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A self-determination theory approach to predicting school achievement over time: the unique role of intrinsic motivation

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ABSTRACT

Although many studies have examined the relation of academic motivation to school achievement using the Self-Determination Theory perspective, the results have been inconsistent. The present investigation represents the first systematic attempt to use a meta-analysis and controlled, longitudinal studies to examine the relations of specific types of motivation to overall academic achievement. The meta-analysis (Study 1) pointed toward a potentially important role of intrinsic motivation in predicting school achievement. Three empirical studies of high school and college students in Canada (Studies 2 and 3) and in Sweden (Study 4) showed that intrinsic motivation was the only motivation type to be consistently positively associated with academic achievement over a one-year period, controlling for baseline achievement. Amotivation was significantly associated with lower academic achievement in Studies 3 and 4. Interestingly, intrinsic motivation was also associated with reduced amotivation in two of our studies and it was reciprocally associated with higher school achievement in another study. Overall, our findings highlight the unique importance of intrinsic motivation for the future academic success of high school and college students.

1. Introduction

Teachers and parents all know that school motivation is crucial for academic success, which has been long known as a determinant for a host of adaptive outcomes such as school completion, career success, mental and physical health (Archambault, Janosz, Morizot, & Pagani, 2009; Guay, Ratelle, & Chanal, 2008). However, there is little agreement regarding which one should be promoted. While some researchers focus on intrinsic motivation as the most important (Deci & Ryan, 2000), others emphasize either extrinsic motivation (Wigfield & Eccles, 2000), or a combination of both intrinsic and extrinsic motivation (Elliot & Moller, 2003; Lepper, Corpus, & Iyengar, 2005). The present investigation examines which types of motivation are most beneficial for academic achievement, over time, in different school contexts and cultures. It also assesses whether there are reciprocal relations among academic achievement and different motivation types.

1.1. Self-determination theory in education

Self-Determination Theory (SDT; Deci & Ryan, 2000) adopts a multidimensional approach to motivation. It specifies different types of autonomous and controlled forms of intentional action. Autonomous actions are initiated by a sense of choice and personal volition, whereas controlled actions are regulated by external or internal pressures. Individuals who are controlled in their actions have an external locus of causality, whereas those who are autonomous have an internal locus of causality (DeCharms, 1968). Intrinsic motivation is viewed as the prototype of autonomy (Deci & Ryan, 1985, 2000; Lepper, Greene, & Nisbett, 1973). When intrinsically motivated, individuals freely engage in an interesting activity simply for the enjoyment and excitement it brings, rather than to get a reward or to satisfy a constraint (Deci & Ryan, 1985). They perceive themselves as the causal agent of their own behaviour (DeCharms, 1968). By contrast, extrinsic motivation is instrumental in nature. Behaviour

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that is extrinsically motivated is not performed out of interest, but for the consequence it is thought to be instrumentally linked to (Wrzesniewski et al., 2014). Extrinsic motivation is thought to be important for socially prescribed activities, such as doing homework, because they are often not inherently interesting. Unlike many conceptualizations of motivation (e.g., Harter, 1981), SDT does not view extrinsic motivation as one-dimensional and opposed to intrinsic motivation. Instead, it specifies different types of extrinsic motivation, which vary in the extent to which they are autonomous (Deci & Ryan, 1985).

These types, from the least to the most autonomous, consist of external, introjected and identified regulation. External regulation refers to behaviours that are initiated by an external contingency, for example, being offered a reward to do one's homework. Introjected regulation refers to internalizing a regulation without fully accepting it into one's sense of self. It involves feelings of internal coercion and pressure, and refers to attempts to avoid feeling unworthy, guilty or ashamed, or to prove one's worth (Assor, Vansteenkiste, & Kaplan, 2009). An example of introjected regulation would be a student who studies long hours to prove to herself that she is worthy. Identified regulation takes place when the value of an instrumental behaviour has come to be identified with one's sense of self. This type of regulation is considered to be more autonomous than the other types of extrinsic motivation because it is initiated from a sense of personal meaning and volition (Deci & Ryan, 2000; Koestner & Losier, 2002). A student who does extra exercises at the end of a history chapter because she believes it will help her fully understand the subject matter is regulated by identification.[1] SDT also considers amotivation, the absence of motivation that happens when an individual does not experience intentionality or a sense of personal causation. These different forms of motivation have been proposed to lie along a continuum of relative autonomy, starting with the form that exhibits the lowest level to the one that represents the highest level of autonomy (Deci & Ryan, 1985). SDT (Ryan & Connell, 1989) also mentions that, adjacent motivations on the continuum (e.g., intrinsic motivation and identified regulation) should relate more strongly to each other than distal ones (e.g., intrinsic motivation and external regulation). However, evidence for the continuum is inconsistent. While some findings corroborate this pattern, others deviate from it in various ways (e.g., intrinsic motivation being more strongly related to introjected than to identified regulation) (for examples, see Boiché, Sarrazin, Grouzet, Pelletier, & Chanal, 2008; Ntoumanis, 2002; Otis, Grouzet, & Pelletier, 2005; Ratelle, Guay, Vallerand, Larose, & Senécal, 2007).

1.2. Academic motivation and educational achievement

Although many studies have examined the relation of academic motivation to school achievement from the SDT perspective (e.g., Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003; Deci, Vallerand, Pelletier, & Ryan, 1991), the majority have been cross-sectional and have yielded inconsistent results (Cokley, Bernard, Cunningham, & Motoike, 2001; D'Ailly, 2003; Fortier, Vallerand, & Guay, 1995; Grolnick, Ryan, & Deci, 1991; Hardre & Reeve, 2003; Noels, Clement, & Pelletier, 1999; Otis et al., 2005; Petersen, Louw, & Dumont, 2009; Soenens & Vansteenkiste, 2005; Walls & Little, 2005). A careful examination of past research shows that *only a few* studies have adopted a prospective design while also controlling for previous achievement (Baker, 2003; Black & Deci, 2000; Burton, Lydon, D'Alessandro, & Koestner, 2006, Study 2b). The details of these controlled prospective studies merit review. Burton et al. (2006) conducted a 6-week prospective study of university students to examine the relations of intrinsic motivation and identified regulation to final exam performance in a single psychology course. Results showed that, controlling for previous grades, identified regulation significantly positively predicted final examination grades whereas intrinsic motivation was unrelated to the final grades. Black and Deci (2000) examined the relation of relative autonomy in a sample of college chemistry students over a one-semester period. They found that relative autonomy did not significantly predict final course grade, after controlling for previous ability and grade point average (GPA). Results for specific types of motivation were not reported. Finally, Baker (2003) examined the relations of academic motivation types to total GPA in a sample of university students and controlled for academic achievement as measured by entry qualifications upon entering university. Her results showed that intrinsic motivation, assessed during the second semester of the first year of university, was the only type of motivation to significantly predict overall academic performance measured one year later, controlling for entry qualifications.

An example of another longitudinal study that has controlled for baseline achievement is one by (Guay, Ratelle, Roy, & Litalien, 2010). Using a cross-lagged model to examine the reciprocal relations of academic motivation and achievement in a population of high school students, they found that autonomous motivation, as defined by a relative autonomy score, was positively associated with academic achievement over the course of one year, even after controlling for baseline achievement. However, they did not estimate the contribution of each type of motivation to later achievement, making it difficult to understand which type of motivation was driving this relation.

Given the inconsistent results of past cross-sectional studies and the paucity of longitudinal studies that have controlled for baseline levels of achievement, a more systematic review of the research is needed in order to fully understand the effect of each different motivation type on school achievement. Moreover, as Ratelle et al. (2007) have suggested, more longitudinal studies are necessary to provide some information about the causal mechanisms between motivation and achievement. Finally, no studies have examined these longitudinal relations in samples of high school students. Since failure to achieve is a prevalent problem in high school and leads to undesirable consequences such as dropout, it is imperative to conduct carefully controlled studies in such a pre-university population.

1.3. Overview of studies

In an attempt to overcome the limitations of past research, we conducted a meta-analysis and a series of three empirical studies to systematically examine the contribution of the different motivation types to school achievement. The meta-analysis (Study 1) reviewed cross-sectional and longitudinal studies that have assessed the relation of motivation types to school achievement according to SDT, using the Academic Motivation Scale (AMS) designed by Vallerand et al. (1992). This is the most widely used scale of school motivation from the SDT framework. We also designed three controlled, longitudinal studies that used the AMS to measure five different types of academic motivation and to examine their relation to school achievement over time. To ensure that our findings were robust and generalizable, we varied the school context

[1] Integrated regulation, the most autonomous form of extrinsic motivation, occurs when the value of the instrumental behaviour has come to be in harmony with other various aspects of a person's values and identity to form a coherent sense of self. A student who does not like math but understands the importance and benefits of taking a statistics class and does so because he wants to eventually become a psychologist displays integrated regulation. It must be noted that integrated regulation requires much effort, self-awareness, and reflection (Vansteenkiste, Niemiec, & Soenens, 2010). Moreover, this type of motivation has not typically been included in measures of academic motivation because some early studies showed that students could not differentiate it from identified regulation on self-report scales (Robert J. Vallerand et al., 1992).

and cultural context across the three studies. Studies 2 and 4 included high school students, while Study 3 included college students. Studies 2 and 3 included Canadian students, while Study 4 included students from Sweden. In each study, we controlled for baseline levels of achievement. SDT also predicts that different motivation types relate to each other but past research examining these relations longitudinally is scarce and does not provide a clear picture (Guay et al., 2010; Otis et al., 2005). We thus tested the relations among different types of motivation in an exploratory way. Finally, we examined the reciprocal relations between academic motivation and achievement since some studies that have tested cross-lagged models have shown that prior academic achievement predict subsequent academic motivation (Garon-Carrier et al., 2014; Goldberg & Cornell, 1998).

Study 2 examined the relations of motivation types to school achievement over a one-year period in a large Canadian high school sample. Study 3 examined the relations of different types of motivation to achievement after the transition from high school to college, which is compulsory after high school in the Canadian province of Québec for those wanting to pursue university studies. Study 4 examined the relations of motivation types to school achievement in a sample of high school students attending their final year of the science stream in Sweden.

2. Study 1

In this meta-analysis, we compiled results of cross-sectional and prospective studies employing the Academic Motivation Scale (AMS; Vallerand et al., 1992). An investigation of each motivation subtype was conducted to assess its relations to academic achievement. Our hypotheses were as follows. First, in line with SDT, we predicted that intrinsic and identified regulation would each have a positive association with school achievement, and thus a positive effect size. Second, we expected a negative effect size for the relation of introjected regulation, external regulation, and amotivation to school achievement. Lastly, we predicted that the relations of the autonomous motivation types (intrinsic motivation and identified regulation) to achievement would be stronger than those of the controlling motivation types (introjected and external regulations). Furthermore, amotivation was expected to have the strongest negative association with school achievement.

Since past studies differ in design (cross-sectional vs. longitudinal) and have been conducted in different school contexts, we explored whether the study design, and the school context (i.e., elementary, high school or college/university) of the studies obtained in the meta-analysis would moderate the relations of the different motivation types on achievement.

2.1. Method

2.1.1. Selection of studies

An electronic search was conducted using Social Sciences Citation Index (1956–2013), Science Citation Index Expanded (1900–2013) and Arts & Humanities Citation Index (1975–2013) to identify all articles that have cited Ryan and Connell (1989) and/or Vallerand et al. (1992). The review by Deci and Ryan (2000) and meta-analyses conducted by Deci et al. (1999) and Chatzisarantis et al. (2003) were also used to locate any articles that might not have been included in the database. The resulting list of articles was then reviewed to identify the studies that had tested self-determination theory in a school/education context.

From this pool of articles, studies were rejected on the basis of the following criteria: (1) studies that did not include correlations or multiple regression coefficients between motivation and achievement, (2) studies that did not use the AMS to assess academic motivation, and (3) studies that did not include a measure of academic achievement.

Based on these three criteria, 18 studies that assessed the relation of motivation types according to SDT to school achievement were obtained. Of these, 6 studies had a cross-sectional design, whereas 12 studies reported prospective data. However, of the 12 prospective studies, only 3 studies controlled for baseline achievement (Baker, 2003; Black & Deci, 2000; Burton et al., 2006). In other words, few studies measured the relation of academic motivation to changes in achievement over time. All studies were questionnaire-based field studies. Table 1 shows the list of studies included in the meta-analysis.

2.1.2. Dependent measure and computation of effect sizes

The following dependent variables reflecting academic achievement in the set of selected studies were included: GPA (actual or self-reported), performance as rated by a teacher, grades obtained directly from the school administration and national achievement test scores.

In this meta-analysis, correlations and regression coefficients for each study were converted to Cohen's *d*. Composite mean weighted

Table 1
List of all studies included in the meta-analysis.

