the interpretation of the coefficient values, Fig. 2a shows the graphical representation in the three-dimensional space of the estimates derived from the model with its contour lines drawn on the x, y plane to help clarify the shape of the surface. The same contours are shown in a clearer fashion in the two-dimension Fig. 2b.

3.1.2. Response surface analysis

The response surface analysis was employed to interpret the joint linear and curvilinear relations of autonomous and controlled motivation to grades. As displayed in Fig. 2a (and its contours for better visual inspection in Fig. 2b), the surface was mildly convex with its highest estimated level corresponding to high scores of autonomous motivation and low scores of controlled motivation. The location of the stationary point, which represents the point in the surface where the slope of the estimated surface is null at all directions, was at autonomous motivation = −0.52 and controlled motivation = 0.51, about 1 *SD* below the midscale of autonomous motivation and close to 1 *SD* above the midpoint of controlled motivation (see the dot in Fig. 2a and b). A detailed presentation of the response surface analysis aiming to address our research questions is as follows.

3.1.2.1. Hypothesis 2a: line of congruence between autonomous and controlled motivation. The line of congruence is projected to the x, y plane as a dotted line running from near corner to the far corner in Fig. 2a and b. The slope was nonsignificant ($\alpha_1 = -1.15$, $SE = 0.61$, $t_{[3093]} = -0.1.88$, $p = .061$, 95%-CI: −2.35, 0.03), but its curvature was statistically significant ($\alpha_2 = 4.59$, $SE = 0.92$, $t_{[3093]} = 4.97$, $p < .001$, 95%-CI: 2.77, 6.43). Inspection of the line of congruence shows that grades decreased as autonomous and controlled motivation jointly increased up to a point after which they rebounded. This result provides no support to Hypothesis 2a, though the results show an inconclusive pattern given that there were no systematic additive effects between autonomous and controlled motivation in the prediction of grades.

3.1.2.2. Hypothesis 2b: line of incongruence between autonomous and controlled motivation. In contrast to the line of congruence, both the slope and the curvature along the line of incongruence (x = -y; see the projected dotted line on the x, y plane running from back-left corner to near-right corner in Fig. 2a and b) were positive and statistically significant (respectively, $\alpha_3 = 5.68$, $SE = 0.80$, $t_{[3093]} = 7.12$, $p < .001$, 95%-CI: 4.11, 7.25 and $\alpha_4 = 5.61$, $SE = 1.39$, $t_{[3093]} = 4.05$, $p < .001$, 95%-CI: 2.87, 8.29). Inspection of the surface along the line of incongruence shows that grades increased substantially when autonomous motivation surpassed the midpoint and controlled motivation was low;

specifically, when it was less than the midpoint of the scale. These findings provide support to Hypothesis 2b and suggest that autonomous motivation predicts higher grades when it coincides with lower controlled motivation.

3.1.2.3. Hypotheses 3a & 3b: controlled motivation at low, moderate, and high levels of autonomous motivation. Using the estimates from the polynomial regression model after following Edwards and Parry's (1993) recommendations, we bootstrapped these estimates with 10,000 samples to get the 95% confidence interval for the linear slope of controlled motivation in the prediction of grades at low (i.e., 1 *SD* below the scale midpoint), moderate (i.e., at the scale midpoint), and moderately high (1 *SD* above the scale midpoint) levels of autonomous motivation. The means, standard errors, and the 95% confidence intervals of these estimates are shown in Table 3. Also, the estimated linear slopes of controlled motivation at scores of moderately high (+1) and moderately low (−1) levels of autonomous motivation are also shown in Fig. 2a and b. Setting aside the curvature of controlled motivation (i.e., the quadratic relation of controlled motivation to grades which was $b\chi^2 = 1.95$ [95%-*CI*: 0.94, 2.97]), it can be noticed in Table 3 the linear relation of controlled motivation to grades was negative when autonomous motivation was low (at −1 *SD* below the scale midpoint: $bx = -3.29$ [95%-*CI*: −5.38, −1.23]) or moderate (at the scale midpoint: $bx = -3.41$ [95%-*CI*: −4.49, −2.32]) and that the estimated confidence interval included zero when autonomous motivation was relatively high (at 1 *SD* above the scale midpoint: $bx = -1.12$ [95%-CI: −2.40, 0.11]).[2] Taken together, these findings and inspection of the surface along the relevant lines provide support to Hypotheses 3a and 3b as controlled motivation did not predict higher grades either when autonomous motivation was relatively low (Hypothesis 3a) or relatively high (Hypothesis 3b).

Table 3
Estimated Linear Slope of Autonomous and Controlled motivation to Grades under different Levels of Controlled and Autonomous Motivation, Respectively.

