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Exploring the antecedents of learning-related emotions and their relations with achievement outcomes

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Abstract

Recent work suggests that learning-related emotions (LREs) play a crucial role in performance especially in the first year of university, a period of transition for most students; however, additional research is needed to show how these emotions emerge. We developed a framework which links a course-contextualized antecedent – academic control in Pekrun's (2006) Control Value Theory of Achievement Emotions – with generic antecedents – adaptive and maladaptive cognitions and behaviors from Martin's (2007) Motivation and Engagement Wheel framework – to explain a classical problem: the emergence of LREs in a transition period. Using a large sample (N = 3451) of first year university students, our study explores these two antecedents to better understand how four LREs (enjoyment, anxiety, boredom and hopelessness) emerge in a mathematics and statistics course. Through the use of path-modelling, we found that academic control has a strong effect on all four LREs – with the strongest impact observed for learning hopelessness and secondary, for learning anxiety. Academic control, on its turn, builds on contributions from adaptive and mal-adaptive cognitions. Furthermore, adaptive cognitions have an impact on learning enjoyment (positive) and on boredom (negative). Surprisingly though, the maladaptive behaviors impact positively learning enjoyment and negatively learning anxiety. Following this, we predicted performance outcomes in the course and found again academic control as the main predictor, followed by learning hopelessness. Overall, this study brings evidence that adaptive and maladaptive cognitions and behaviours act as important antecedents of academic control, the main predictor of LREs and course performance outcomes.

Keywords: Learning-related emotions; Academic control; Adaptive and non-adaptive cognitions and behaviors; Academic achievement; First year of university.

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1. Introduction

The first year experience of university is known as a transition period (Baker & Syrik, 1999; Tinto, 1997), when students are confronted with novel situations over which they have low control, yet still hold high expectations for success (Perry, Hladkyj, Pekrun, Clifton, & Chipperfield, 2005). These conditions typically create negative emotional reactions towards learning in academic situations (Stupnisky, Perry, Hall, & Guay, 2012), which can lead to voluntary withdrawal at the course level (Ruthig et al., 2007) and overall poor performance across all courses taken at the university (Hall, Perry, Ruthig, Hladkyj, & Chipperfield, 2006). Such emotions, known as achievement related emotions, can have serious consequences on how students perform within a course (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011). This is particularly true for mathematics and statistics courses, in which students experience high levels of negative emotions, especially in in learning- or homework-related situations (Dettmers et al., 2011; Goetz et al., 2012). Within these courses, negative emotions emerge from beliefs about a low capacity to influence outcomes (Frenzel, Pekrun, & Goetz, 2007; Pekrun, 2000), referred to as appraisals of control (Pekrun, Goetz, Titz, & Perry, 2002). At the same time, students come into these courses holding generic predispositions towards learning at university, such as adaptive and maladaptive cognitions and behaviours, which will also influence their experiences within a course (Martin, 2007).

Although we know that emotions experienced in learning- or homework-related situation are particularly important for performance (Leone & Richards, 1989; Verma, Sharma, & Larson, 2002), additional research is needed in the first year of university to help us understand how these emotions emerge and how they can be influenced (Putwain, Sander, & Larkin, 2013). Such information can inform the design of educational interventions to create "emotionally sound" (Astleitner, 2000) learning environments which can potentially improve academic achievement.

The present study focuses on two different antecedents of achievement learning-related emotions: 1) the course contextualized antecedents (appraisal of control) and, 2) the generic antecedents towards learning at university (adaptive and maladaptive cognitions and behaviours). Both antecedents need to be integrated, as they are complementary in providing information about the emergence of emotions in a course setting. Direct antecedents are necessary for explaining the emergence of distinct emotions at a course level and distal antecedents can explain the individual differences that arise in the emergence of these emotions. Finally, relations and implications for academic achievement are further discussed.

1.1 Theoretical framework

Over the past twenty years we have seen a growing interest in, and increased research that explores the role of achievement emotions across various educational contexts and course settings. Such research investigates different functions of academic emotions within a course, such as their effects on self-regulation (Artino Jr. & Jones II, 2012), learning engagement (Ainley & Ainley, 2011), learning choices (Tempelaar, Niculescu, Rienties, Gijselaers, & Giesbers, 2012) and achievement (Dettmers et al., 2011; Goetz, Frenzel, Pekrun, & Hall, 2006; Goetz et al., 2012). The transition required in the first year of university involves several challenges which may include perceived competition and pressure to perform – both demanding heightened self-reliance and autonomy (Perry, Hladkyj, Pekrun, & Pelletier, 2001). Since students are expected to engage in more individual self-study, the importance of achievement emotions in individual learning- or homework- related situations (as compared to the classroom setting, for example) is particularly important. These emotions are referred to in the literature as achievement learning-related emotions (Pekrun, 2000). At the same time, a closer investigation of students' experiences is necessary to clarify how learning-related emotions (LREs) emerge at the course level.