Authors and date	*N*	Design	School context	Dependent measure of achievement
Assor et al. (2009) Study 2	141	Prospective	High school	Teacher-rated general achievement
Baker (2003)	91	Prospective (c)	University	GPA
Black and Deci (2000)	137	Prospective (c)	University	Final chemistry grade
Burton et al. (2006) Study 1	241	Prospective	Elementary school	Report card grades
Burton et al. (2006) Study 2b	53	Prospective (c)	University	Final exam grade
Cokley et al. (2001)	263	Cross-sectional	University	GPA
D'Ailly (2003)	806	Prospective	Elementary school	Final test scores
Fortier et al. (1995)	263	Prospective	High school	National test scores
Grolnick et al. (1991)	456	Prospective	Elementary school	Math and reading grades
Hardre and Reeve (2003)	483	Cross-sectional	High school	Self-reported GPA
Noels et al. (1999)	78	Prospective	University	Final grade in language course
Petersen et al. (2009)	194	Prospective	University	Final average score
Ratelle et al. (2007) Study 2	942	Prospective	High school	Report card grades
Ratelle et al. (2007) Study 3	410	Prospective	College	Final semester grades
Soenens and Vansteenkiste (2005) Study 1	328	Cross-sectional	High school	Self-reported GPA
Soenens and Vansteenkiste (2005) Study 2	285	Cross-sectional	High school	Self-reported GPA
Vallerand et al. (1993)	217	Cross-sectional	College	Self-reported grades
Walls and Little (2005)	786	Cross-sectional	High school	Teacher-assigned grades

Note: The notation (c) = prospective studies that controlled for academic achievement. GPA = grade point average. Here, college refers to the schooling system from the province of Québec, Canada. In this system, high school ends in grade 11 and students move on to college for grades 12 and 13 to complete their pre-university education, which is mandatory to move on to university. College students can also choose to enter a 3-year technical program, which allows one to work directly after graduation.

effect-size estimates ($d+$) were obtained from the average of the individual effects (d) weighted by the reciprocal of their variance. Although the correlation coefficient r is often recommended as an effect size measure (e.g., Rosenthal & DiMatteo, 2001), meta-analysis experts such as Field and Gillett (2010) indicate that Cohen's d may be privileged in situations when group sizes are very discrepant, because, unlike r, it accounts for base rates and is less biased, thereby giving superior weight to the more reliable effect-size estimates (Hedges & Olkin, 1985). All effect-size computations and summary analyses were done according to procedures suggested by Hedges and Olkin (1985) using a meta-analytic software called DSTAT (Johnson, 1993). The calculations of composite d values provided both a significance test and a 95% confidence interval (CI). To interpret effect sizes, the benchmarks of $d = .10$, .30, and .50 have been proposed by Cohen (1992) as representing small, medium and large effects, respectively. The homogeneity of each set of effects sizes was tested by the within-class goodness-of-fit statistic (Qw), which has an approximate chi-square distribution with $k - 1$ degrees of freedom, where k equals the number of effect sizes (Johnson, 1993). A significant Qw value indicates systemic variation within a set of effect sizes, which suggests the presence of moderator variables.

2.1.3. Moderator analyses

Study design and school context were examined as moderators when the Q_w value was found to be significant (i.e., when the set of effect sizes was heterogeneous). These moderators were divided into categories. First, we focused on studies that had a cross-sectional design and compared them with studies that had a prospective design, but that had controlled for baseline achievement, and with studies that had a prospective design and had *not* controlled for baseline achievement. Second, we categorized studies according to the school context in which they were conducted. The studies were either conducted in elementary school, in high school, or in college/university. The moderating effects of these categorical variables were calculated by classifying each study according to these moderator categories, and by testing for homogeneity of effect sizes across categories, using a between-class goodness-of-fit statistic (Q_B). A significant Q_B value indicates systemic variation across moderator categories. It is comparable to a significant main effect in ANOVA (Sitzmann, Kraiger, Steward, & Wisher, 2006).

2.2. Results

2.2.1. Effect sizes for individual types of motivation

Table 2 shows the results of the meta-analysis. Overall, a significant effect size emerged for intrinsic motivation, $d+ = .27$ (CI = .23, .32), as well as for identified regulation, $d+ = .35$ (CI = .31, .39), showing that both intrinsic motivation and identified regulation were moderately positively related to achievement in school. However, these two sets of effect sizes were not homogeneous, $Q_w(9) = 33.02$, $p < .001$ and $Q_w(12) = 67.49$, $p < .0001$, respectively. Significant effect sizes were found for introjected regulation, $d+ = -.12$ (CI = −.16, −.08) and external regulation, $d+ = -.22$ (CI = −.26, −.17). This indicated that introjected regulation had a weak significant negative relation to school achievement, while external regulation had a moderate negative relation to school achievement. Once again, both of these sets of effect sizes were not homogeneous ($Q_w(9) = 57.52$, $p < .001$ for introjected regulation and $Q_w(10) = 93.05$, $p < .001$ for external regulation). Finally, a large effect size was obtained for amotivation, $d+ = -.61$ (CI = −.67, −.55), suggesting that amotivation had a strong significant negative relation to school achievement. This set of effect sizes that was also not homogeneous, $Q_w(6) = 71.46$, $p < .001$.

Table 2
Meta-analysis results: effect sizes of all individual types of motivation on school achievement, presented as composite d, corrected for sample size.

	k	N of studies	d	95% CI From	95% CI To
Intrinsic motivation	10	4270	.27	.23	.32
Identified regulation	11	4705	.35	.31	.39
Introjected regulation	10	4411	−.12	−.16	−.08
External regulation	11	4411	−.22	−.26	−.17
Amotivation	7	2195	−.61	−.67	−.55

Note: The N of studies represents the total number of participants of all the relevant studies in a specific analysis. CI = confidence interval.

2.2.2. Moderator analyses

No significant differences were found between different types of study designs for intrinsic motivation, identified regulation, and external regulation. However, a difference emerged for introjected regulation and amotivation. More specifically, introjected regulation had a modest negative relation to achievement in cross-sectional studies, $d = -.26$ (CI = −.33, −.19), but no relation in non-controlled longitudinal studies, $d = -.02$ (CI = −.08, .03). Moreover, non-controlled longitudinal studies had a significantly larger negative composite effect size for amotivation ($d = -.71$ (CI = −.78, −.63)) than cross-sectional studies ($d = -.37$ (CI = −.49, −.24)). Finally, non-controlled prospective studies had a significantly larger and stronger negative composite effect size for amotivation and achievement, ($d = -.71$ (CI = −.78, −.63)), than the controlled prospective study, ($d = -.22$ (CI = −.51, .07)).

A significant difference between age groups emerged for all individual motivation types, except for introjected regulation. First, intrinsic motivation had a significantly stronger positive relation to school achievement for high school and college students than for elementary school pupils, $Q_B(2) = 6.53$, $p < .05$. Second, identified regulation had a larger positive effect size on school achievement for elementary school pupils and high school students than for older students, $Q_B(2) = 5.80$, $p = .05$. In contrast, regarding identified regulation, the effect size was almost twice as large for college/university students, $d = .62$ (CI = .51-.72), than for high school students, $d = .36$ (CI = .32-.39). On the other hand, age did not seem to moderate the relation of introjected regulation to achievement. While external regulation had a moderate negative relation to school achievement for high school, $d = -.29$ (CI = −.34, −.23), and college/university students only, $d = -.21$ (CI = −.28, −.13), it was found that amotivation had a larger negative effect on school achievement for high school students, $d = -.77$ (CI = −.86, −.68), than for college/university students, $d = -.49$ (CI = −.57, −.41). This suggests that amotivation is potentially more harmful to younger students' school achievement.

2.3. Brief discussion

Overall, this meta-analysis shows that intrinsic motivation and identified regulation have a moderately strong, positive relation with school achievement. Introjected and external regulation had a weaker, but significant negative relation with school achievement. Finally, we found that amotivation had a strong, negative relation to school achievement. Moderator analyses also demonstrated that intrinsic motivation had a stronger relation to achievement for high school and college students, but that identified regulation presented a stronger relation to achievement for elementary school pupils. However, these results must be interpreted with caution given the small number of studies as well as some methodological problems that were uncovered during this review.

3. Study 2

The meta-analysis presented above highlighted that a large proportion of past studies comparing the effects of different motivation types have been cross-sectional or have assessed motivation and achievement over time without taking baseline levels into account. Furthermore, all of these controlled prospective studies were conducted solely with college or university students, and two of them included relatively short-term follow-ups or did not report results for all individual types of motivation as proposed by SDT. Stated differently, this review points to the need for more studies to undertake a careful empirical analysis of the relations of different forms of motivation on academic achievement across the high school and early college years.

In order to address these issues, Study 2 focused on high school students and examined self-reported academic achievement as an outcome variable. Cross-lagged structural equation modeling was used to test which of the different motivation types was most strongly related to changes in achievement one year later, when controlling for earlier academic achievement as well as for the reciprocal relation of prior achievement to subsequent motivation types.

Our predictions for this study, as well as for Studies 3 and 4, were as follows. First, we hypothesized that prior intrinsic motivation and identified regulation would be positively related to subsequent academic achievement, whereas introjected and external regulation, as well as amotivation, would be negatively related to it. In addition, based on the evidence provided by our meta-analysis, and on the only well-controlled prospective study that included a broad measure of school achievement (Baker, 2003), we expected that the positive relation of prior intrinsic motivation to academic achievement would be stronger than the relations of other types of motivation to the same outcome. In other words, we expected that intrinsic motivation would be the best positive predictor of school achievement. Finally, we predicted that this relation should be significantly positive even after controlling for baseline achievement, as well as for the reciprocal relation between prior achievement and subsequent academic motivation.

3.1. Method

3.1.1. Participants

Students attending a French-speaking high school in suburban Montreal completed a questionnaire twice over a school year. The participants were in grades 7 to 11 and aged between 12 and 17 years old. From the initial sample of students who were invited to participate in the study ($N = 524$), a total of 319 students (159 boys, 160 girls) completed all measures of interest. This represents a 60.8% response rate. The mean age for the sample was 14.32 years. The vast majority of students were French Canadian (99.3%). According to the socioeconomic index used by the Quebec Ministry of Education (2013), this school was located in an upper-middle class area.

3.1.2. Procedure

The students completed a survey on a voluntary basis with the authorization of the school's principal and teachers. Parental consent was obtained through letters distributed to the students at school. In the winter of each year, three trained research assistants (one per group) administered the questionnaire during class time and stayed present to answer students' questions. Students were told that the questionnaire concerned adolescents' attitudes toward school and student relationships in an educational setting. They were also informed that their participation was voluntary; that they were allowed to skip items of the questionnaire and that their responses would remain anonymous and confidential.

3.1.3. Measures

This study focused on baseline demographic variables (Time 1), academic motivation (Time 1 and Time 2) and academic achievement (Time 1 and Time 2). Other variables were included in the surveys but were not the focus of the present study. One article based on this data set has been published, focusing on the similarity in life aspirations between teenagers and their parents (Lekes, Joussemet, Koestner, Taylor, Hope, & Gingras, 2011).

3.1.3.1. Academic motivation. To measure the different types of academic motivation, items from the French version of the Academic Motivation Scale developed by Vallerand, Blais, Brière, and Pelletier (1989) were used. The scale was composed of twenty items from the five subscales proposed by Self-Determination Theory (Deci & Ryan, 2002). In order to create one intrinsic motivation scale, we used items from each of the original three intrinsic motivation scales (to know, towards accomplishment and to experience stimulation). This procedure has been followed in other studies (Ntoumanis, Barkoukis, & Thøgersen-Ntoumani, 2009; Otis et al., 2005).

The items provide possible answers to the question "Why do you go to school?" An example for each subscale is described as follows: intrinsic motivation (e.g. "Because I experience pleasure and satisfaction while learning new things"); identified regulation (e.g. "Because I think that education will help me better prepare for the career I have chosen"); introjected regulation (e.g. "To show myself that I am an intelligent person"); external regulation (e.g. "To have a better salary later"); and amotivation (e.g. "I cannot see why I go to school and frankly I could not care less"). Respondents rated their agreement with each reason for going to school on a 7-point Likert type scale ranging from 1 (*totally disagree*) to 7 (*totally agree*), with a higher score indicating a higher level of endorsement of the particular regulatory style. The reliability and predictive validity for these scales has been consistently established in previous research (e.g., Ratelle et al., 2007; Vallerand, Fortier, & Guay, 1997; Vallerand et al., 1989, 1993). In this study, internal consistency coefficients obtained were as follows: intrinsic motivation (.84 at Time 1, .87 at Time 2), identified regulation (.72 at Time 1, .77 at Time 2), introjected regulation (.85 at Time 1, .89 at Time 2), external regulation (.58 at Time 1, .73 at Time 2) and amotivation (.82 at Time 1, .89 at Time 2).