Coefficients	Grades as a function of controlled motivation			
	Sample 1		Sample 2	
	B	95%-CI	*B*	95%-CI
Curvature of controlled motivation	3.15	(1.61, 4.64)	−0.32	(-2.84, 2.06)
Slope of controlled motivation when autonomous motivation was …				
moderately low (−1 *SD*)	−3.29	(-5.38, −1.23)	−0.53	(-5.98, 4.58)
moderate (~0)	−3.41	(-4.49, −2.32)	−1.61	(-4.41, 1.11)
moderately high (+1 *SD*)	−1.12	(-2.40, 0.11)	0.23	(-1.97, 2.38)
	Grades as a function of Autonomous motivation			
	Sample 1		Sample 2	
	B	95%-CI	*B*	95%-CI
Curvature of autonomous motivation	1.95	(0.94, 2.97)	2.08	(0.17, 3.93)
Slope of autonomous motivation when controlled motivation was …				
moderately low (−1 *SD*)	5.75	(4.17, 7.31)	4.84	(2.24, 7.47)
moderate (~0)	2.26	(1.41, 3.11)	2.69	(0.60, 4.98)
moderately high (+1 *SD*)	1.88	(0.70, 3.07)	0.14	(-2.97, 3.18)

Note. Based on 10,000 replications. ~0 and ± 1 stand, respectively, for midpoint and one *SD* above and below the scale midpoint.

3.1.2.4. Hypotheses 4a & 4b: autonomous motivation at low, moderate, and high levels of controlled motivation. Following the same procedures as before, we estimated through bootstrap the linear slope of autonomous motivation in the prediction of grades at moderately low (1 *SD* below the scale midpoint), moderate (i.e., at the scale midpoint), and moderately high (1 *SD* above the scale midpoint) levels of controlled motivation. The means, standard errors, and the 95% confidence intervals of these estimates are shown in Table 3. Also, the estimated linear slopes at scores of moderately high (+1) and moderately low (−1) scores of controlled motivation are also shown in Fig. 2a and b. Setting aside the curvature of autonomous motivation (i.e., the quadratic relation of autonomous motivation to grades which was $b\chi^2 = 3.15$ [95%-*CI*: 1.61, 4.64]),[3] the linear relation of autonomous motivation to grades was positive either when controlled motivation was relatively low, moderate, or moderately high (see Table 3). These findings supplement the previous ones and provide support to Hypothesis 4a but not to 4b as they show that autonomous motivation predicted higher and higher grades, regardless the levels of controlled motivation.

3.2. Sample 2

3.2.1. Regression analysis

Three univariate and multivariate outliers (1.2% of the sample) were identified and thus were removed before regression and the subsequent response surface analyses. The estimates for the first-order, interaction, and full polynomial regression models are shown in the upper panel in Table 2 (right column). Similar to Sample 1, and in support of Hypothesis 1, end-of-the-semester grades were predicted positively by autonomous motivation and negatively by controlled motivation in the first-order model (see Table 2, right column, upper panel). Unlike to Sample 1, the interaction model was nonsignificant (see Table 2, right column, middle panel). Also, unlike Sample 1, adding the interaction in Step 2 rendered controlled motivation nonsignificant. Although the full polynomial regression model was nonsignificant (see Table 2, right column, lower panel), autonomous motivation squared was found to predict grades ($b = 1.94$, $SE = 0.96$, $p = .044$, 95%-CI: 0.05, 3.83; $\beta = 0.15$). Given that in the full polynomial regression model, grades were predicted by autonomous motivation and autonomous motivation squared, a finding which provides support to Hypothesis 1, we proceeded with the response surface analysis.

3.2.2. Response surface analysis

A graphical representation of the three-dimensional surface with its contour lines being projected on the x, y plane is shown in Fig. 2a; the same contour lines are also shown in the two-dimension Fig. 2b. An inspection of Fig. 2a shows that the surface resembled that of Fig. 2a as it was also mildly convex (but, saddle shaped as well) with its highest estimated level corresponding to high scores of autonomous motivation and low scores of controlled motivation. The stationary point was at autonomous motivation = −0.75 and controlled motivation = −0.20, (see the dot in Fig. 2a and b), in a similar position that was also found in Sample 1.

3.2.2.1. Hypothesis 2a: line of congruence between autonomous and controlled motivation. Neither the slope ($\alpha_1 = 1.07$, $SE = 1.62$, $t_{[253]} = 0.66$, $p = .51$, 95%-CI: −2.04, 4.26), nor the curvature ($\alpha_2 = -0.36$, $SE = 1.92$, $t_{[253]} = -0.19$, $p = .85$, 95%-CI: −4.22, 3.19) of the x = y line was statistically significant. These findings, along with the inspection of the line of congruence in Fig. 3a, provide support to Hypothesis 2a as they suggest that there were no additive effects between autonomous and controlled motivation. Indeed, the mildly upward curvature at low levels of autonomous and controlled motivation flattened out around the

[2] In the analysis with listwise deletion, all these slopes were null, given that their confidence intervals contained zero.

[3] In the analysis with listwise deletion, the curvature was null, given that its confidence interval contained zero.