1.1.1 Achievement emotions

Achievement emotions are defined as "emotions that are directly linked to achievement activities and outcomes" (Pekrun et al., 2011, p. 37). In the Control-Value Theory of Achievement Emotions (CVTAE; Pekrun, 2006), emotional experiences have a situational context, meaning that they can be

experienced in different academic situations within a course: 1) being in class, 2) taking tests and exams and, 3) studying outside of class (while learning or when preparing homework). Of particular interest are the emotions experienced in learning-related situations as students seem to experience the most unpleasant emotions when compared with other academic situations, such as learning in the classroom (Leone & Richards, 1989). Indeed, according to the CVTAE, first year university students experience a variety of learning-related emotions, whether the emotions are positive or negative.

1.1.2 Learning – related emotions and their course contextualized antecedents

According to the Control-Value Theory of Achievement Emotions (CVTAE; Pekrun, 2006), discrete learning-related emotions (LREs) arise from the appraisal of achievement activities and outcomes. Emotions that result from such appraisals can indirectly influence achievement outcomes. There are two dimensions of appraisals: control and value. The appraisal of control refers to a student's belief about whether he/she has control over learning activities/outcomes; the appraisal of value describes the subjective value attributed to these activities/outcomes. These appraisals are considered direct antecedents of LREs and are acquired at the course level (Pekrun, 2006).

Control appraisals describe the perceived controllability of one's own competency towards achievement activities and outcomes; as a general rule, low and high levels of control appraisals influence emotions differently (Pekrun, 2000). For instance, low control leads to an increased level in negative emotions (e.g., learning anxiety) and a more elevated level of control favours a heightened experience of positive emotions (such as learning enjoyment). Empirical evidence shows that the appraisal of control longitudinally relates to emotions (Perry et al., 2001; Perry et al., 2005), as well as to subsequent academic achievement in the first year of university (Hall et al., 2006; Ruthig et al., 2008; Stupnisky et al., 2012). For instance, Perry et al. (2001) found that students who reported higher levels of primary control also felt less bored (-.48) and less anxious (-.35) towards the course, and obtained higher final grades (.27). Similar relations are shown by Hall et al. (2006): correlations between primary control and several emotions (anger, regret, happiness and pride) are in the range of -.27 to .24; primary control relates positively to the final course grade (.21) as well as to cumulative GPA (.25). Overall, this correlational evidence suggests relations between primary control, emotions and performance which are of moderate size (Cohen, 1992). There are also documented gender differences in the beliefs students hold towards their abilities to perform in mathematics (female students tend to generally believe they are not very good at mathematics), with implications on how the two genders feel about this subject (Robinson & Clore, 2002; Frenzel et al., 2007). Finally, the implications of studying course specific antecedents of LREs is relevant when explaining the development of emotions over time and, indirectly, for understanding their consequences on achievement.

1.1.3 Generic antecedents of learning-related emotions

There are also more general expectancies and predispositions towards learning at university students already hold when entering a course, which can be considered generic antecedents of LREs and achievement. Students enter a new course holding background characteristics (intelligence, personality, high school GPA etc.) but also possessing a set of adaptive and impeding cognitions, and adaptive and impeding behaviors, towards learning in the new setting of university (Martin, 2007). Therefore, we applied the 'motivation and engagement wheel' framework of Martin (2007, 2009) as a model for distal antecedents of learning-related emotions (LREs). The motivation and engagement wheel breaks down all motivation and engagement concepts into four categories: adaptive cognitions, adaptive behaviors, impeding cognitions, and maladaptive behaviors. These four categories each consist of two or three sub-dimensions. For adaptive cognitions, the dimensions consist of self-belief, valuing school, and learning focus. Student's confidence to do well in university, their belief that learning will be useful and relevant, and their interest in learning new topics/developing new skills, all contribute to various academic outcomes (Martin, 2011). Furthermore, the adaptive behavioral dimensions include persistence, planning, and task management. To date, a study of Martin and Marsh (2006) shows that self-efficacy, control, planning, low anxiety, and persistence predict enjoyment and class participation. Conversely, the impeding or deactivating antipodes of the cognitions (that obstruct learning rather than enhance it) include anxiety, failure avoidance and uncertain control. The maladaptive behaviors are twofold: self-handicapping and disengagement. In turn, self-handicapping (as a

disruptive behaviour) can predict negative academic outcomes (Martin, Marsh, & Debus, 2001). Although the experience of the adaptive and mal-adaptive cognitions and behaviors can differ on average for female and male students (Liem & Martin, 2012), the concepts operating in this motivation and engagement wheel represent generic orientations that are relatively stable over contexts (Martin, 2009). For this reason, in Pekrun's Theory, such generic orientations can be integrated as distal antecedents of LREs. Although it may appear that some of the concepts (e.g. self-belief/efficacy, persistency and control) from the "motivation and engagement wheel" are closely related to the appraisal of control in the CVTAE, it is important to ensure clarity (distinction) between them: while the distal antecedents are more trait-type of constructs, the direct antecedent (appraisal of control) is a subject specific type of appraisal. Overall, the motivation and engagement concepts play an important role in students' cognitive appraisals, in their emotions during learning, and in achievement outcomes (Martin & Marsh, 2006; Martin, 2011). Figure 1 summarizes the conceptual model used in our study.