3.1.3.2. Perceived academic achievement. Participants were asked to report their most recent general grade percent average (%). There is evidence showing that self-reported school grades are strongly correlated with actual school grades (Dornbusch, Ritter, Leiderman, Roberts, & Fraleigh, 1987; Hennan, Dornbusch, Herron, & Herting, 1997; Soenens & Vansteenkiste, 2005).

3.1.4. Statistical analyses

All structural equation modeling analyses were performed using Amos 7 with the maximum likelihood estimation procedure. Following the guidelines of Marsh and colleagues outlined by (Guay et al., 2010) and Retelsdorf, Köller, and Möller (2014), we used the "full-forward" SEM approach to allow for a rigorous test of reciprocal effects. In this type of model, stability coefficients, as well as within-time correlations and cross-lagged relations are estimated, where each variable has paths leading to all other variables at the other wave of assessment (see Fig. 1). Moreover, in line with Marsh and Hau (1996), we estimated correlated uniqueness, i.e., correlations between the residuals of the same constructs measured on two different occasions within the same person, to control for method effects. In doing so, we avoid positively biased stability coefficients.

We first performed a confirmatory factor analysis (CFA) to verify the adequacy of the measurement model and the extent to which our indicators satisfactorily related to their associated latent variable (Model 1). To create the measurement model, we used the four individual items of each subscale of the Academic Motivation Scale as indicators for their respective type of motivation (intrinsic, identified, introjected, external and amotivation). We used the average course grade as the single indicator for achievement. If we obtained acceptable fit of the measurement model, we then tested the invariance of factor loadings to ensure that the meaning of the constructs was the same across measurement times. Finally, we tested the structural model to evaluate its ability to explain students' academic motivation and achievement over time.

To evaluate model fit, we first used the χ^2 test statistic. An acceptable model should have a nonsignificant χ^2 value. However, given that this test is known to be overly sensitive to sample size and small deviations from multivariate normality (Morin, Madore, Morizot, Boudrias, & Tremblay, 2009), three additional criteria were used to evaluate model fit: the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root mean square error of approximation (RMSEA). CFI and TLI values of .90 or more was used to guide decisions regarding acceptable model fit (see Marsh, Hau, & Grayson, 2005). For the RMSEA, which is a summary statistic for the residuals (i.e., the lower the number, the better), we followed Kline's (2011) recommendation to use values of .06 or less as indicative of good fit.

3.2. Results

3.2.1. Preliminary analyses

3.2.1.1. Missing data. On average, the proportion of missing data across all variables included in the model at both measurement times was 19.1%. Missing data resulted from usual factors in longitudinal research with adolescents such as absence on the day of assessment or refusal to complete the questionnaire. Sample attrition from T1 to T2 was moderate (39%) with dropout students joining non-participating classrooms in special education classes, graduating or changing schools after the first year of the study. Comparisons for all main variables were performed to examine whether students who completed both waves of assessment were equivalent to those who provided data at T1 only. A MANOVA was performed to test the main effect of participant group (1 wave vs. 2 waves) on the 21 indicators of latent constructs at T1. Using Wilks' lambda, results revealed a significant difference between the two groups ($\Lambda = .85$, $F[21, 308] = 2.51$, $p < .001$). Of the 21 indicators, six presented a significant effect (29%). Of these significant effects, one explained 6% of the variance while others explained less than 1.8%. Specifically, students who completed both assessments ($M = 77.51$, $SD = 7.98$) had a higher grade average than students who only participated at T1 ($M = 72.72$, $SD = 9.43$).

Although very common in the school engagement literature, these differences can reduce statistical power and/or bias the results. To correct for these potential problems, we followed the guidelines by Buhi, Goodson, and Neilands (2008) and Schlomer, Bauman, and Card (2010), and used full information maximum likelihood (FIML) to estimate missing observations. FIML has been shown to perform well with missing data—whether data are missing at random or not and when there is a moderate amount of missing data (Buhi et al., 2008). This technique has also been shown to outperform older ad-hoc procedures such as listwise deletion or mean substitution (Schlomer et al., 2010), and several studies have indicated that it yields the least biased and most efficient parameter estimates (Peugh & Enders, 2004).

3.2.1.2. Descriptive statistics. Means, standard deviations and intercorrelations between latent variables across both assessment times are presented in Table 3.

Overall, students reported primarily identified regulation and external regulation reasons for going to school. Students reported moderate levels of introjected regulation and intrinsic motivation, as well as relatively low levels of amotivation. Correlations seemed to follow the pattern expected based on our meta-analysis of the current literature. The five autocorrelations between T1 and T2 were strong, ($rs > .50$), suggesting that constructs were stable over time. Finally, the correlations among motivational subscales were examined. We found that motivation types mostly related to each other in a continuum-like way, with adjacent motivations (e.g., intrinsic motivation and identified regulation) correlated more strongly than distal ones (e.g., intrinsic motivation and external regulation). However, some correlations did not fit this pattern: (a) The correlations of intrinsic motivation with introjected regulation were higher (.57 at T1 and .54 at T2) than with identified regulation; (b) at both assessment waves, the correlations of identified regulation with introjected and external regulation were very similar; (c) the correlations between identified and external regulations was higher than the correlation between introjected and external regulations. This issue is addressed in the discussion.

3.2.2. Measurement model and factor loadings invariance

The goodness of fit statistics for all models are presented in Table 4. First, we tested the adequacy of the measurement model at T1 and T2 (Model 1). This model yielded adequate fit indices, which provides good evidence for the factorial validity of scores, i.e., the fact that indicators relate to their respective factor in the ways proposed by the measurement model. Factor loadings were all acceptable across both measurement waves, except for one

Table 3
Study 2: descriptive statistics and intercorrelations matrix for all latent constructs.

	1	2	3	4	5	6	7	8	9	10		*M*	*SD*
1. T1 ACH												74.88	8.72
2. T2 ACH	.80**											74.89	9.33
3. T1 IM	.33**	.35**										2.85	.97
4. T1 ID	.15**	.07	.36**									4.39	.64
5. T1 INTROJ	.07	.06	.57**	.44**								3.31	1.08
6. T1 EXT	–.00	–.06	.11*	.42**	.28**							4.37	.62
7. T1 AMOT	–.36**	–.31**	–.46**	–.33**	–.24**	–.05						1.81	.90
8. T2 IM	.37**	.41**	.71**	.28**	.44**	.02	–.37**					2.71	.80
9. T2 ID	.13**	.18**	.37**	.54**	.29**	.20**	–.23**	.50**				4.15	.63
10. T2 INTROJ	.02	.12**	.44**	.39**	.68**	.26**	.17**	.54**	.48**			3.03	.95
11. T2 EXT	–.07	–.10*	–.11**	.26**	.10*	.55**	.17**	–.01	.41**	.32**		4.21	.62
12. T2 AMOT	–.32**	–.38**	–.42**	–.22**	–.20**	.03	.65**	–.53**	–.41**	–.25**	.04	1.76	.77

Note: ACH = academic achievement; IM = intrinsic motivation; ID = identified regulation; INTROJ = introjected regulation; EXT = external regulation; AMOT = amotivation.
* $p < .05$.
** $p < .01$.

Table 4
Study 2: goodness of fit statistics for confirmatory factor analyses and structural equation modeling analyses.

Model	χ^2	*Df*	CFI	TLI	RMSEA	90% CI RMSEA	$\Delta\chi^2$	CM
CFA models								
Model 1 (measurement model)	1335.73	675	.91	.90	.042	[.038, .045]		
Model 2 (factor loadings invariance)	1351.64	690	.91	.90	.041	[.038, .045]	15.91[a]	M1
SEM model								
Model 3 (full model: disturbances and uniquenesses correlated)	1451.21	750	.91	.89	.041	[.038, .044]		

Note: CFI = comparative fit index; TLI = Tucker–Lewis Index; RMSEA = root mean square error of approximation; CI = confidence interval; CM = comparison model.
[a] Non significant.

indicator of external regulation, whose factor loading was relatively low (.32 at T1 and .38 at T2). After establishing the adequacy of the measurement model, we tested the invariance of factor loadings across measurement times (Model 2). The fit indices for Model 2 were adequate and the chi-square difference test showed no significant difference with Model 1, indicating that the meaning of the constructs did not change over time. Therefore, the factor loadings were fixed to equality for subsequent analyses.

3.2.3. *Stability and reciprocal effects model*

According to the guidelines presented above, the reciprocal effects model (Model 3) yielded a good fit to the data. Moreover, as depicted in Fig. 1, the results show stability across time of both academic achievement and academic motivation types, since all direct path coefficients within one construct between the two waves were strong and positive, ranging from .59 to .69. The results also showed the following positive significant paths between different motivation types: the path connecting T1 intrinsic motivation to T2 identified regulation ($\beta = .27$) and the path connecting T1 amotivation to T2 external regulation ($\beta = .22$). No other significant paths between different motivation types across measurement waves emerged.

Regarding the relationship between motivation types and academic achievement, results showed that T1 intrinsic motivation significantly predicted increases in T2 achievement, and that no other T1 motivation type was significantly related to T2 achievement. Finally, T1 achievement significantly predicted an increase in T2 intrinsic motivation. Overall, the model explained a considerable proportion of variance in all six outcomes at T2, including achievement ($R^2 = .56$), intrinsic motivation ($R^2 = .51$), identified regulation ($R^2 = .33$), introjected regulation ($R^2 = .45$), external regulation ($R^2 = .40$), and amotivation ($R^2 = .41$).

3.3. *Brief discussion*

Study 2 showed that when different motivation types were analyzed concurrently within the same model, intrinsic motivation was the only motivation type to be significantly positively related to an increase in achievement over time. This result matches the findings in our meta-analysis, showing that the relation of intrinsic motivation to school achievement had a substantial effect size. Moreover, it supports the predictions of SDT as well as Baker's (2003) controlled longitudinal study showing that intrinsic motivation predicted an increase in the academic achievement of university students over time, controlling for baseline achievement. This study extends these findings to a younger population, indicating that intrinsic motivation plays an important role for the future academic success of high school students. Another interesting finding was that academic achievement predicted later intrinsic motivation. In other words, our results provide support for a reciprocal relation between intrinsic motivation and academic achievement over time.

4. Study 3

We conducted Study 3 to test the whether the findings obtained in Study 2 could extend to a population of college students enrolled in a science program. One advantage of this study was that objective grades were obtained as a measure of academic achievement. Another advantage was the focus on students in science, an area that is known for higher base rates of dropout than other fields of study (Lavigne, Vallerand, & Miquelon, 2007). In fact, almost 30% of Canadian and American college students registered in science programs leave the field before they have graduated (Duchesne, Ratelle, Larose, & Guay, 2007). One way to address why some students experience difficulties in science is to clarify how the different types of motivation contribute to their achievement over time, which is associated with persistence. Few studies have attempted to investigate the retention problem of science students by examining different motivations during a school transition and using a controlled, prospective design. Following the results obtained in Study 2, we predicted that intrinsic motivation would be the most strongly positively related to academic science achievement among all the motivation types.

4.1. *Method*

4.1.1. *Participants*

Participants were students who graduated from high school (grade 11) in June 2003 and entered the science program in one of the four public English-speaking colleges in Montreal, Canada in the fall of that year. In the Québec education system, students complete high school in grade 11 and then make the transition to college. A general college diploma is usually obtained after two years, and leads to university. Students can also enrol in a three-year technical program, which leads directly to the job market. In Quebec, a college diploma is required for students to enter university.[2] From the initial sample of 1135 students (510 males, 625 females) who were eligible to take part in the study, a total of 638 students (296 men, 342 women) aged between 17 and 30 years (mean age = 17 years, 11 months) completed Time 1 and Time 2 measures. In this final sample, 22.5% of the students spoke French at home, 46.5% spoke English at home, and 31% spoke another language at home (e.g., Mandarin, Arabic, Italian, Greek, or Vietnamese).

4.1.2. *Procedure*

Data for this study were collected as part of a larger research project on academic success and perseverance in science led by a team of researchers, some of which were also instructors at the

[2] In the province of Quebec, high school ends in grade 11 and students have to move on to college for grades 12 and 13 to complete their pre-university education, or to enter a 3-year technical program, which allows one to work after graduation from college. College students registered in a pre-university program must complete this before attending university.