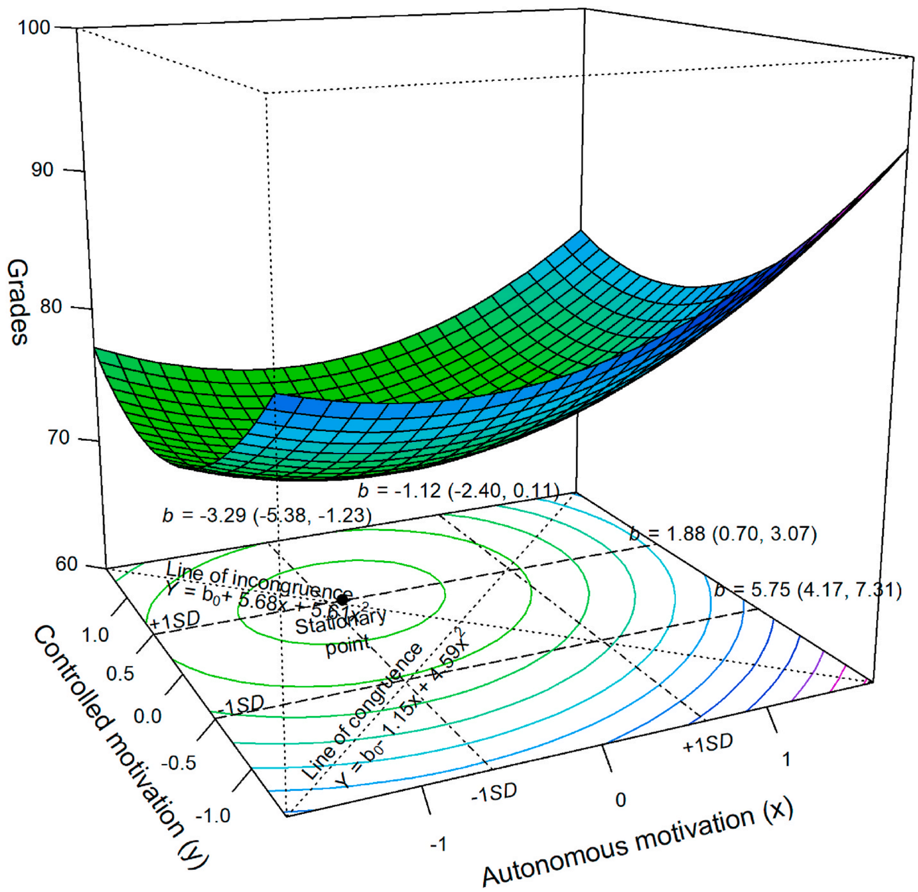

Fig. 2a. Response surface analysis of end-year grades in Sample 1 as a function of T1 autonomous motivation (X) and controlled motivation (Y). In the X–Y plane, the dotted line running diagonally from the near corner to the far corner represents the line of congruence between autonomous and controlled motivation; the dotted line running diagonally left to right represents the line of incongruence between autonomous and controlled motivation. The stationary point shows the point where the slope of the estimated surface is null in all directions. The two dashed (and dot-dashed) lines running parallel to autonomous (and controlled) motivation represent the estimated (through bootstrap) linear relations of autonomous (controlled) motivation to grades at moderate high (+1 *SD*) and moderate low (−1 *SD*) scores of controlled (autonomous) motivation (95% confidence intervals in parentheses).

midpoint of the scale (see in Fig. 3a the surface that corresponds to the dotted line running from the near corner to the far corner). Grades were sufficiently predicted by autonomous motivation as controlled motivation failed to further predict them according to the present model.

3.2.2.2. Hypothesis 2b: line of incongruence between autonomous and controlled motivation. In contrast to the line of congruence, and in line with the findings from Sample 1, the slope along the line of incongruence, x = -y, was positive and statistically significant ($\alpha_3 = 4.29$, $SE = 1.96$, $t_{[253]} = 2.19$, $p = .030$, 95%-CI: 0.61, 8.31), though the same was marginally true for its curvature ($\alpha_4 = 3.92$, $SE = 2.14$, $t_{[253]} = 1.83$, $p = .069$, 95%-CI: −0.38, 8.91),. Again, these findings provide some support to Hypothesis 2b. Inspection of the surface along the line of incongruence shows that grades markedly increased when autonomous motivation increased from moderate to high levels and controlled motivation decreased from moderate to low levels.