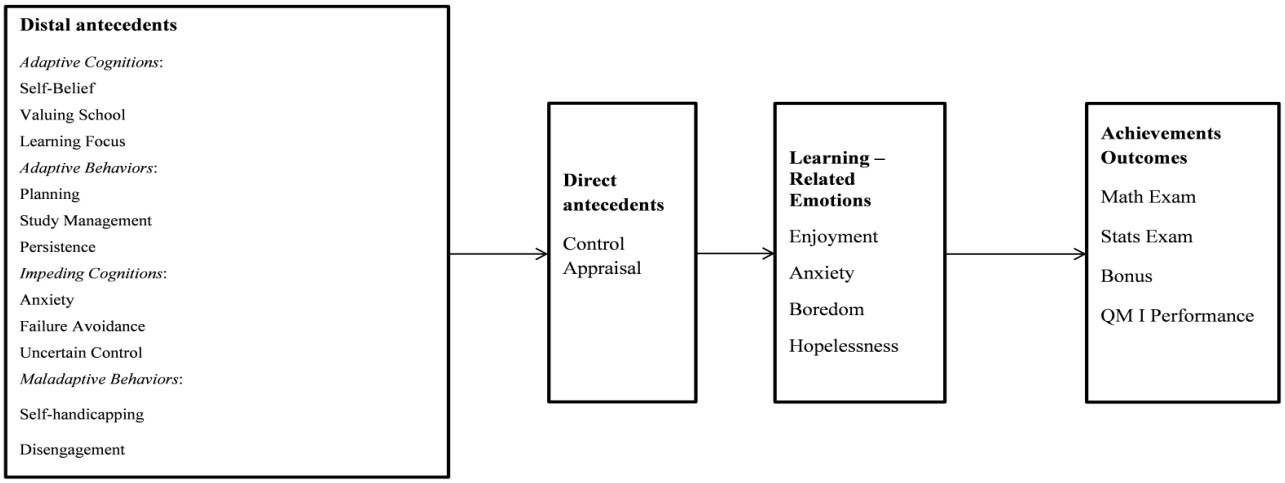

Figure 1. The conceptual framework of the study

To sum-up, the added value of integrating both direct and distal antecedents into one framework is to explain: 1) the emergence of distinct emotions through direct antecedents, and 2) through distal antecedents, the individual differences that arise in learning emotions when students enroll in a course.

1.1.4 Learning – related emotions and academic performance

While other settings have been extensively studied, such as the exam situation, few studies have investigated situations outside the class (Putwain, Larkin, & Sander, 2013; Schutz & Pekrun, 2006; Trautwein et al., 2009). Recent research discusses students' emotional experiences during individual learning activities such as mathematics homework (Dettmers et al., 2011; Goetz et al., 2012) in which the assignments are considered "emotionally charged activities" (Dettmers et al., 2011, p. 25). In the homework situation students seem to experience the most unpleasant emotions when compared with other academic situations (Leone & Richards, 1989; Verma, Sharma, & Larson, 2002). Furthermore, learning – related emotions (LREs) are of particular interest, as they demonstrate a strong relationship with achievement outcomes. While it is already known that positive emotions have a positive impact on academic performance (Dettmers et al., 2011; Pekrun et al., 2002), by focusing on the experience of unpleasant emotions during homework, Dettmers et al. (2011) demonstrates how elevated anxiety and boredom levels shape effort and disengagement in study, to predict negative achievement in mathematics. Considering the transition represented by the first year of university, more evidence is needed – particularly in this period – about

students' emotional experiences in learning situations. To our best knowledge, only few studies (Putwain, Sander, et al., 2013) have addressed this issue in the first year of university context. To our best knowledge, we found only one study (Tempelaar et al., 2012) which investigates how these emotions emerge and influence learning outcomes in the setting of an undergraduate introductory mathematics or statistics course. The present study builds further on the Tempelaar et al. (2012) work to look how distinct LREs emerge from course contextualized and generic antecedents and further, how they influence achievement outcomes in a first year university mathematics and statistics course.

1.2 Research questions and hypotheses

We have asked the following research questions:

RQ1. What role do distal and direct antecedents play in the development of LREs?

RQ2. To what extent can the direct and distal antecedents together explain student performance at the course level?

Furthermore, we hypothesize:

H1. The distal antecedents will have effects on both control appraisals and LREs, with differential roles for adaptive and maladaptive distal antecedents.

H2. The direct antecedents, control appraisals, will have an effect on LREs. This effect will be different for positive versus negative (or neutral) LREs. The control appraisals will influence positively enjoyment and negatively anxiety, boredom and hopelessness.