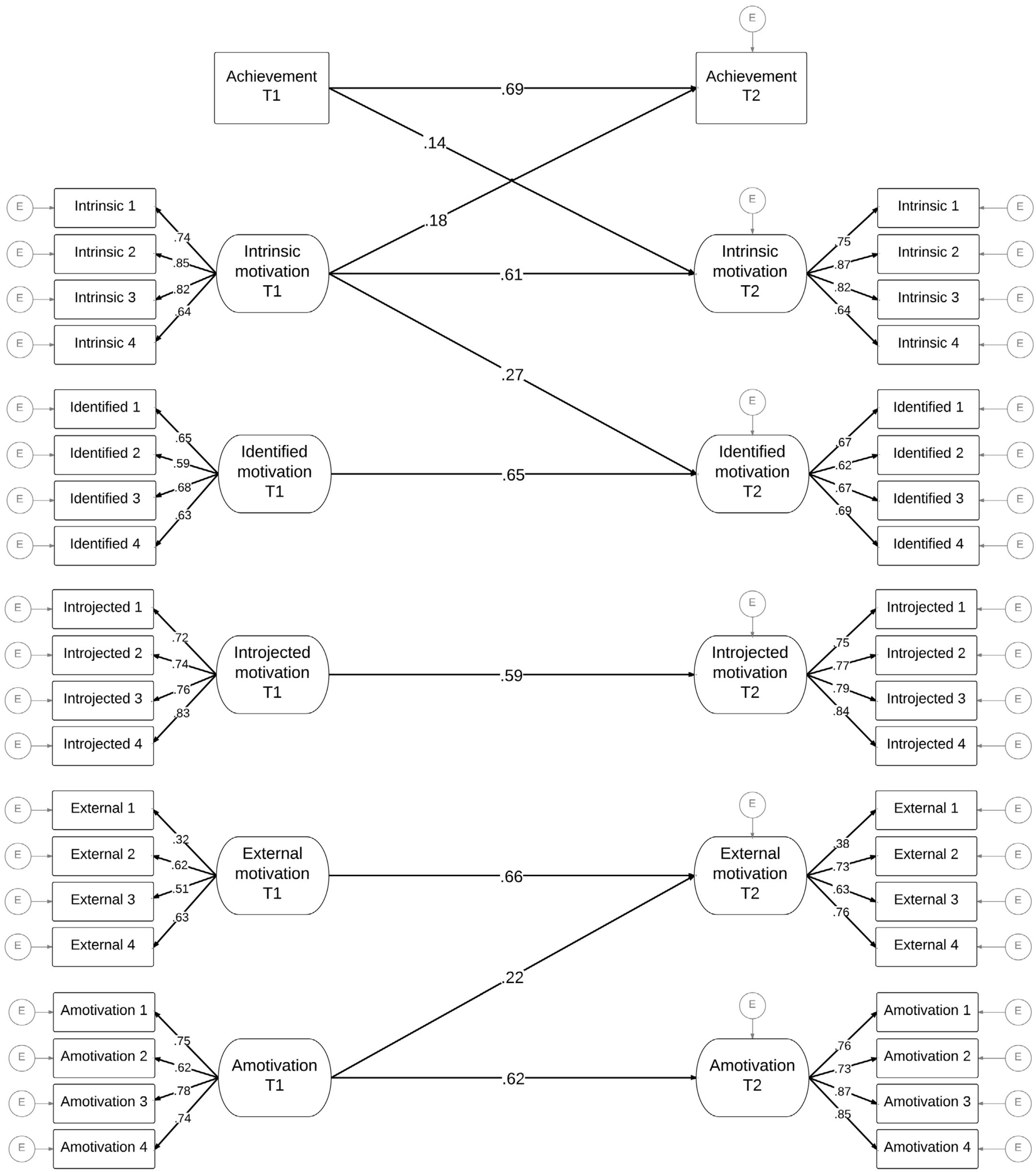

Fig. 1. Cross-lagged panel modelling of academic achievement and types of motivation in Study 2. Note: Correlations between each item's error term at each assessment, between factors at Time 1 and between disturbances were estimated. Equality constraints were imposed on same items' loading across time. Only significant paths are presented but all were allowed to covary.

colleges involved. Students participated on a voluntary basis with the authorization of their instructors and the college administrations. Students' grades in all science and mathematics courses taken in grade 10 and 11 were obtained from the *Ministère de l'Éducation, du loisir et des sports du Québec* (MELS—Ministry of Education of Quebec) records, with participants' consent (Time 1). These included: Physical Science courses, Mathematics courses, and Chemistry. Similarly, the raw data for students' grades in all

Table 5
Study 3: descriptive statistics and intercorrelations matrix for all variables.

	1	2	3	4	5	6	7	8	9	10	11	*M*	*SD*
1. T1 ACH												72.92	20.95
2. T2 ACH	.39**											68.62	14.18
3. T1 IM	.02	.24**										3.73	.57
4. T1 ID	.07**	.15**	.33**									4.31	.53
5. T1 INTROJ	–.02	–.11**	.26**	.21**								3.30	.67
6. T1 EXT	.14**	.02	.08**	.48**	.32**							4.06	.62
7. T1 AMOT	–.06**	–.22**	–.34**	–.51**	–.06**	–.28**						1.56	.62
8. T2 IM	.02	.25**	.68**	.21**	.18**	–.07**	–.28**					3.66	.80
9. T2 ID	–.05**	.18**	.22**	.47**	.20**	.21**	–.40**	.37**				4.08	.46
10. T2 INTROJ	–.07**	–.09**	.23**	.11**	.67**	.31**	–.08**	.26**	.17**			3.18	.59
11. T2 EXT	–.09**	–.16**	.02	.35**	.34**	.64**	–.08**	–.01	.26**	.47**		3.37	.60
12. T2 AMOT	.01	–.23**	–.28**	–.33**	.05*	–.12**	.43**	–.40**	–.58**	–.03	–.05*	1.94	.52

Note: ACH = academic achievement; IM = intrinsic motivation; ID = identified regulation; INTROJ = introjected regulation; EXT = external regulation; AMOT = amotivation.
* $p < .05$.
** $p < .01$.

Mathematics and Science courses taken during the first semester of college studies were obtained from MELS records during the winter of 2004 (Time 2). All college Mathematics and Science courses were similar for students within the same institution.

Students filled out two questionnaires assessing academic motivation in class or on the web, depending on the college they were attending. The first questionnaire was administered in class during the beginning of students' first semester, in the fall of 2003 (Time 1). The second questionnaire was administered during the middle of the second semester of the Science program, in winter 2004 (Time 2).

4.1.3. Measures

4.1.3.1. Academic motivation. We assessed academic motivation with the Academic Motivation Scale (AMS; Vallerand et al., 1992, 1993) described in Study 2. The scale was composed of 10 items from the five subscales proposed by Self-Determination Theory (Deci & Ryan, 2002). Students rated their agreement with each reason for going to college on a 5-point Likert type scale ranging from 1 (totally disagree) to 5 (totally agree), with a higher score indicating a higher level of endorsement of the particular regulatory style. The internal reliability for each of the subscales was acceptable for two-item scales (Eisinga, Grotenhuis, & Pelzer, 2013), with Cronbach alphas as follows: intrinsic motivation (.73 at Time 1 and Time 2), identified regulation (.68 at Time 1, 1.00 at Time 2), introjected regulation (.54 at Time 1, .67 at Time 2), external regulation (.61 at Time 1, .68 at Time 2) and amotivation (.75 at Time 1 and Time 2).

4.1.3.2. Academic achievement. Official math and science grades from high school (Time 1 achievement) and from the first completed semester of college (Time 2 achievement) were obtained directly from the Ministry of Education of Quebec. Grades from each subject were then compiled into a percent average to create one variable.

4.1.4. Statistical analyses

In this study, we used path analysis with Amos 7 to test the fit between the data and the hypothesized reciprocal effects model using the maximum likelihood estimation procedure. This analysis was chosen given the recommendation by Kline (2011) who suggests the use of a path analysis with observed variables in studies where there are only two indicators per factor. To evaluate model fit, we followed the same guidelines that were outlined in Study 2.

4.2. Results

4.2.1. Missing data

The descriptive analyses indicated that 37.2% of the initial sample at T1 completed the second assessment wave. This attrition resulted from absence on the day of the T2 assessment, as well the students changing programs or colleges. Comparisons for all main variables were performed to examine whether students who completed both waves of assessment were equivalent to those who provided data at T1 only. We performed a MANOVA to test the main effect of participant group (1 wave vs. 2 waves) on the observed variables at T1. Using Wilks' lambda, results revealed a significant difference between the two groups ($\Lambda = .80$, $F[6, 1057] = 44.37$, $p < .001$). Specifically, students who completed both assessments had a higher high school science achievement than students who only participated at T1 ($F[1, 1063] = 242.45$, $p < .001$, $R^2 = .18$). In addition, the students who completed both assessments had higher identified regulation ($F[1, 1063] = 24.20$, $p < .001$, $R^2 = .02$), lower amotivation ($F[1, 1063] = 18.66$, $p < .001$, $R^2 = .02$), but higher external regulation ($F[1, 1063] = 19.29$, $p < .001$, $R^2 = .02$). As mentioned in Study 2, to account for these differences, we followed the guidelines by Buhi et al. (2008) and Schlomer et al. (2010) and used full information maximum likelihood (FIML) to estimate missing observations.

4.2.2. Preliminary analyses

4.2.2.1. Descriptive statistics. Means, standard deviations and intercorrelations between observed variables across both assessment times are presented in Table 5.

Overall, the most popular reasons students gave for studying science were identified and external regulation. They reported moderate levels of intrinsic motivation and introjected regulation, and relatively low levels of amotivation. Similar to Study 1, correlations seemed to follow the pattern expected based on our meta-analysis of the current literature. Moreover, correlations show that T1 academic achievement was strongly positively associated with later T2 achievement. Longitudinal stability coefficients between T1 and T2 were relatively strong, ranging from $r = .43$ for amotivation to $r = .68$ for intrinsic motivation. Finally, the correlations among motivational subscales were examined to see whether they reflected the simplex pattern in line with the autonomy continuum postulated by SDT. We found that motivation types at both assessment waves were related to each other in the simplex pattern predicted by SDT, with adjacent motivations (e.g., intrinsic motivation and identified regulation) correlated more strongly than distal ones (e.g., intrinsic motivation and external regulation).

4.2.3. Stability and reciprocal effects path model

The results of the reciprocal effects path model are presented in Fig. 2.

Since all the parameters in this model were estimated (Model 4), thus leaving no degrees of freedom, the model fit could not be tested. Several paths were significant. Results show stability across

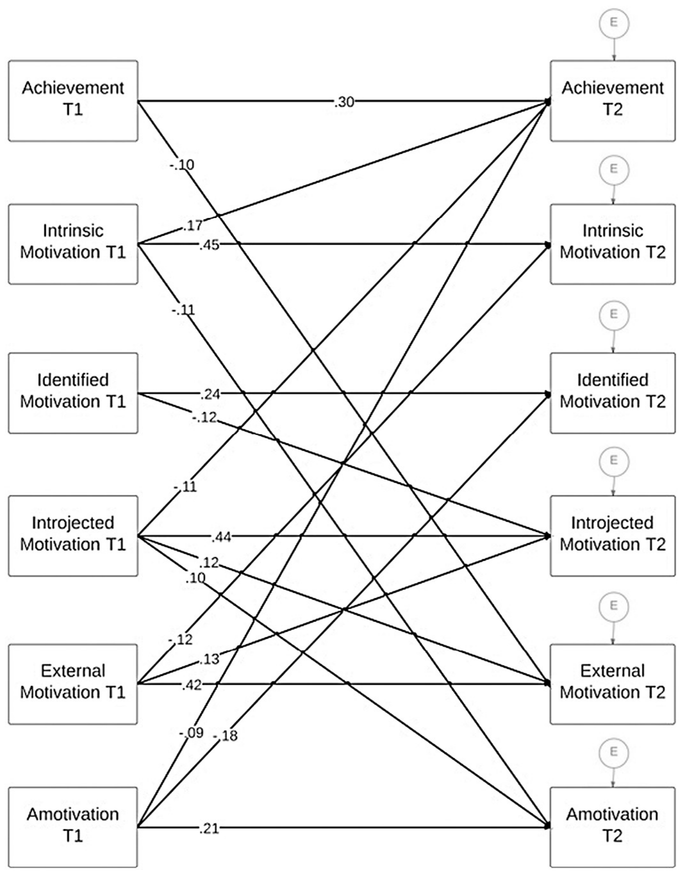

Fig. 2. Cross-lagged panel modelling of academic achievement and types of motivation in Study 3. Notes: Correlations between variables at Time 1 and between disturbances were estimated. Only significant paths are presented but all were allowed to covary.

time of both academic achievement and academic motivation types, since most direct path coefficients within one construct between the two waves were moderately strong and positive, ranging from .30 to .45. The path coefficient connecting amotivation at both assessment waves was significant, but lower ($\beta = .21$). The results also showed the following positive significant paths between different motivation types: the path connecting T1 intrinsic motivation to T2 amotivation ($\beta = -.11$), the path connecting T1 identified regulation to T2 introjected regulation ($\beta = -.12$), the path connecting T1 introjected regulation to T2 external regulation ($\beta = -.11$) and to T2 amotivation ($\beta = .10$), the path connecting T1 external regulation to T2 intrinsic motivation ($\beta = -.12$) and to T2 introjected regulation ($\beta = .13$), and the path connecting T1 amotivation to T2 identified regulation ($\beta = -.18$).