3.2.2.3. Hypotheses 3a & 3b: controlled motivation at low, moderate, and high levels of autonomous motivation. Similar to Sample 1, we estimated through bootstrap approach the 95% confidence interval for the linear slope of controlled motivation in the prediction of grades at moderately low, moderate, and moderately high levels of autonomous motivation. The curvature was nonsignificant ($b\chi^2 = -0.32$ [95%-*CI*: −2.84, 2.06]), and the same was held true for the linear relation of controlled motivation to grades when autonomous motivation was either relatively low (at −1 *SD* below the scale midpoint: $bx = -0.53$ [95%-*CI*: −5.98, 4.58]) moderate (at the scale midpoint: $bx = -1.61$ [95%-*CI*: −4.41, 1.11]), or relatively high (at 1 *SD* above the scale midpoint: $bx = 0.23$ [95%-*CI*: −1.97, 2.38]). In sum, these findings and inspection of the surface along the relevant lines (see Fig. 3a and b) indicate that controlled motivation did not predict higher grades either when autonomous motivation was relatively low (providing support to Hypothesis 3a) or relatively high (providing support to Hypothesis 3b).

3.2.2.4. Hypotheses 4a & 4b: autonomous motivation at low, moderate, and high levels of controlled motivation. The means and the 95% confidence interval of the linear slope of autonomous motivation in the prediction of grades at moderately low, moderate, and moderately high levels of controlled motivation are shown in Table 3 (right column; see also Fig. 3a and b). Setting aside the statistically significant curvature of autonomous motivation (i.e., the quadratic relation of autonomous motivation to grades which was $b\chi^2 = 2.08$ [95%-CI: 0.17, 3.93]), the linear relation of autonomous motivation to grades was positive when controlled motivation was relatively low, or moderate, but not when it was moderately high (see Table 3). These findings provide support to both Hypothesis 4a and 4b as they indicate that autonomous motivation predicted higher and higher grades, when controlled motivation was moderate or moderately low. Instead, when controlled motivation was relatively high autonomous motivation could hardly predict higher grades (see dashed line at +1 *SD* of controlled motivation in Fig. 3a and b).

4. Discussion

In this study, we examined the degree to which linear and curvilinear relations of autonomous and controlled motivation, and their interaction, predict higher grades in two different samples of adolescent students. In support to our first hypothesis, we found autonomous motivation to emerge as the only consistent, positive, predictor of grades in both samples. Notably, the positive association between autonomous motivation and grades was found in both samples and in all the three regression models (i.e., [a] the typical no-interaction, no-polynomial

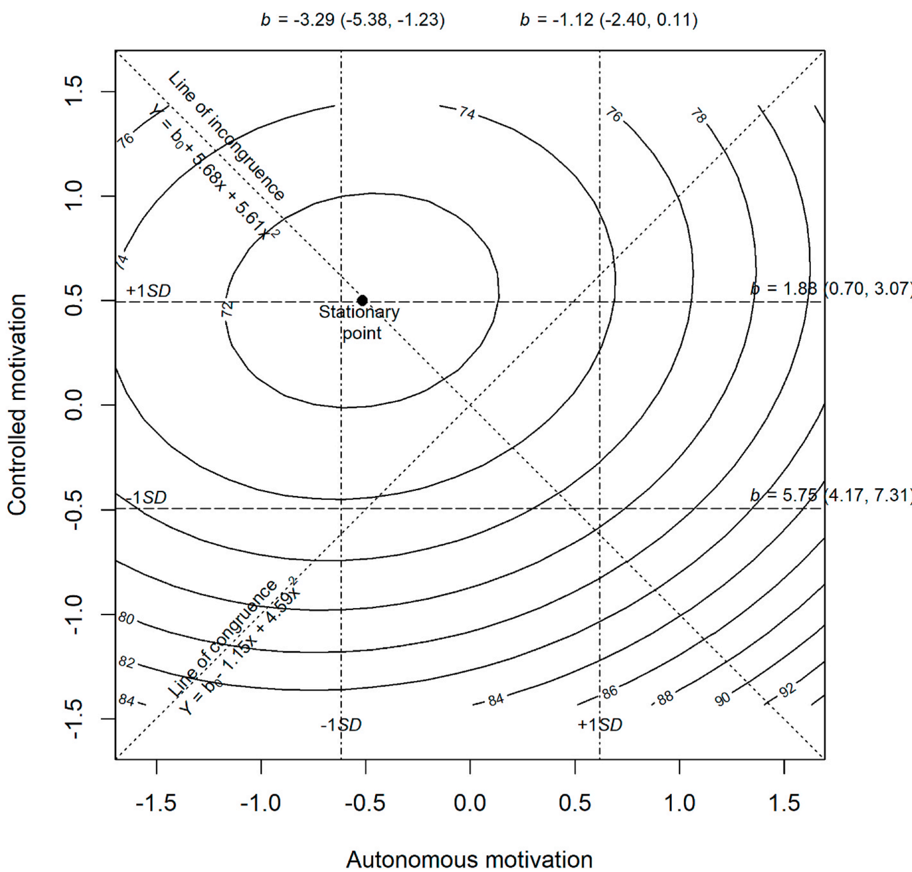

Fig. 2b. The contour plot for Sample 1, the projection of which is also shown in Fig. 2a and which exhibits the prediction of end-year grades as a function of T1 autonomous and controlled motivation.
Stationary point: the point where the slope of the estimated surface is null at all directions.
Line of congruence: Autonomous motivation = controlled motivation.
Line of incongruence: Autonomous motivation = - controlled motivation.
The two dashed (and dot-dashed) lines running parallel to autonomous (and controlled) motivation represent the estimated (through bootstrap) linear relations of autonomous (controlled) motivation to grades at moderate high (+1 *SD*) and moderate low (−1 *SD*) scores of controlled (autonomous) motivation (95% Confidence intervals in parentheses).