H3. Distal antecedents, direct antecedents and LREs all explain student performance in the course.

Research hypotheses are graphically depicted in the Figure 2, demonstrating the a priori structural model. To facilitate the reading of this conceptual model, all three negative emotions are taken together, as well as the two adaptive cognitions and behaviours, and the two maladaptive ones.

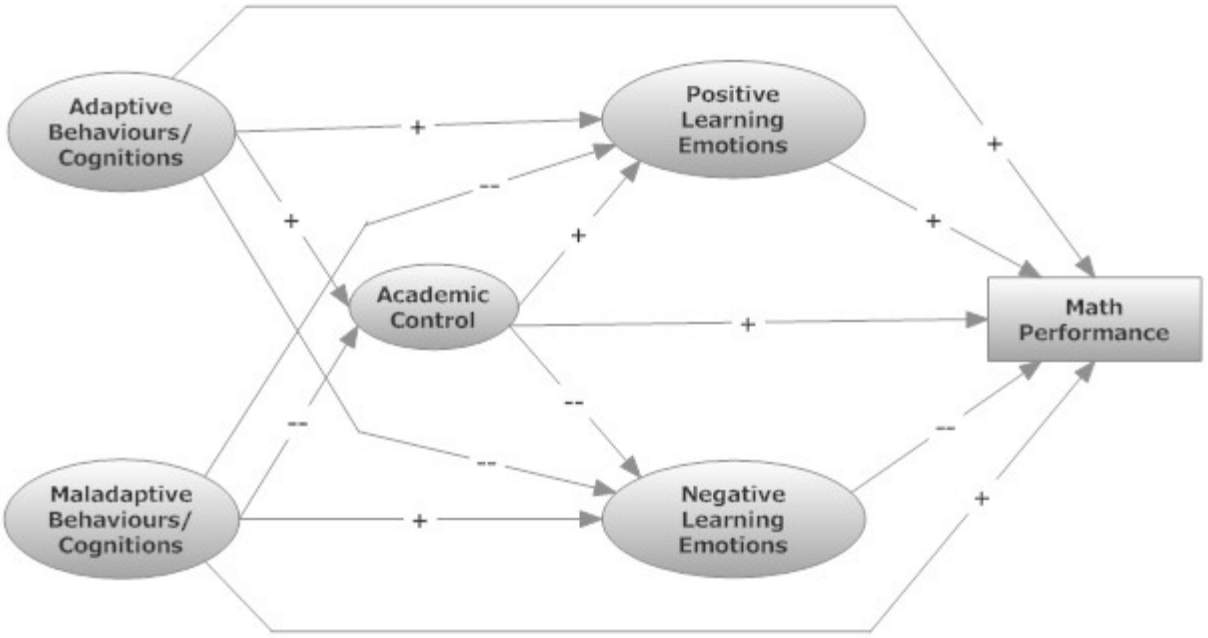

Figure 2. The hypothesized structural model

The hypothesized structural model expresses that adaptive cognitions and behaviours, academic control, positive emotion, and performance are all hypothesized to be positively related, whereas maladaptive cognitions and behaviours and negative emotions are hypothesized to be positively related amongst them, but negatively related with the first subset of variables. Not explicit in this conceptual model is that distal antecedents are represented by second order factors of the motivation and engagement instrument, however allowing for path estimates being different from factor loadings.

2. Method

2.1. Sample and setting

The participants were 3451 freshmen (19 years old on average, 62.5% male) enrolled over four consecutive academic years (10/11, 11/12, 12/13, 13/14) in a Business and Economics program at a European University. Most students had an international background, a vast majority (77.4%) holding an international education diploma and one third of the sample had been previously educated in the field of mathematics (mathematical major specialization).

The setting was a compulsory introduction course to mathematics and statistics, scheduled in the first term of the academic year. It had a duration of eight weeks out of which, seven weeks were scheduled for education and the last week was reserved for exams.

2.2. Procedure

In week two of the course students completed an online questionnaire concerning their adaptive and maladaptive cognitions and behaviors towards learning at university in general. In week four participants completed another online questionnaire, this time about their control appraisals and LREs regarding the specific subject of the course. The timing was chosen to capture sufficient experience with the learning activities.

In weeks three, five and seven of the course, voluntary mathematics and statistics quizzes were planned which, if performed successfully, added a bonus score to the final course grade. Every week, students were expected to prepare homework assignments which, if solved, granted students bonus points. In week eight of the course, students participated in the written exam. All students included in this study provided informed consent for the data collected by means of online questionnaires and for use of their study results.

2.3. Measures and variables

We measured Learning-related emotions through four scales: Enjoyment, Anxiety, Boredom and Hopelessness, of the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011). The Enjoyment scale (10 items, e.g. “I enjoy accruing new knowledge”), Anxiety scale (11 items, e.g. “I get tense and nervous while studying”), Boredom scale (11 items, e.g. “The material bores me to death”) and Hopelessness scale (11 items, e.g. “I feel hopeless when I think about studying”) were slightly re-phrased to match the specific situation of our course. For reasons of consistency in our research, all items were answered on a 7-point Likert scale (1 = ‘completely disagree’ and 7 = ‘completely agree’).