Regarding the relationship between motivation types and academic achievement, the model showed that T1 intrinsic motivation significantly predicted increases in T2 academic achievement ($\beta = .17$). At the same time, T1 introjected regulation and T1 amotivation both significantly predicted decreases in T2 academic achievement ($\beta = -.11$ and $\beta = -.09$, respectively). Finally, the model showed that T1 academic achievement predicted decreases in T2 external regulation ($\beta = -.10$). In order to test whether the path going from T1 intrinsic motivation to T2 achievement was stronger than the path going from T1 amotivation to T2 achievement, we tested another model in which these parameters were constrained to equality. We then compared the fit of this model to the final, unconstrained one (Model 4). The chi-square difference test was significant, $\Delta\chi^2(1) = 25.95$, $p < .001$. However, the fit of the constrained model was significantly worse, ($\chi^2(20) = 25.95$, $p = .15$; CFI = .98; TLI = .93; RMSEA = .029, 90% CI [.020, .037]), meaning that a model where the relation of T1 intrinsic motivation to T2 achievement is almost twice as strong as the one between T1 amotivation and T2 achievement fit the data in a significantly better way. Overall, the final model (Model 4) explained a significant proportion of variance in all six outcomes at T2, including achievement ($R^2 = .15$), intrinsic motivation ($R^2 = .25$), identified regulation ($R^2 = .15$), introjected regulation ($R^2 = .24$), external regulation ($R^2 = .24$), and amotivation ($R^2 = .11$).

4.3. Brief discussion

Overall, our results replicate the findings from Study 2 showing that students' intrinsic motivation positively predicts their academic achievement one year later, above and beyond the effect of baseline academic achievement, extending them to a college science student population. Importantly, the grades were not self-reported as in Study 2; instead they were obtained directly from the college administration. Moreover, results of this study also showed that introjected regulation and amotivation were significantly negatively associated with science achievement over time. The negative relation for amotivation is not surprising given the results of our meta-analysis, which indicated that amotivation was the most strongly related with school achievement. However, it is interesting to note that the positive relation of intrinsic motivation with school achievement was twice as strong as the negative association of amotivation with the same outcome.

The negative relation of introjected regulation with achievement suggests that college students who choose to study science for internally coercive reasons, such as wanting to prove to others that they are intelligent, may experience more negative outcomes than high school students who have the same motivation, given that they operate in an environment where there is more freedom of choice and where they have to rely on their own motivational devices (Ratelle et al., 2007). This result supports the cross-sectional findings of Assor et al. (2009), who showed that students who regulated in an introjected way were more likely to experience lower achievement than those who were more autonomously motivated. Another interesting result was that students' science achievement in high school negatively predicted their external regulation at T2, showing another reciprocal effect between achievement and motivation.

A potential problem with the present study was that the measure of academic motivation contained only two items for each type of regulation. Moreover, the internal reliability coefficients were lower, which is typical for subscales that contain only two items (Eisinga et al., 2013). It would have been better to include more items to assess motivation in this study as well as to employ the same 7-point Likert scale as in the other studies. Nevertheless, the descriptive and predictive results closely matched those obtained in Study 2.

5. Study 4

Study 4 aimed to replicate the relation of different academic motivation types to academic motivation found in Studies 2 and 3 and to extend these results cross-culturally. In this study, we explored the relation between these variables in a sample of Swedish high school students who had chosen to study natural sciences. Because SDT postulates that autonomy is a basic psychological need that is relevant to all humans, it becomes important to examine the relation of different types of motivation to academic achievement across cultures. While there is a growing literature on cross-cultural applications of SDT in education (Assor et al., 2009; Chirkov & Ryan, 2001; Levesque, Zuehlke, Stanek, & Ryan, 2004), to our knowledge, no studies have examined the relation of the different types of motivation to academic achievement, *separately*, using a longitudinal design, and controlling for prior achievement.

The relevance of attempting to replicate these relations in Sweden becomes clearer once we consider how it differs from Canada along Hofstede's (1983) dimensions of national cultures, which are reflected in the education system. Although both countries score similarly on individualism and power distance, they differ significantly in their emphasis on working toward goals because of competition versus cooperation or interest. Hofstede (1983) distinguishes a cultural dimension (called masculinity/femininity), which focuses on what motivates people—wanting to be the best (masculine) versus liking what you do (feminine). Compared to Canada, Sweden scores extremely low on the masculinity dimension, meaning that Swedish culture is mostly based on values of quality of life and cooperation. This is reflected in the Swedish education system where students do not receive official grades until they reach grade 6, and where teachers tend to encourage cooperation and create equal opportunities by focusing on group projects and refraining from using external rewards and competition between students (Ministry of Education and Science, 2001). This key difference between the cultural and educational systems of Sweden and Canada (where competition, rewards and grades are much more present) makes it interesting to examine the relations between academic motivation and achievement, in order to establish whether autonomous types of motivation have a similar role in an environment that seems to be supportive of autonomy (Sweden), compared with an environment that focuses mostly on competence (Canada). Given the universality perspective of SDT, we hypothesized that results of the previous studies would replicate in a different cultural context, i.e., that intrinsic motivation would be more strongly related to higher levels of academic achievement than the other motivation types.

5.1. Method

5.1.1. Participants

Students attending a science program in metropolitan high schools in Sweden completed a questionnaire in September and April of their final school year. In Sweden, high school begins in the students' tenth year, when they are 15 to 16 years old, and lasts for three years. Students select a high school orientation in the spring of their ninth school year, for example social science, business or science. They must complete high school in order to move on to university. The sample at the first measurement time consisted of 440 participants (226 males, 214 females). Out of this first sample, 288 participants completed the follow-up questionnaire. This follow-up sample was composed of 143 males and 145 females. Official grade transcripts were received regarding 247 of the students. The age of the participants ranged from 18 to 19 years old.

5.1.2. Procedure

The students completed a questionnaire assessing academic motivation once a year for two years on a voluntary basis with the authorization of the school's principal and teachers (Time 1 and Time 2). The questionnaire was in Swedish and was distributed during class time by one researcher, who informed them that the questionnaire concerned adolescents' attitudes toward school in an educational setting. The students were also informed that their participation was voluntary and that they were allowed to skip items of the questionnaire. The researcher was present to answer any questions that the students may have had during the completion of the questionnaire. The questionnaire took approximately twenty minutes to complete. Three months after the students had completed the second questionnaire, official grades in science courses were obtained directly from the school administration (Time 2). Moreover, students' science grades for their second year of high school were obtained from the school administration and represented the baseline grade assessment (Time 1).

5.1.3. Measures

5.1.3.1. Academic motivation. As in Studies 2 and 3, we assessed academic motivation by adapting items from the English version of the Academic Motivation Scale (AMS; Vallerand et al., 1992, 1993) described above. The scale was composed of 20 items from the five subscales proposed by Self-Determination Theory (Deci & Ryan, 2002). Students rated their agreement with each reason for going to high school on a 4-point Likert type scale ranging from 1 (totally disagree) to 4 (totally agree). In this study, the Cronbach alphas obtained were as follows: intrinsic motivation (.91 at Time 1, .90 at Time 2), identified regulation (.80 at Time 1 and Time 2), introjected regulation (.75 at Time 1, .74 at Time 2), external regulation (.75 at Time 1, .78 at Time 2) and amotivation (.91 at Time 1, .90 at Time 2). All scales were translated from English to Swedish. The translation was independently carried out by two Swedish-speakers. The Swedish items were then back translated into English, and discrepancies were arbitrated by two consultants, English-speaking college Science teachers from Canada, and solutions were reached by consensus.

5.1.3.2. Academic achievement. Grade transcripts were received from each high school's administrative office. The Swedish grading system uses letter grades for each course. These letter grades were converted to a numerical scale: fail = 1; pass = 2; pass with distinction = 3; and pass with great distinction = 4. Science achievement at Time 1 was calculated as the mean of grades in the two Mathematics courses that students take in their second year in high school and a course in basic Physics that they take during their first two years in high school. The students received their grades in these three courses during their second year, which would thus represent science achievement at Time 1. Achievement at Time 2 was calculated as the mean of three compulsory courses: an advanced course in mathematics, an advanced course in physics and a course in chemistry of their final year of high school.

5.1.4. Statistical analyses

The same analytical approach outlined in Study 2 was used in this study.

5.2. Results

5.2.1. Preliminary analyses

5.2.1.1. Missing data. On average, the proportion of missing data across all variables included in the model at both measurement times was 27%. Missing data resulted from usual factors in longitudinal research with adolescents such as absence on the day of assessment or refusal to complete the questionnaire. Sample attrition from T1 to T2 was 34% with these students joining non-participating classrooms in special education classes, graduating or changing schools after the first year of the study. Comparisons for all main variables were performed to examine whether students who completed both waves of assessment were equivalent to those who provided data at T1 only. A MANOVA was performed to test the main effect of participant group (1 wave vs. 2 waves) on the 23 indicators of latent constructs at T1. Using Wilks' lambda, results showed no significant difference between the two groups ($\Lambda = .90$, $F[23, 217] = 1.08$, $p = .37$). Nevertheless, to avoid decreases of power that typically result from missing data, we followed the guidelines by Buhi et al. (2008) and Schlomer et al. (2010) and used full information maximum likelihood (FIML) to estimate missing observations.

5.2.1.2. Descriptive statistics. Means, standard deviations, and intercorrelations between latent variables across both assessment times are presented in Table 6.

Overall, the most popular reasons students reported for studying science were identified regulation and intrinsic motivation.

Table 6
Study 4: descriptive statistics and intercorrelations matrix for all latent constructs.

	1	2	3	4	5	6	7	8	9	10	11	*M*	*SD*
1. T1 ACH												3.09	.55
2. T2 ACH	.40**											3.05	.69
3. T1 IM	.04	.45**										2.78	.82
4. T1 ID	.05	.26**	.63**									2.91	.70
5. T1 INTROJ	–.00	.03	.22**	.29**								2.21	.71
6. T1 EXT	.02	.10*	.19*	.47**	.42**							2.51	.71
7. T1 AMOT	–.10*	–.46**	–.65**	–.56**	–.07**	–.15**						1.55	.73
8. T2 IM	.04	.43**	.83**	.52**	.23**	.14**	–.53**					2.84	.80
9. T2 ID	.03	.23**	.54**	.72**	.26**	.37**	–.44**	.67**				2.94	.66
10. T2 INTROJ	–.11*	–.03	.11**	.18**	.66**	.27**	–.02	.26**	.32**			2.30	.66
11. T2 EXT	–.02	.09*	.00	.29**	.31**	.67**	–.03	.12**	.37**	.47**		2.61	.71
12. T2 AMOT	–.13**	–.47**	–.53**	–.37**	–.03	–.03	.70**	–.60**	–.51**	–.03	–.03	1.58	.72

Note: ACH = academic achievement; IM = intrinsic motivation; ID = identified regulation; INTROJ = introjected regulation; EXT = external regulation; AMOT = amotivation.
* $p < .05$.
** $p < .01$.

Students reported moderate levels of external regulation and introjected regulation, and relatively low levels of amotivation. Once again, the correlations seemed to follow the pattern expected based on our meta-analysis of the current literature. Finally, the correlations among motivational subscales were examined to test whether they reflected the pattern in line with the autonomy continuum postulated by SDT. We found that motivation types mostly related to each other in a continuum-like way, with adjacent motivations (e.g., intrinsic motivation and identified regulation) correlated more strongly than distal ones (e.g., intrinsic motivation and external regulation). However, some correlations did not replicate this simplex pattern: (a) at both assessment waves, the correlations of identified regulation with introjected (T1 $r = .29$ and T2 $r = .32$) were lower than with external regulation (T1 $r = .47$ and T2 $r = .37$), and (b) the correlations between identified and external regulations was higher than the correlation between introjected and external regulations. This issue will be addressed in the discussion.

5.2.2. Measurement model and factor loadings invariance

The goodness of fit statistics for all models are presented in Table 7.

First, we tested the adequacy of the measurement model at T1 and T2 (Model 5). According to the guidelines described in Study 1, this model yielded adequate fit indices, which provides good evidence for the factorial validity of scores, i.e., the fact that indicators relate to their respective factor in the ways proposed by the measurement model. Factor loadings were all acceptable across both measurement waves. After establishing the adequacy of the measurement model, we tested the invariance of factor loadings across measurement times (Model 6). The fit indices for Model 6 were adequate and the chi-square difference test showed no significant difference with Model 5, indicating that the meaning of the constructs did not change over time. Therefore, the factor loadings were fixed to equality for subsequent analyses.

5.2.3. Stability and reciprocal effects model

According to the guidelines presented above, the reciprocal effects model (Model 7) yielded a good fit to the data. Moreover, as depicted in Fig. 3, the results show stability across time of both academic achievement and academic motivation types, since all direct path coefficients within one construct between the two waves were strong and positive, ranging from .43 for achievement to .86 for intrinsic motivation. The results also showed a positive significant path between T1 intrinsic motivation and T2 amotivation ($\beta = -.18$). No other significant paths between different motivation types across measurement waves emerged.