model; [b] the interaction, no-polynomial model, and [c] the polynomial model). More importantly, we found only slim evidence for Hypothesis 2a, if any at all, that a congruence between autonomous and controlled motivation can predict higher academic performance. In contrast, in line with Hypothesis 2b our findings suggest that it was incongruence rather than congruence between autonomous and controlled motivation, which mainly predicted higher grades. This finding supported our second hypothesis.[4]

Concerning the line of congruence, our analyses revealed that when autonomous and controlled motivation coincide, no higher grades are predicted. On the contrary, the statistically significant line of incongruence in both samples provides adequate support to the notion that higher grades are expected when autonomous motivation goes up and controlled motivation goes down. This pattern is in line with both Hypotheses 2a and 2b and with SDT (Ryan & Deci, 2017) which claims that it is high autonomous motivation combined with low controlled motivation rather than high autonomous motivation combined with high controlled motivation that counts for students' optimal functioning. When only volitionally engaged, students feel that they are the owner of their own actions – that they have an internal locus of control in what they do. This volition becomes intrinsically valuable because it aligns well with their interests and preferences. In such cases, students are more likely to maximize their efforts and hence to attain higher grades (Findley & Cooper, 1983; Skinner, Wellborn, & Connell, 1990) as the reason for striving – the locus of causality that energizes, directs, and regulates human behavior (deCharms, 1968) - resides to the very same person. In contrast, when students feel forced to behave or even to think or feel in certain ways either due to internal or external pressures, they are less likely to invest further resources than needed to get the job done. In fact, they are more likely to react, defy, or even rebel against such psychological pressures (Van Petegem, Soenens, Vansteenkiste, & Beyers, 2015) to restore their sense of agency (Brehm, 1966). Moreover, when high levels of feelings of pressure together with high levels of interest and feelings of agency regulate their behavior, students seem less likely to reach their full potential, as expressed through grades.

Further, our polynomial regression analyses uncovered such curvilinear relations of grades to autonomous motivation (in both samples) and to controlled motivation (in Sample 1). Had we stopped our analyses at the interaction model without polynomial coefficients, we would have erroneously inferred that the relation of autonomous and controlled motivation is linear. This finding raises a red flag for most studies that typically overlook testing whether the pattern of relations between quality of motivation and motivational outcomes is nonlinear. Future researchers thus should ascertain the readers that the relations between motivational variables of interest are not curvilinear before testing their research questions through typical linear regression models.

The positive association between autonomous motivation and grades coincides with several previous studies that have pointed out that autonomous motivation reliably predicts desired school outcomes such as grades (Froiland & Davison, 2016; Guay et al., 2010; Li et al., 2018). Likewise, consistent with previous studies, controlled motivation failed to predict higher grades in the typical regression model – in fact it predicted lower grades. Yet, the pattern of relation between controlled motivation and grades was quite more complex when curvilinear relations were considered. Specifically, controlled motivation appeared not to predict lower grades when autonomous motivation was high; concurrently, however, it was controlled motivation which was found to partly cancel out the strong positive relation of autonomous motivation

[4] These hypotheses were also confirmed with a third sample that involved Greek adolescent students. The results with the respective figures were not included in the main study for reasons of brevity but are available for inspection as an online supplementary material.