Control appraisals were measured with the Academic Control Scale (ACS) of Perry et al. (2001). Academic control as described by Perry et al. is a domain, course-specific measure of college students’ beliefs. The scale is composed of eight items, each answered on a 7-point scale (1 = ‘strongly disagree’ and 7 = ‘strongly agree’), e.g. “I have a great deal of control over my academic performance in this course”.

Adaptive and maladaptive cognitions and behaviors were measured with the Motivation and Engagement Scale (MES; Martin, 2007). The MES consists of four scales and eleven subscales subsumed under the four scales. The Adaptive Cognition scale is composed of three sub-scales: Self-Belief (e.g. "If I try hard, I believe I can do my university work well"), Valuing School (e.g. "Learning at university is important for me") and Learning Focus (e.g. "I feel very pleased with myself when I really understand what I'm taught at the university"). The second scale, Adaptive Behavior contains the following subscales: Persistence (e.g. "If I can't understand my university work at first, I keep going over until I do"), Planning (e.g. "If I start an assignment I plan out how I am going to do it") and Study Management (e.g. "When I study, I usually study in places where I can concentrate"). The third sub-scale, Maladaptive (Impeding) Cognition includes the Anxiety (e.g. "When exams and assignments are coming up, I worry a lot"), Failure Avoidance (e.g. "Often the main reason I work at university is because I don't want to disappoint others") and Uncertain Control (e.g. "I am often unsure how I can avoid doing poorly at university") sub-scales. Finally, Maladaptive Behavior includes the Self-Handicapping (e.g. "Sometimes I don't study very hard before exams so I have an excuse if I don't do as well as I hoped") and Disengagement (e.g. "I often feel like giving up at university") sub-scales.

Academic Achievement was measured with a performance portfolio consisting of three separate parts: MathPerformance, StatsPerformance and BonusPerformance. First, the two performance outcomes MathPerformance and StatsPerformance were assessed in a final written exam which covered a mathematics component and a statistics component, graded separately. Second, the BonusPerformance represented the sum of bonus scored in quizzes and homework. Quizzes, although optional, were available for both mathematics and statistics in an online format. Some further bonus could be achieved by doing weekly homework, containing assignments for mathematics and statistics. Finally, the three separate parts were summed in the QMPerformance which represented the total score for the course.

We accounted for any potential influences coming from gender (Female and Male) and level of introductory mathematics education (distinguishing between two tracks, MathMajor and MathMinor) as control variables.

2.4. Statistical analyses

As a preliminary step in the analysis, the four cohorts were checked upon invariance of mean levels and correlation structures. Next, beyond descriptive analyses, this study applies structural equation modeling. Models were estimated with LISREL (version 8.8) using maximum likelihood (ML) estimation. To prevent capitalization on chance, rather conservative model building rules were adapted: p-values of 1% or less were required as a cutoff value for significance for the adoption of any structural path; correlated traits were only allowed for variables measured by the same instrument. As measurement model for the motivation and engagement constructs, a second order confirmatory factor model was postulated, with second the order factors Adaptive Cognitions, Adaptive Behaviors, Impeding Cognitions, and Maladaptive Behaviors (see Martin, 2007). We identified both second order and first order latent factors for motivation and engagement variables, and in order to derive a parsimonious model, we based the relationships with LRE's and control appraisal on the second order factors. However, we allowed for differentiated effects of first order factors, by testing if first order factors would add predictive power to the already included second order factors.

We report the Chi-square and degrees of freedom values, the Comparative Fit Index (CFI), the Non-Normed Fit Index (NNFI, also known as TLI) and the Root Mean Square Error of Approximation (RMSEA) as indicators of goodness of fit. Hu and Bentler (1999) suggested for CFI/TLI values larger than .90 for a satisfactory fit and for RMSEA values should not exceed .08 and preferably be .06 or lower.

3. Results

3.1. Preliminary analysis

We checked the assumptions of normality through SPSS 22. Values of skewness and kurtosis were in the expected range of chance fluctuations in that statistic for all scales. To make the performance measures equivalent over cohorts, we transformed exam scores into cohort specific z-scores. These transformed variables were used in all subsequent analyses. We provide descriptive statistics and reliabilities (Table 1) – as well as measures for differences between gender and prior education track. All analyses were based on a subset of students for which background characteristics, LREs variables and performance data were all available (3355 of the 3451 students, 97%).

Table 1.