Regarding the relationship between motivation types and academic achievement, results showed that T1 intrinsic motivation significantly positively predicted T2 science achievement. Moreover, T1 external regulation was positively associated with T2 science achievement. We also found that T1 amotivation was negatively related to T2 science achievement. However, absolute values of the coefficients show that this relation was not as strong as the relation of T1 intrinsic motivation to T2 science achievement ($\beta = .41$ for intrinsic motivation and $\beta = -.22$ for amotivation). Finally, T1 achievement negatively predicted T2 introjected regulation.

In order to test whether the path going from T1 intrinsic motivation to T2 achievement was stronger than the path going from T1 amotivation to T2 achievement, we tested another model in which these parameters were constrained to equality. We then compared the fit of this model to the final, unconstrained one (Model 4). The chi-square difference test was significant, $\Delta\chi^2(1) = 30.48$, $p < .001$. However, the fit of the constrained model was slightly lower (see Table 7), meaning that a model where the relation of T1 intrinsic motivation to T2 achievement is almost twice as strong as the one between T1 amotivation and T2 achievement fits the data in a significantly better way. Overall, the model explained a large

Table 7
Study 4: goodness of fit statistics for confirmatory factor analyses and structural equation modeling analyses.

Model	χ^2	*Df*	CFI	TLI	RMSEA	90% CI RMSEA	$\Delta\chi^2$	CM
CFA models								
Model 5 (measurement model)	1412.93	675	.92	.90	.045	[.042, .049]		
Model 6 (factor loadings invariance)	1431.49	690	.92	.90	.045	[.042, .048]	18.56[a]	M5
SEM models								
Model 7 (full model: disturbances and uniquenesses correlated)	1696.56	918	.92	.91	.040	[.037, .043]		
Model 8 (constrained model)	1727.034	919	.92	.91	.041	[.038, .044]	30.48[b]	M7

Note: CFI = comparative fit index; TLI = Tucker–Lewis Index; RMSEA = root mean square error of approximation; CI = confidence interval; CM = comparison model.
[a] Non significant.
[b] Significant.

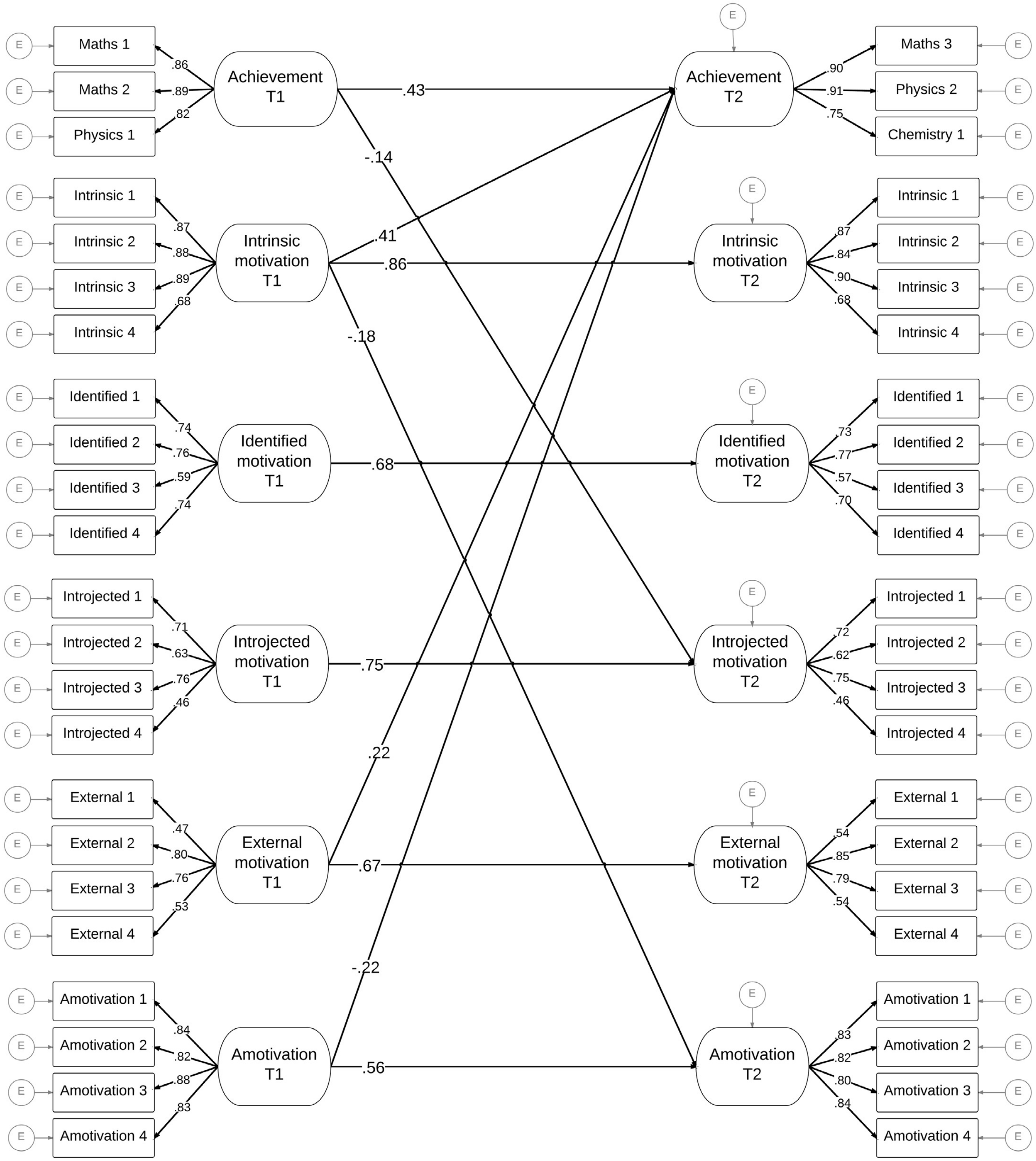

Fig. 3. Cross-lagged panel modelling of academic achievement and types of motivation in Study 4. Notes: Correlations between each motivation item's error term at each assessment, between factors at Time 1 and between disturbances were estimated. Equality constraints were imposed on same items' loading across time. Only significant paths are presented but all were allowed to covary.

proportion of variance in all six outcomes at T2, including achievement ($R^2 = .44$), intrinsic motivation ($R^2 = .66$), identified regulation ($R^2 = .52$), introjected regulation ($R^2 = .51$), external regulation ($R^2 = .47$), and amotivation ($R^2 = .44$).

5.3. Brief discussion

Overall, we replicated results found in Studies 2 and 3 showing that intrinsic motivation was the most strongly positively associated with achievement over a one-year period, in a population of Swedish high school science students. This indicates that science students who feel that they have freely chosen the academic orientation that they are interested in and stimulated by will have the needed engagement and drive to succeed over time. The results also showed that amotivation was related to lower science achievement over one year, which is not surprising and confirms previous research (Guay et al., 2008). If a science student lacks motivation, it can be very difficult to achieve well in science courses, which are known to be demanding. Moreover, it is interesting to note that the positive relation of intrinsic motivation with school achievement was nearly twice as strong as the negative association of amotivation with the same outcome.

Our results also showed that T1 external regulation was positively associated with achievement at T2. However, this relation was weaker than the relation of intrinsic motivation to achievement. This result does not support the predictions of SDT (Deci & Ryan, 2000). One possible explanation for it is that science students who are about to graduate are thinking about university applications and future jobs, and that this external focus may push them to do better in school during their final year. In other words, extrinsic motivation may have a positive effect at this stage of their education. No relationships were obtained between the other types of motivation (identified, introjected). Finally, T1 achievement was found to negatively predict T2 introjected regulation, suggesting that the higher a student's achievement, the less she will be motivated by wanting to prove her worth or by wanting to avoid feeling guilty.

6. General discussion

The objective of the present investigation was to examine the relations of different types of motivation to overall academic achievement in order to adequately test which types play the most important role. We first performed a meta-analysis of the literature showing that, in general, intrinsic motivation and identified regulation (i.e., both types of autonomous motivation) have the strongest positive relations to academic achievement, whereas amotivation has the strongest negative relation. Introjection and external regulation had weaker and more inconsistent relations to academic achievement. However, it also uncovered that most studies have used cross-sectional designs, or have not controlled for baseline levels of achievement. These methodological issues were addressed with three controlled, longitudinal studies of high school and college students in Canada and in Sweden. The results across all three studies showed that intrinsic motivation was the only motivation type to be *consistently* positively associated with academic achievement over a one-year period, controlling for baseline achievement, and for its reciprocal relation to subsequent academic motivation types. This replicates results reported in one of the few controlled longitudinal studies in the field (e.g., Baker, 2003) and supports Self-Determination Theory, which highlights intrinsic motivation as the prototype of autonomy (Deci & Ryan, 2000).

Amotivation was significantly associated with lower school achievement in our final two studies. The fact that students who feel like they do not know why they are in school have difficulty maintaining their grades is not surprising. Amotivation entails feelings of alienation and incompetence, both of which will naturally lead to problems in academic self-regulation (Legault, Green-Demers, & Pelletier, 2006).

Interestingly, our findings also provide some evidence that the relations between academic motivation types and achievement may be reciprocal. Indeed, we showed that prior achievement can positively predict subsequent intrinsic motivation (Study 2), and that it can negatively predict external regulation (Study 3), and introjected regulation (Study 4). This is not surprising in light of SDT, which posits that the satisfaction of competence, along with the other basic needs of autonomy and relatedness, leads to the development of more autonomous forms of motivation (Deci & Ryan, 2000). In our studies, achievement may have influenced students' perceptions of their academic competence at T1, which then may have led to more intrinsic motivation and less introjected and external regulation at T2. These results also corroborate findings by Garon-Carrier et al. (2014) and Goldberg & Cornell (1998) who showed that prior achievement was associated with later intrinsic motivation over time. However, our results were not consistent across studies, and the pattern of relations found between motivation and achievement provides more evidence to suggest that the direction of the relation goes from motivation to achievement.

6.1. The importance of intrinsic motivation for academic achievement

Interestingly, several researchers argue that intrinsic motivation is not necessarily the most important for young learners. For example, Eccles and Wigfield (2002) have argued that extrinsic motivation in the form of attainment or utility value, (e.g., pursuing an activity because it is important for the pursuit of future goals or to please one's parents) is crucial in determining a young person's achievement in school. Moreover, researchers working with SDT would also expect identified regulation, another form of autonomous motivation, to be very important for the regulation of school-related activities that are not necessarily interesting for children, such as homework (Koestner & Losier, 2002). However, our studies provide consistent evidence that intrinsic motivation seems to be the most important "motivational ingredient" in the recipe for academic achievement.

Our result regarding intrinsic motivation is also surprising given that this type of motivation has been repeatedly shown to decrease as children move into higher grades (Lepper et al., 2005; Otis et al., 2005; Ratelle et al., 2005; Wigfield & Eccles, 2002). Like those before us, we also found evidence that intrinsic motivation decreased over time—as reflected in lower mean scores at Time 2 than Time 1. Moreover, we found that intrinsic motivation was less commonly endorsed by high school and college students than identified regulation, or even introjected regulation. Nonetheless, it seems that intrinsic motivation was the type of motivation that played the most robust role in predicting school achievement.

This finding provides strong support for the prediction of SDT that intrinsic motivation is positively associated with school achievement (Deci et al., 1991; Niemiec & Ryan, 2009; Pintrich, 2003) because it reflects a sense of volition and personal interest rather than external pressure. Thus, a student who goes to school because he enjoys learning new things and is stimulated by his accomplishments will be more likely to work harder to receive better grades, and to want to stay in school. This finding is consistent across all three studies showing that intrinsic motivation had a positive relation to achievement in high school, and that it could predict positive changes in this outcome over time, as well as during an important school transition and in different cultures. Our findings are also consistent with other research on the benefits of intrinsic motivation for conceptual learning (Benware & Deci, 1984), creativity (Amabile, 1983; Lepper et al., 1973), flow (see Ryan & Deci, 2000), vitality (e.g., Moller, Deci, & Ryan, 2006), and psychological well-being (see Miquelon et al., 2005), obtained across various spheres of life such as physical education (Ntoumanis, 2001), management (Gagné & Deci, 2005; Taylor & Adalsteinsdottir, 2003), parenting (Grolnick & Apostoleris, 2002) and weight loss and health (Koestner, Otis, Powers, Pelletier, & Gagnon, 2008; Williams et al., 2006).