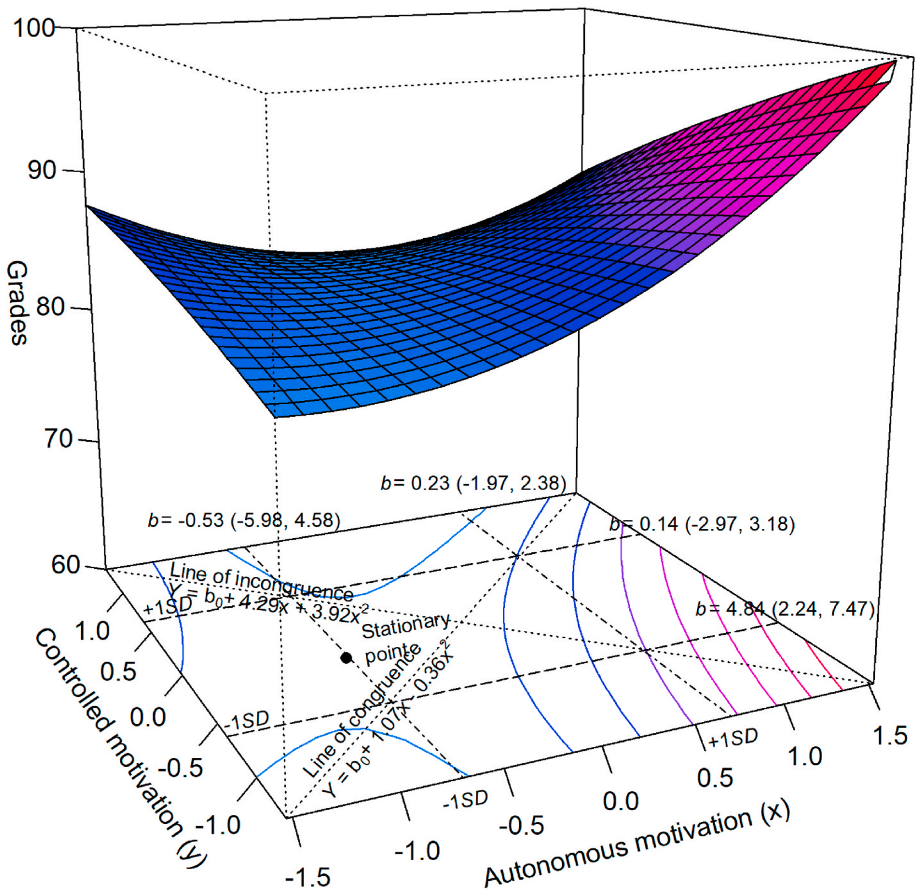

Fig. 3a. Response surface analysis of end-year grades in Sample 2 as a function of T1 autonomous motivation (X) and controlled motivation (Y). In the X–Y plane, the dotted line running diagonally from the near corner to the far corner represents the line of congruence between autonomous and controlled motivation; the dotted line running diagonally left to right represents the line of incongruence between autonomous and controlled motivation.
The stationary point shows the point where the slope of the estimated surface is null in all directions. The two dashed (and dot-dashed) lines running parallel to autonomous (and controlled) motivation represent the estimated (through bootstrap) linear relations of autonomous (controlled) motivation to grades at moderate high (+1 *SD*) and moderate low (−1 *SD*) scores of controlled (autonomous) motivation (95% confidence intervals in parentheses).

to grades when it was especially high. Both these findings show the enhancing role of autonomous motivation and the likely undermining role that controlled motivation can play in students' academic achievement. Such results provide further evidence to teachers and parents about which type of motivation they need to encourage if they desire their students or children to succeed academically in school.

Further support that quality of motivation does matter is coming from our testing of Hypotheses 3 and 4. Specifically, and in support to Hypothesis 3a and 3b controlled motivation appeared to add nothing when autonomous motivation was either low or high as the lines running parallel to controlled motivation at, respectively, −1 *SD* and +1 *SD* of autonomous motivation suggest. Moreover, inspecting the slopes of autonomous motivation to grades under relatively low and high scores of controlled motivation implies that controlled motivation could partly undermine the positive role of autonomous motivation. In both samples, autonomous motivation predicted higher grades when controlled motivation was moderately low, but it became a weaker predictor of grades when controlled motivation was moderately high (i.e., 1 *SD* above the midpoint). In fact, in Sample 2, it became nonsignificant predictor. Again, these findings speak highly of the minor, if not hampering role, that academic striving for acquiring a promised reward or avoiding punishments, or enhancing contingent self-worth, or avoiding feelings of guilt can have on students who in the first place do their best because they find schoolwork interesting, challenging, or useful. Controlled motivation seems to add almost nothing in the prediction of grades, a finding which seems to apply to both high school (Sample 1) and middle school students (Sample 2).

Taken together, these results seem to contradict the ones being reported by Phillips and Johnson (2018) as in both our samples we barely found any evidence suggesting that controlled motivation could be conducive even if it is accompanied with certain levels of autonomous motivation. A possible explanation for the inconsistency between the present results and those of Phillips and Johnson (2018) may stem from the different type of dependent variables being employed, the different context, and the different cultural background and population samples. Specifically, whereas in our study we examined grades as an outcome by recruiting underaged students from a non-Western cultural background, Phillips and Johnson (2018) focused on physical activity as an outcome among (mainly young) adults from the US. It is possible that behavioral engagement such as physical activity may also emerge even when one is partly motivated for controlling reasons (Oliver & Kemps, 2018). Yet, compared to autonomous motivation, controlled motivation seems incapable of promoting qualitative aspects of engagement such as well-being, subjective vitality or deep-learning processes (Ryan & Deci, 2017). At any rate, further research with polynomial regression and response surface analytical approach is needed to examine in what contexts and for what outcomes might controlled motivation contribute next to autonomous motivation to yield desired responses.