Means (M), standard deviations (SD), Cronbach's alpha and test statistics for gender and prior mathematics education differences: t-value and Cohen d-value

	M	SD	α	Gender difference		Math prior education	
				t –value	*d–value*	*t –value*	*d–value*
Adaptive Cognitions:							
Self-Belief	5.82	0.73	0.73	1.08	0.04	2.86**	0.10
Valuing School	5.84	0.67	0.67	-5.15 ***	-0.18	1.65	0.06
Learning Focus	5.95	0.73	0.80	-9.65***	-0.34	-0.14	0.00
Adaptive Behaviors:							
Planning	4.79	0.99	0.73	-9.73***	-0.34	0.15	0.01
Study Management	5.56	0.89	0.74	-9.04***	-0.32	-2.66*	-0.09
Persistence	5.34	0.85	0.78	-6.79***	-0.24	1.00	0.04
Impeding Cognitions:							
Anxiety	4.50	1.27	0.83	-16.12***	-0.57	-6.07***	-0.21
Failure Avoidance	2.57	1.19	0.83	0.90	0.03	-1.45	-0.05
Uncertain Control	3.45	1.18	0.80	-5.418***	-0.19	-4.58***	-0.16
Maladaptive Behaviors:							
Self-handicapping	2.43	1.08	0.81	5.68***	0.32	-0.45	-0.02
Disengagement	1.97	0.90	0.74	7.09***	0.25	1.20	0.04
Academic Control	5.26	0.89	0.82	3.868***	0.14	13.68***	0.48
Learning-related Emotions							
Anxiety	3.85	1.11	0.91	-11.41***	-0.40	-15.13***	-0.53
Boredom	2.94	1.13	0.93	7.65***	0.27	-4.44***	-0.16
Hopelessness	3.01	1.22	0.94	-7.18***	-0.25	-17.08***	-0.60

Enjoyment	4.11	0.92	0.85	-0.55	-0.02	10.40***	0.37
Performance outcomes							
Math performance				-1.03	-0.04	20.47***	0.72
Stats performance				1.68	0.06	11.87***	.042
Bonus performance				-6.70***	-0.24	11.73***	0.41
QM performance				-1.00	-0.04	18.41***	0.65

Note: performance scores are normalized scores; concerning gender differences, a negative score represents *female* students; a positive score in the differences in previous math education represents *math major*.

3.2. Bivariate correlations

Bivariate correlations are reported in Table 2. Due to the large number of manifest variables, the correlation table contains scale values rather than individual item values for the survey data based on the AEQ, ACS and MES instruments. The four performance measures are manifest variables too.

Table 2.

Correlations of scales of the AEQ, ASC, and MES instruments (1-16) and performance measures (17-20)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
01 Self-Belief	1.00																			
02 Valuing School	.55	1.00																		
03 Learning Focus	.56	.63	1.00																	
04 Planning	.27	.33	.35	1.00																
05 Study Management	.34	.40	.43	.54	1.00															
06 Persistence	.47	.47	.49	.49	.44	1.00														
07 Anxiety	-.14	.02	.11	.05	.09	-.01	1.00													
08 Failure Avoidance	-.26	-.21	-.20	.07	-.13	-.21	.27	1.00												
09 Uncertain Control	-.33	-.17	-.13	-.12	-.11	-.24	.51	.39	1.00											
10 Self-handicapping	-.29	-.30	-.34	-.28	-.28	-.39	.10	.43	.30	1.00										
11 Disengagement	-.45	-.47	-.47	-.23	-.30	-.39	.07	.41	.32	.53	1.00									
12 Academic Control	.73	.23	.24	.11	.12	.29	-.32	-.22	-.44	-.20	-.26	1.00								
13 Anxiety	-.20	.05	.00	-.04	.00	.11	.61	.25	.48	.17	.14	-.57	1.00							
14 Boredom	-.24	-.29	-.31	-.26	-.28	-.39	.08	.24	.24	.36	.34	-.34	.35	1.00						
15 Hopelessness	-.32	-.11	-.16	-.12	-.10	-.29	.49	.30	.50	.28	.28	-.70	.82	.51	1.00					
16 Enjoyment	.22	.21	.26	.25	.21	.35	-.09	-.04	-.14	-.15	-.10	.37	-.31	-.50	-.45	1.00				
17 Math performance	.10	.04	.07	.03	-.03	.12	-.18	-.12	-.17	-.16	-.12	.36	-.32	-.20	-.39	.24	1.00			
18 Stats performance	.10	.02	.04	-.02	-.08	.06	-.21	-.14	-.17	-.16	-.14	.27	-.24	-.10	-.30	.09	.60	1.00		
19 Bonus performance	.09	.08	.12	.11	.09	.16	-.08	-.13	-.12	-.22	-.17	.25	-.20	-.24	-.30	.22	.56	.50	1.00	
20 QM performance	.11	.05	.07	.03	-.03	.12	-.21	-.15	-.19	-.20	-.16	.36	-.32	-.20	-.30	.21	.90	.86	.71	1.00

Note: all correlations larger or equal to .05 in absolute size, are statistically significant at the .01 level; performance scores are normalized scores.