Previous studies appear to have missed the unique importance of intrinsic motivation in predicting school achievement over time. This is largely due to the fact that most studies measuring academic motivation according to SDT have been cross-sectional and only a few prospective studies have controlled for previous achievement (Baker, 2003; Black & Deci, 2000; Burton et al., 2006), and for reciprocal relations between motivation types and achievement (Guay et al., 2010). Because it is known that students who are high in intrinsic motivation and identified regulation also tend to have higher achievement (Niemiec & Ryan, 2009), it is thus difficult to interpret the findings of studies that have failed to control for one of the most important predictors of future school achievement. In addition, cross-sectional studies do not provide any information about the potential predictive power of motivational variables over time. Our findings extend current knowledge by using a prospective design and controlling for previous school achievement, to examine the specific role of academic motivation in the prediction of achievement over time.

Amotivation was found to be a significant predictor of achievement in two of our studies. This supports past research suggesting that amotivation is highly detrimental for school achievement (Lavigne et al., 2007; Otis et al., 2005). However, the relation obtained between amotivation and changes in achievement was considerably weaker than in previous cross-sectional studies and those that did not control for a baseline measure of achievement. We believe it is noteworthy that amotivation, which reflects strong feelings of alienation and incompetence, was not as strongly related to poor school achievement as was having a lack of intrinsic motivation. Our results are similar to those obtained in a study conducted by Otis et al. (2005) examining different motivation types separately and showing that students who were intrinsically motivated at the end of junior high school were the least vulnerable to the long-term negative effects of the senior high school transition, whereas amotivated students were the most vulnerable.

6.2. Intrinsic motivation across different cultures

It is interesting to note that the significantly positive path between intrinsic motivation and achievement was replicated across different school settings and across two cultures, i.e., Canada and Sweden, which differ in their emphasis on what motivates people—wanting to be the best versus liking what one does. A difference between the educational systems of Sweden (where cooperation, support for autonomy and lack of external constraints are the rule) and Canada (where competition, rewards/grades are much more present) made it interesting to examine the relations between academic motivation and achievement, in order to test the universality hypothesis of SDT, i.e., that autonomous forms of motivation will be positively related to achievement, even across different cultures. Replicating the results of several studies conducted across Israeli, Belgian, German, and Korean samples in education (Assor et al., 2009; Jang, Reeve, Ryan, & Kim, 2009; Levesque et al., 2004), our longitudinal findings provide additional support for the generalizability of motivational processes across cultures (Deci & Ryan, 2000).

However, it must be noted that the relation between T1 intrinsic motivation and T2 achievement was much stronger in the Swedish sample than in the other Canadian samples. One explanation for this could be based on the way achievement is assessed across these two educational systems. Because the Swedish system is more autonomy-supportive and less focused on rigid external constraints than the Canadian system, achievement is assessed accordingly, using more open-ended performance criteria such as written essays, demonstrating reasoning processes, or collaborative problem solving (Nusche, Halász, Looney, Santiago, & Shewbridge, 2011). Since intrinsic motivation has been shown to promote conceptual learning (Benware & Deci, 1984) and creativity (Amabile, 1983; Lepper et al., 1973), which are best measured with open-ended performance tests, it is likely that the intrinsic motivation that Swedish students develop within this environment is more strongly linked with achievement when it is measured in such a congruent way.

6.3. Relations between different academic motivation types over time

It is interesting that our studies not only indicate that different academic motivation types can influence achievement over time, but that they can also influence each other. Specifically, in Study 1, high school students' intrinsic motivation positively predicted their levels of identified regulation one year later. More interestingly, we also found that for Swedish and Canadian science students (Studies 3 and 4), intrinsic motivation was associated with less amotivation one year later, which suggests that intrinsic motivation can also serve to prevent academic disengagement at a time that can define the rest of their educational path. By contrast, there was some evidence that introjected regulation was associated with greater amotivation over time.

6.4. Practical implications

Our studies provide consistent support for the beneficial role of engaging in school activities because of interest and enjoyment. These findings can serve to provide practical guidelines for teachers' professional development as well as for the design of interventions to promote school achievement by focusing on igniting students' interests for different subjects or fields and by maintaining this intrinsic motivation through the support of students' basic psychological needs of autonomy, competence and relatedness by teachers (Deci & Ryan, 2000; Deci et al., 1991; Reeve, Jang, Carrell, Jeon, & Barch, 2004; Vallerand et al., 1997). The findings also imply that parents would do well to focus on encouraging their adolescents to pursue studies that are interesting and exciting to them.

6.5. Limitations and future research

The central limitation of our prospective studies was that we relied mostly on self-report measures of motivation. It would have been useful to collect measures from other sources such as parents and peers. Another limitation of the present investigation concerns the cross-cultural application of SDT. Even though Sweden differs from Canada in terms of masculinity and school environments, they are both Western cultures and have many other similarities. It would be interesting for future research to examine whether intrinsic motivation predicts further achievement in more radically different cultures (e.g., countries in Asia or Africa), given that some cross-cultural studies based on different theoretical frameworks have shown that some external types of motivations, such as social goals (Cheng & Lam, 2013) and performance goals (King, McInerney, & Watkins, 2012), seem to be similarly predictive of achievement.

Finally, our studies adopted a variable-oriented approach. We found that prior intrinsic motivation is consistently positively associated with subsequent achievement in school. However, this approach did not allow us to identify whether a student who endorsed autonomous motivations for going to school also endorsed controlled motivations. Because these two types of motivation are correlated in most studies (Ryan & Deci, 2002), it would be important for future studies to examine whether reporting both types of motivations *simultaneously* is beneficial for students. Research in SDT has recently started using such a person-centered approach in order to evaluate which motivational profiles are most beneficial for students' academic adjustment (Poulin, Duchesne, & Ratelle, 2010; Ratelle et al., 2007).

7. Conclusion

Many studies have shown that autonomous motivation is positively related to academic achievement (Niemiec & Ryan, 2009). However, these relations have rarely been investigated in prospective studies of high school students that controlled for baseline achievement. The objective of the present investigation was to use a controlled prospective design to examine whether these motivation types could predict changes in academic achievement over time, during the transition from high school to college, and in different cultures. We showed that intrinsic motivation is consistently the most beneficial form of motivation for students' achievement. Our findings highlight the importance of encouraging students to pursue subjects that they are passionate about. They also appear to give credence to Socrates' idea that education is about "the kindling of a flame, not the filling of a vessel" (Socrates, 470 BC).

References marked with an asterisk indicate studies included in the meta-analysis.

References

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology*, *45*, 357–376. doi:10.1037/00223514.45.2.357.

Archambault, I., Janosz, M., Morizot, J., & Pagani, L. (2009). Adolescent behavioral, affective, and cognitive engagement in school: Relationship to dropout. *The Journal of School Health*, *79*, 408–415. doi:10.1111/j.1746-1561.2009.00428.x.

*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*, 482–497. doi:10.1037/a0014236.

*Baker, S. R. (2003). A prospective longitudinal investigation of social problem-solving appraisals on adjustment to university, stress, health, and academic motivation and performance. *Personality and Individual Differences*, *35*, 569–591. doi: 10.1016/S01918869(02)00220-9.

Benware, C. A., & Deci, E. L. (1984). Quality of learning with an active versus passive motivational set. *American Educational Research Journal*, *21*, 755–765. doi:10.3102/00028312021004755.

*Black, A. E., & Deci, E. L. (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science Education*, *84*, 740–756. doi:10.1002/1098-237X(200011)84:6 < 740::AID-SCE4>3.0.CO;2-3.

Boiché, J. C. S., Sarrazin, P. G., Grouzet, F. M. E., Pelletier, L. G., & Chanal, J. P. (2008). Students' motivational profiles and achievement outcomes in physical education: A self-determination perspective. *Journal of Educational Psychology*, *100*, 688–701. doi:10.1037/0022-0663.100.3.688.

Buhi, E. R., Goodson, P., & Neilands, T. B. (2008). Out of sight, not out of mind: Strategies for handling missing data. *American Journal of Health Behavior*, *32*(1), 83–92.

*Burton, K. D., Lydon, J. E., D'Alessandro, D. U., & Koestner, R. (2006). The differential effects of intrinsic and identified motivation on well-being and performance: Prospective, experimental, and implicit approaches to self-determination theory. *Journal of Personality and Social Psychology*, *91*, 750–762. doi:10.1037/0022-3514.91.4.750.

Chatzisarantis, N. L. D., Hagger, M. S., Biddle, S. J. H., Smith, B., & Wang, J. C. K. (2003). A meta-analysis of perceived locus of causality in exercise, sport, and physical education contexts. *Journal of Sport & Exercise Psychology*, *25*(3), 284–306.

Cheng, R. W., & Lam, S. (2013). The interaction between social goals and self-construal on achievement motivation. *Contemporary Educational Psychology*, *38*(2), 136–148. doi:10.1016/j.cedpsych.2013.01.001.

Chirkov, V., & Ryan, R. M. (2001). Parent and teacher autonomy-support in Russian and U.S. adolescents: Common effects on well-being and academic motivation. *Journal of Cross-Cultural Psychology*, *32*(5), 618–635.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. doi:10.1037/0033-2909.112.1.155.

*Cokley, K.O., Bernard, N., Cunningham, D., & Motoike, J. (2001). A psychometric investigation of the Academic Motivation Scale using a United States sample. *Measurement and Evaluation in Counseling and Development*, *34*(2), 109–119.

*D'Ailly, H. (2003). Children's autonomy and perceived control in learning: A model of motivation and achievement in Taiwan. *Journal of Educational Psychology*, *95*, 84–96. doi:10.1037/0022-0663.95.1.84.

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

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*, 227–268. doi:10.1207/S15327965PLI1104_01.

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*, 627–668. doi:10.1037/0033-2909.125.6.627.

Deci, E. L., & Ryan, R. M. (2002). Overview of Self-Determination Theory: An organismic dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of Self-Determination Research* (pp. 3–33). Rochester, NY: University of Rochester Press.

Deci, E.L., Vallerand, R.J., Pelletier, L.G., & Ryan, R.M. (1991). Motivation and education: The self-determination perspective. *Educational Psychologist*, *26*, 325–346. doi:10.1080/00461520.1991.9653137.

DeCharms, R. (1968). *Personal causation: The internal affective determinants of behavior*. New York: Academic Press.

Dornbusch, S. M., Ritter, P. L., Leiderman, P. H., Roberts, D. F., & Fraleigh, M. J. (1987). The relation of parenting style to adolescent school performance. *Child Development*, *58*, 1244. doi:10.2307/1130618.

Duchesne, S., Ratelle, C. F., Larose, S., & Guay, F. (2007). Adjustment trajectories in college science programs: Perceptions of qualities of parents' and college teachers' relationships. *Journal of Counseling Psychology*, *54*, 62–71. doi:10.1037/0022-0167.54.1.62.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goal. *Annual Review of Psychology*, *53*, 109–132. doi:10.1146/annurev.psych.53.100901.135153.

Eisinga, R., Grotenhuis, M., & Pelzer, B. (2013). The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? *International Journal of Public Health*, *58*(4), 637–642. doi:10.1007/s00038-012-0416-3.

Elliot, A. J., & Moller, A. C. (2003). Performance-approach goals: Good or bad forms of regulation? *International Journal of Educational Research*, *39*(4–5), 339–356. doi:10.1016/j.ijer.2004.06.003.

Field, A. P., & Gillett, R. (2010). How to do a meta-analysis. *British Journal of Mathematical and Statistical Psychology*, *63*, 665–694. doi:10.1348/000711010X502733.

*Fortier, M.S., Vallerand, R.J., & Guay, F. (1995). Academic motivation and school performance: Toward a structural model. *Contemporary Educational Psychology*, *20*, 257–274. doi:10.1006/ceps.1995.1017.

Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, *26*, 331–362. doi:10.1002/job.322.

Garon-Carrier, G., Boivin, M., Forget-Dubois, N., Guay, F., Kovas, Y., Lemelin, J.-P., et al. (2014). Une étude longitudinale de l'association entre la motivation intrinsèque et le rendement en mathématiques [A longitudinal study of the association between intrinsic motivation and mathematics achievement]. Paper presented at the Association francophone pour le savoir (ACFAS), Montreal, Quebec, Canada.

Goldberg, M. D., & Cornell, D. G. (1998). The influence of intrinsic motivation and self concept on academic achievement in second- and third-grade students. *Journal for the Education of the Gifted*, *21*, 179–205. doi:10.1177/016235329802100204.

Grolnick, W. S., & Apostoleris, N. H. (2002). What makes parents controlling? In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 161–203). Rochester, NY: University of Rochester Press.

*Grolnick, W. S., Ryan, R. M., & Deci, E. L. (1991). Inner resources for school achievement: Motivational mediators of children's perceptions of their parents. *Journal of Educational Psychology*, *83*, 508–517. doi:10.1037/0022-0663.83.4.508.

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

Guay, F., Ratelle, C. F., Roy, A., & Litalien, D. (2010). Academic self-concept, autonomous academic motivation, and academic achievement: Mediating and additive effects. *Learning and Individual Differences*, *20*(6), 644–653. doi:10.1016/j.lindif.2010.08.001.