There might be occasions where controlled motivation - especially the one that is reflected when grades are viewed as a token of academic success (but not as a promised reward) - function in concert with autonomous motivation to yield positive outcomes (Cerasoli, Nicklin, & Ford, 2014). Perhaps this is the case that might explain why there are occasions for which minimum amount of controlled motivation might be needed (Phillips & Johnson, 2018). Future research could use more sensitive scales that will try to tease apart extrinsic motivation that is derived from expected, promised, performance-contingent rewards and extrinsic motivation that is derived from symbolic rewards (Harackiewicz & Sansone, 2000, pp. 79–103); or extrinsic motivation emerging from achievement-oriented, secure, and unconditional pride (for example, when one views one's high grades as an additional token of one's academic efforts and takes pride in that) from extrinsic motivation

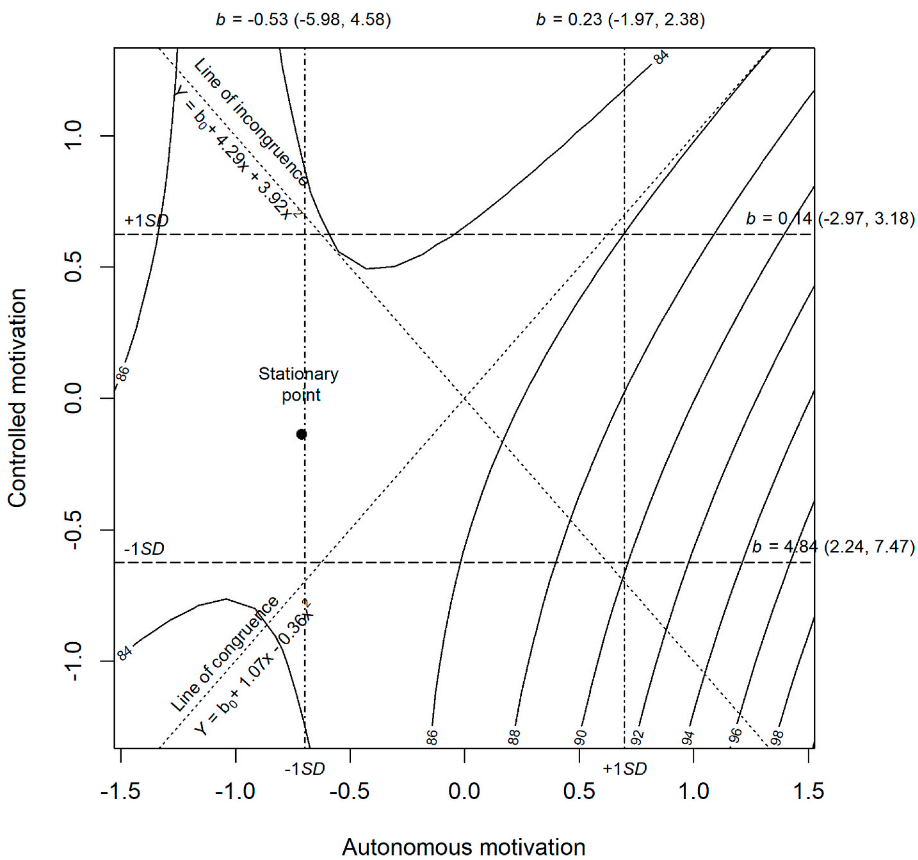

Fig. 3b. The contour plot for Sample 2, the projection of which is also shown in Fig. 3a and which exhibits the prediction of end-year grades as a function of T1 autonomous and controlled motivation.
Line of congruence: Autonomous motivation = controlled motivation.
Line of incongruence: Autonomous motivation = -controlled motivation.
The two dashed (and dot-dashed) lines running parallel to autonomous (and controlled) motivation represent the estimated (through bootstrap) linear relations of autonomous (controlled) motivation to grades at moderate high (+1 *SD*) and moderate low (−1 *SD*) scores of controlled (autonomous) motivation (95% Confidence intervals in parentheses).

that derives from fragile, vulnerable, and firmly contingent upon one's own success pride (e.g., when one feels worthy only when he or she gets high grades at school) (Kernis, 2003; Park, Ward, & Naragon-Gainey, 2017).

The present findings also speak in favor of the usefulness of the polynomial regressions and the resultant response surface analysis to answer the research questions we posed to examine. These findings are interesting because they lend credence to the arguments provided by Edwards (2001) that it is necessary to include the squared predictors to uncover the conditional linear and curvilinear relations between autonomous and controlled motivation. Especially as concerns the canceling role that controlled motivation might have in the relation of autonomous motivation to grades, this finding is intriguing and seems to be in line with a previous meta-analysis showing that extrinsic incentives may shrink the key role that intrinsic motivation might have on human performance (Cerasoli et al., 2014).