The signs of the bivariate correlations express the divide into adaptive and maladaptive constructs. Adaptive cognitions and behaviours are positively correlated to 1) Academic Control, 2) the positive LRE of Enjoyment, and to 3) performance measures. Correlations with performance measures are however weak, and not fully consistent for Study Management. Correlations between Academic Control and Enjoyment versus performance measures are stronger, and consistently positive. A reverse pattern exists for the maladaptive cognitions and behaviours: positively correlated to negative LREs, negatively correlated to Academic Control, Enjoyment and performance measures. However, within the motivation and engagement variables, Anxiety is unique in that it acts as a maladaptive cognition dimension in relation to LREs and performance. Yet, it correlates weakly with other maladaptive MES variables, as well as with the adaptive constructs (Learning Focus, Study Management, and Planning) but to a lesser degree.

3.3. Structural models

Separate structural equation models were estimated for each of the four performance constructs, each of them having identical relationships between the motivation and engagement latent constructs, and the latent constructs based on LREs and Academic Control. Figure 3 contains the diagram of the structural part of the structural equation model (leaving out the measurement parts of the LRE, academic control and motivation and engagement constructs for reasons of readability), having only the mathematics score in the exam as performance construct. It is relevant to mention that structural models for the other performance constructs deviate only in terms of the equation predicting the performance constructs, and these equations are provided at the end of this section, in Table 3. All regression paths are expressed as standardized betas. Structural models were estimated in two multi-group specifications: on the basis of gender, and on the basis of prior mathematics track in high school. Both result in a rejection of invariant latent means, fully in line with the outcomes of the descriptive analyses: differences in mean scales between female and male students, and between students educated in the math major, versus math minor track, also show up as significant differences in latent means. However, at the stringent .01 significance level, no rejection of the hypothesis of invariant estimates in the variance-covariance structure was found: the structural relations appear to be the same for the subgroups. Fit indices of both two-group models were nearly identical, with $\chi 2$ = 26,424 and 25,946 respectively, and identical measures for df = 9,030, CFI = .98, NNFI = .98, RMSEA = .39, 95% CI RMSEA = (.38, .39), for the structural models including the mathematics score as performance measure.