*Hardre, P. L., & Reeve, J. (2003). A motivational model of rural students' intentions to persist in, versus drop out of, high school. *Journal of Educational Psychology*, *95*, 347–356. doi:10.1037/0022-0663.95.2.347.

Harter, S. (1981). A new self-report scale of intrinsic versus extrinsic orientation in the classroom: Motivational and informational components. *Developmental Psychology*, *17*, 300–312. doi:10.1037/0012-1649.17.3.300.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. New York: Academic Press.

Hennan, M. R., Dornbusch, S. M., Herron, M. C., & Herting, J. R. (1997). The influence of family regulation, connection, and psychological autonomy on six measures of adolescent functioning. *Journal of Adolescent Research*, *12*, 34–67. doi:10.1177/0743554897121004.

Hofstede, G. (1983). National cultures in four dimensions: A research-based theory of cultural differences among nations. *International Studies of Management & Organization*, 46–74.

Jang, H., Reeve, J., Ryan, R. M., & Kim, A. (2009). Can self-determination theory explain what underlies the productive, satisfying learning experiences of collectivistically oriented Korean students? *Journal of Educational Psychology*, *101*, 644–661. doi:10.1037/a0014241.

Johnson, B.T. (1993). *DSTAT 1.10: Software for the meta-analytic review of literatures*. Hillsdale, NJ: Erlbaum.

King, R. B., McInerney, D. M., & Watkins, D. A. (2012). Competitiveness is not that bad. . .at least in the East: Testing the hierarchical model of achievement motivation in the Asian setting. *International Journal of Intercultural Relations*, *36*(3), 446–457. doi:10.1016/j.ijintrel.2011.10.003.

Kline, R. B. (2011). *Principles and practice of structural equation modeling*. New York: Guilford Press.

Koestner, R., & Losier, G. F. (2002). Distinguishing three ways of being highly motivated: A closer look at introjection, identification, and intrinsic motivation. In E. L. Deci & R. M. Ryan (Eds.), *The handbook of self-determination theory research* (pp. 101–121). Rochester, NY: University of Rochester Press.
Koestner, R., Otis, N., Powers, T. A., Pelletier, L., & Gagnon, H. (2008). Autonomous motivation, controlled motivation, and goal progress. *Journal of Personality*, *76*, 1201–1230. doi:10.1111/j.1467-6494.2008.00519.x.
Lavigne, G. L., Vallerand, R. J., & Miquelon, P. (2007). A motivational model of persistence in science education: A self-determination theory approach. *European Journal of Psychology of Education*, *22*(3), 351–369.
Legault, L., Green-Demers, I., & Pelletier, L. (2006). Why do high school students lack motivation in the classroom? Toward an understanding of academic amotivation and the role of social support. *Journal of Educational Psychology*, *98*, 567–582. doi:10.1037/0022-0663.98.3.567.
Lekes, N., Joussemet, M., Koestner, R., Taylor, G., Hope, N. H., & Gingras, I. (2011). Transmitting intrinsic value priorities from mothers to adolescents: The moderating role of a supportive family environment. *Child Development Research*, *2011*, 1–9. doi:10.1155/2011/167146.
Lepper, M. R., Corpus, J. H., & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology*, *97*, 184–196. doi:10.1037/0022-0663.97.2.184.
Lepper, M. R., Greene, D., & Nisbett, R. E. (1973). Undermining children's intrinsic interest with extrinsic reward: A test of the "overjustification" hypothesis. *Journal of Personality and Social Psychology*, *28*, 129–137. doi:10.1037/h0035519.
Levesque, C., Zuehlke, A. N., Stanek, L. R., & Ryan, R. M. (2004). Autonomy and competence in German and American university students: A comparative study based on self-determination theory. *Journal of Educational Psychology*, *96*, 68–84. doi:10.1037/0022-0663.96.1.68.
Marsh, H. W., & Hau, K. T. (1996). Assessing goodness of fit: Is patrimony always desirable? *Journal of Experimental Education*, *64*(4), 364.
Marsh, H. W., Hau, K. T., & Grayson, D. (2005). Goodness of fit in structural equation models. In R. P. McDonald, A. Maydeu-Olivares, & J. J. McArdle (Eds.), *Contemporary psychometrics: A festschrift for Roderick. P. McDonald*. Mahwah, NJ: Lawrence Erlbaum Associates.
Ministère de l'Éducation, du Loisir et du Sport (MELS). (2013). Indices de défavorisation 2012–2013 [Socioeconomic index 2012–2013]. Retrieved from http://www.mels.gouv.qc.ca/fileadmin/site_web/documents/PSG/statistiques_info_decisionnelle/Indices_par_CS2013p.pdf.
Ministry of Education and Science (2001). *The development of education: National report of Sweden*. <http://www.ibe.unesco.org/International/ICE/natrap/Sweden.pdf>.
Miquelon, P., Vallerand, R. J., Grouzet, F. M. E., & Cardinal, G. (2005). Perfectionism, academic motivation, and psychological adjustment: An integrative model. *Pers Soc Psychol Bull*, *31*, 913–924. doi:10.1177/0146167204272298.
Moller, A.C., Deci, E.L., & Ryan, R.M. (2006). Choice and ego-depletion: The moderating role of autonomy. *Personality and Social Psychology Bulletin*, *32*, 1024–1036. doi:10.1177/0146167206288008.
Morin, A. J. S., Madore, I., Morizot, J., Boudrias, J.-S., & Tremblay, M. (2009). Multiple targets of workplace affective commitment: Factor structure and measurement invariance of the Workplace Affective Commitment Multidimensional Questionnaire. In A. M. Columbus (Ed.), *Advances in psychology research* (Vol. 59, pp. 45–75). Hauppauge, NY: Nova Science Publishers, Inc.
Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom: Applying self-determination theory to educational practice. *Theory and Research in Education*, *7*, 133–144. doi:10.1177/1477878509104318.
*Noels, K. A., Clement, R., & Pelletier, L. G. (1999). Perceptions of teachers' communicative style and students' intrinsic and extrinsic motivation. *The Modern Language Journal*, *83*, 23–34. doi:10.1111/0026-7902.00003.
Ntoumanis, N. (2001). A self-determination approach to the understanding of motivation in physical education. *The British Journal of Educational Psychology*, *71*, 225–242. doi:10.1348/000709901158497.
Ntoumanis, N. (2002). Motivational clusters in a sample of British physical education classes. *Psychology of Sport and Exercise*, *3*(3), 177–194. doi:10.1016/S1469-0292(01)00020-6.
Ntoumanis, N., Barkoukis, V., & Thøgersen-Ntoumani, C. (2009). Developmental trajectories of motivation in physical education: Course, demographic differences, and antecedents. *Journal of Educational Psychology*, *101*, 717–728. doi:10.1037/a0014696.
Nusche, D., Halász, G., Looney, J., Santiago, P., & Shewbridge, C. (2011). OECD reviews of evaluation and assessment in education: Sweden. <http://www.oecd.org/edu/school/47169533.pdf>.
Otis, N., Grouzet, F. M. E., & Pelletier, L. G. (2005). Latent motivational change in an academic setting: A 3-year longitudinal study. *Journal of Educational Psychology*, *97*, 170–183. doi:10.1037/0022-0663.97.2.170.
*Petersen, I., Louw, J., & Dumont, K. (2009). Adjustment to university and academic performance among disadvantaged students in South Africa. *Educational Psychology: An International Journal of Experimental Educational Psychology*, *29*, 99–115. doi:10.1080/01443410802521066.
Peugh, J. L., & Enders, C. K. (2004). Missing data in educational research: A review of reporting practices and suggestions for improvement. *Review of Educational Research*, *74*, 525–556.
Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, *95*, 667–686. doi:10.1037/0022-0663.95.4.667.
Poulin, R., Duchesne, S., & Ratelle, C.F. (2010). Profils de buts d'apprentissage et caractéristiques personnelles des élèves au début du secondaire [Learning goal profiles and personal characteristics of junior high school students]. *Canadian Journal of Behavioural Science. Revue canadienne des Sciences du comportement*, *42*, 44–54. doi:10.1037/a0016544.
Ratelle, C. F., Vallerand, R. J., Senécal, C., & Provencher, P. (2005). The relationship between school-leisure conflict and educational and mental health indexes: A motivational analysis. *Journal of Applied Social Psychology*, *35*, 1800–1823. doi:doi:10.1111/j.1559-1816.2005.tb02196.x.
*Ratelle, C., Guay, F., Vallerand, R.J., Larose, S., & Senécal, C. (2007). Autonomous, controlled, and amotivated types of academic motivation: A person-oriented analysis. *Journal of Educational Psychology*, *99*, 734–746. doi:10.1037/0022-0663.99.4.734.
Reeve, J., Jang, H., Carrell, D., Jeon, S., & Barch, J. (2004). Enhancing students' engagement by increasing teachers' autonomy support. *Motivation and Emotion*, *28*, 147–169. doi:10.1023/B:MOEM.0000032312.95499.6f.
Retelsdorf, J., Köller, O., & Möller, J. (2014). Reading achievement and reading self-concept—Testing the reciprocal effects model. *Learning and Instruction*, *29*, 21–30. doi:10.1016/j.learninstruc.2013.07.004.
Rosenthal, R., & DiMatteo, M. R. (2001). Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology*, *52*, 59–82. doi:10.1146/annurev.psych.52.1.59.
Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology*, *57*, 749–761. doi:10.1037/0022-3514.57.5.749.
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *The American Psychologist*, *55*, 68–78. doi:10.1037/0003-066X.55.1.68.
Schlomer, G. L., Bauman, S., & Card, N. A. (2010). Best practices for missing data management in counseling psychology. *Journal of Counseling Psychology*, *57*(1), 1–10. doi:10.1037/a0018082.
Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology*, *59*, 623–664. doi:10.1111/j.1744-6570.2006.00049.x
*Soenens, B., & Vansteenkiste, M. (2005). Antecedents and outcomes of self-determination in 3 life domains: The role of parents' and teachers' autonomy support. *Journal of Youth and Adolescence*, *34*, 589–604. doi:10.1007/s10964-005-8948-y.
Taylor, G., & Adalsteinsdottir, E. B. (2003). *Empowerment, job characteristics and intrinsic motivation: An examination of the role of managerial autonomy-support* (Unpublished Master's thesis). London School of Economics and Political Science, London, UK.
Vallerand, R. J., Blais, M. R., Brière, N. M., & Pelletier, L. G. (1989). Construction et validation de l'échelle de motivation en éducation (EME) [Construction and validation of the Academic Motivation Scale (AMS)]. *Canadian Journal of Behavioural Science. Revue Canadienne Des Sciences Du Comportement*, *21*, 323–349. doi:10.1037/h0079855.
Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real life setting: Toward a motivational model of high school dropout. *Journal of Personality and Social Psychology*, *72*, 1161–1176. doi:10.1037/0022-3514.72.5.1161.
Vallerand, R. J., Pelletier, L. G., Blais, M. R., Brière, N. M., Sénécal, C., & Vallières, E. F. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement*, *52*, 1003–1017. doi:10.1177/0013164492052004025.
*Vallerand, R. J., Pelletier, L. G., Blais, M. R., Brière, N. M., Sénécal, C., & Vallières, E. F. (1993). On the assessment of intrinsic, extrinsic, and amotivation in education: Evidence on the concurrent and construct validity of the Academic Motivation Scale. *Educational and Psychological Measurement*, *53*, 159–172. doi:10.1177/0013164493053001018.
Vansteenkiste, M., Niemiec, C.P., & Soenens, B. (2010). The development of the five mini theories of self-determination theory: An historical overview, emerging trends, and future directions. In T. Urdan & S. Karabenick (Eds.), (Vol. 16, pp. 105–165,). Advances in motivation and achievement. Bradford, UK: Emerald Group Publishing Limited. doi:10.1108/S0749-7423(2010)000016A007.
*Walls, T. A., & Little, T. D. (2005). Relations among personal agency, motivation, and school adjustment in early adolescence. *Journal of Educational Psychology*, *97*, 23–31. doi:10.1037/0022-0663.97.1.23.
Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68–81. doi:10.1006/ceps.1999.1015.
Wigfield, A., & Eccles, J. S. (2002). *Development of achievement motivation*. San Diego, California: Academic Press.
Williams, G.C., McGregor, H.A., Sharp, D., Levesque, C., Kouides, R.W., & Ryan, R.M., et al. (2006). Testing a self-determination theory intervention for motivating tobacco cessation: Supporting autonomy and competence in a clinical trial. *Health Psychology*, *25*, 91–101. doi:10.1037/0278-6133.25.1.91.
Wrzesniewski, A., Schwartz, B., Cong, X., Kane, M., Omar, A., & Kolditz, T. (2014). Multiple types of motives don't multiply the motivation of West Point cadets. *Proceedings of the National Academy of Sciences*, *111*(30), 10990–10995. doi:10.1073/pnas.1405298111.