However, it should be noted that the present linear and curvilinear relations between autonomous and controlled motivation through polynomial regression analysis and the derived surface response analysis did not substantially deviate from the observed pattern of relations being reported by scholars using linear regression analysis. In that sense, linear regression analysis seems to provide a good approximation of the relations of autonomous and controlled motivation to motivational correlates. At any rate, including curvilinear relations enable us testing a set of theoretically interesting and practically challenging research questions. First, it can help us formally testing whether it holds true the commonly used assumption that the relation between quality of motivation (such as autonomous and controlled motivation) and motivational outcomes is indeed linear – an assumption that is implicitly endorsed whenever regression models with no polynomial coefficients are conducted. Second, it permits us investigating the degree to which controlled motivation can either have any added value next to autonomous motivation or play a hampering role in students' achievement. The latter can be accomplished by examining the slope and curvature of the predicted surface along, respectively, the lines of congruence and incongruence between autonomous and controlled motivation. Third, it allows us examining whether controlled motivation can predict motivational outcomes under certain conditions (e.g., when autonomous and controlled motivation scores lie within a certain range) (see Phillips & Johnson, 2018).

On a broader context, the use of polynomial regressions and response surface analysis could be a viable way to address pertinent questions in motivational literature. For instance, whether performance approach goals could indeed facilitate desired educational outcomes such as higher academic achievement (Senko, Hulleman, & Harackiewicz, 2011) when mastery goals reach certain levels. Likewise, whether extrinsic life goals might predict life satisfaction, well-being (Kasser, 2016), and various educational outcomes, including school grades (Mouratidis, Vansteenkiste, Lens, Michou, & Soenens, 2013) when intrinsic life goals surpass a certain level. Similarly, polynomial regression analyses might be proved useful in disentangling the interplay between different dimensions of the learning environment, such as autonomy support and structure provision in the prediction of motivational processes and outcomes (Jang, Reeve, & Deci, 2010).

4.1. Implications for practice

What do these results may suggest for teachers, parents, and education policy makers? It seems that controlled motivation is needless, and autonomous motivation suffices to get the best of students' potential. No matter how tempting it might be, pressuring students to excel at school relates with no higher school grades; in fact, it might undermine academic performance, even among students who are already autonomous motivated. This phenomenon, known as overjustification effect has been shown to consistently undermine quality of motivation (Deci, 1971; Tang & Hall, 1995). Towards that end, teachers need to refrain from any instructional practices or hints aiming to "boost" their already autonomously motivated students. Trying to highlight the inner value of school related activities, the intrinsic joy of learning, and the personal relevance of things to be learned (Assor, Roth, & Kaplan, 2000) can best guarantee desired educational outcomes.

4.2. Limitations and future directions

The resultant pattern of associations among autonomous motivation, controlled motivation, and grades are based on correlational research design and analyses. Therefore, no causal relations could be claimed. Despite its fruitful approach, polynomial regressions cannot substitute experimental research design in which discrete levels of low, moderate, and high autonomous and controlled motivation can be manipulated and subsequently compared with respect to the outcomes they could yield. Additionally, the coefficients in the two polynomial regression models were not identical, even though the response surface analysis yielded similar pattern across the main lines of interest and across the two samples. Perhaps these discrepancies might be due age difference (high school students in Sample 1, middle school students in Sample 2). Further, the present study focuses solely on adolescents in educational context and on a certain motivational outcome, that of grades. Also, the explained variance of grades was rather low in the first sample, which might be due to almost one-year time difference between the assessment of students' motivation and their graded performance in the particular subject. Besides, there are numerous factors other than motivation (e.g., family support, quality of teacher-student interactions, students' conscientiousness) which may systematically operate throughout a school year and which could influence students' academic performance. Future studies will certainly need to take into account these factors as well. In addition, some of the differences in the regression model coefficients might be due to low statistical power that was observed in Sample 2. Future studies should involve large and more balanced sample sizes as well as a wider array of population samples, contexts, and outcomes to examine the generalizability of the present findings. Especially regarding grades, it should be acknowledged that there are other indices of students' adjustment and academic functioning such as deep-learning strategies, cognitive and behavioral engagement as well as prosocial behavior that are equally if not more valuable educational outcomes than grades. Therefore, the pattern of linear and curvilinear relations among autonomous motivation, controlled motivation, and these outcomes deserves further attention and investigation. These relations should be investigated in the future with respect to the classroom and school context, given that in many setting controlling strategies proliferate.

5. Conclusion

Autonomous motivation seems to be the sole positive and consistent predictor of higher grades at school. Despite what might appear as conventional wisdom, students benefit less when they are psychologically forced to do well at school. This is a loud and clear message for parents and teachers who tend to use more controlling strategies to guarantee children's success. Trying to attain a promised reward, to prove one's worth, or to avoid negative consequences seems counterproductive. Doing schoolwork out of personal interest, curiosity, or relevance to personal values seems enough for a student to attain higher grades at school.

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CRediT authorship contribution statement

Athanasios Mouratidis: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Formal analysis. **Aikaterini Michou:** Conceptualization, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Melike Sayil:** Writing - original draft, Writing - review & editing, Supervision. **Servet Altan:** Investigation, Writing - review & editing.

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