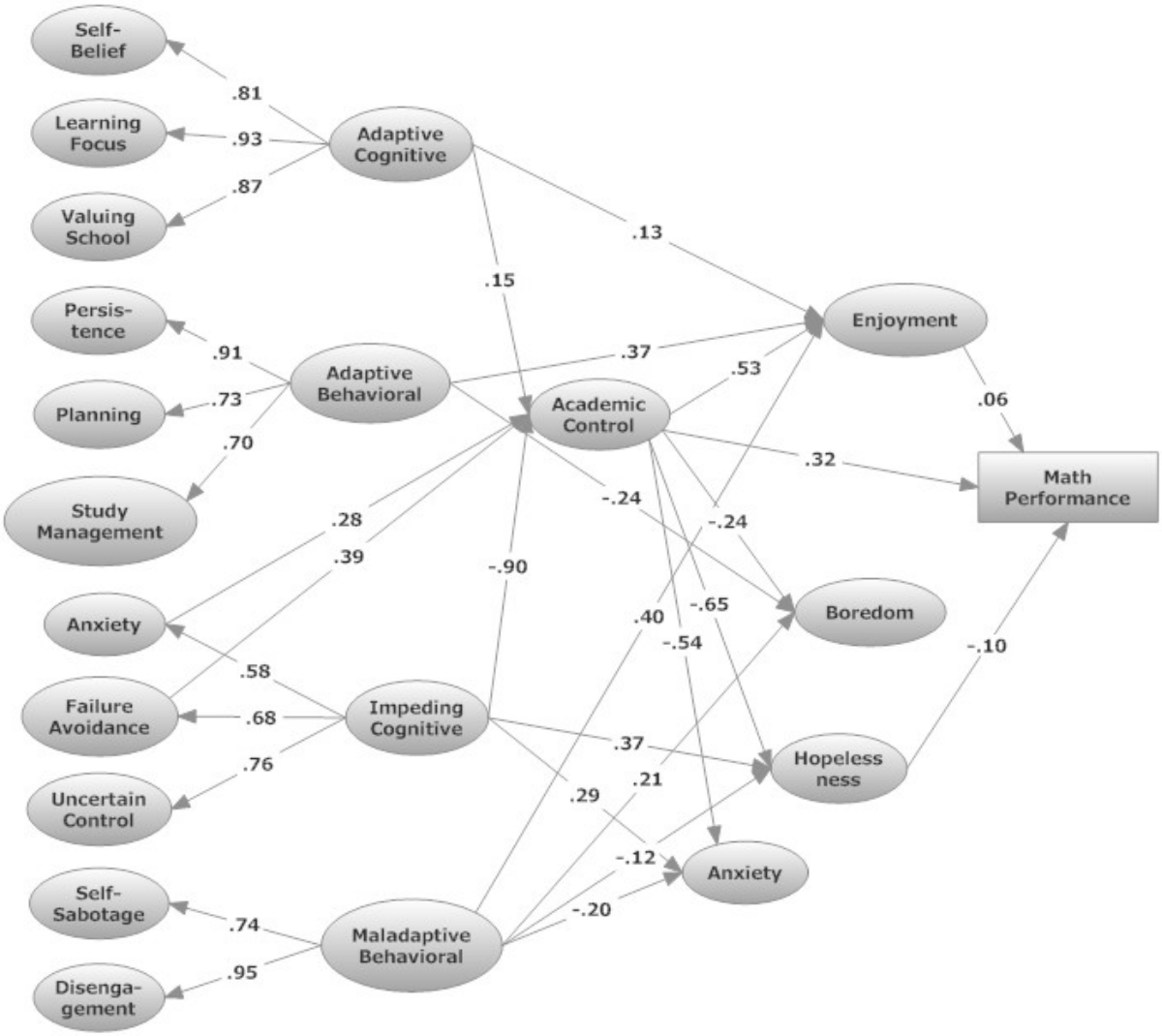

Figure 3. Path diagram of structural part with standardized estimates

3.3.1. Testing Hypotheses

In H1 we expected that the distal antecedents will have effects on both control appraisals and LREs. In agreement with the CVTAE (Pekrun, 2006), Academic Control plays a central role in the antecedent-consequence relationship of adaptive and mal-adaptive cognitions and behaviours, and LREs. Academic Control is a pure cognitive construct: it builds on contributions from adaptive and maladaptive cognitions, excluding any behavioural influence. Impeding cognitions as a whole have a strong negative impact on Academic Control. This is explained by the fact that impeding cognition is most strongly reflected by Uncertain Control (.76). At the same time, that effect is attenuated by the two paths of Anxiety (.56) and Failure Avoidance (.68), which constitute the first order factor of impeding cognition. Since behaviours, both of adaptive and maladaptive type, do not contribute to Academic Control, the relationships between behaviours and emotions are only direct ones. The paths originating from adaptive cognitions are fully in line with the hypotheses: positive impact on Enjoyment (.13), negative impact on Boredom (-.24). However, the maladaptive behaviours do play a rather remarkable role. Although bivariate relations are all in the hypothesised direction (positive with negative emotions, negative with the positive emotion), within the full structural model, the additional impact of maladaptive behaviours on LREs is positive for Enjoyment (.40), whilst its impact on Anxiety is negative (-.20). This is the resultant of a multiple relationship with colinearity amongst maladaptive cognitions and behaviours: for given levels of academic control and maladaptive

cognitions, the additional effect of maladaptive behaviours is adverse to the bivariate effect. Gender differences may also contribute to these adverse effects: male students score much higher than female students on maladaptive behaviours, but at the same time demonstrate less emotion of anxiety and hopelessness.

In H2 we assumed that control appraisals will influence positively enjoyment and negatively anxiety, boredom and hopelessness. As hypothesized and already shown in the bivariate relations analysis, Academic Control has indeed a strong effect on the four LREs. These effects are positive for Enjoyment and negative for all other three emotions. The strongest effect is observed for Hopelessness (-.65). Then, Enjoyment and Academic Control and Boredom and Academic Control respectively, relate rather weaker (.32, -.24). The relation between Academic Control and Anxiety (-.54) is rather strong and has a negative direction: the students in our sample are on average high in Academic Control (M=5.26) which might result on a rather lower level of Anxiety (M=3.85).

In H3 we specified that the distal antecedents, direct antecedents and LREs all explain student performance in the course. We notice a consistent and dominant role of Academic Control on performance. Then, a secondary role of Hopelessness, with a crucial exception: for the bonus score (which is composed of the digital homework and quizzes). This result is very plausible: for students high in Hopelessness, it is rational to allocate relative high levels of time and effort to learning in the digital tool, given its intensive scaffolding. Since the share of the bonus is much smaller in the overall score than the share of Math and Stats exam scores, in the overall score the negative impact of Hopelessness is back. A remarkable role is played by Enjoyment: it impacts performance, as expected, positively for Math; nevertheless, it impacts performance negatively in Stats. Again, this finding can be regarded as very plausible, due to the different nature of mathematics and statistics education. Students who like mathematics a lot tend to prefer it over statistics. Evidence for this claim is indirect: t-test for independent groups indicates that students from the 'math major' track score different in Enjoyment, Hopelessness and Anxiety, from students from the 'math minor' track. European 'math major' tracks focus on mathematics only, not on stats, and very often contain less statistics subjects than the 'math minor' track. Since Enjoyment has opposite impact on Math and Stats Performance, it is no surprise that it drops out as explanatory variable in the total score, QM I Performance. Lastly, Self-Handicapping enters as explanatory variable in one performance category: Bonus. Again, this is very plausible: it requires discipline to do all the homework, so students high in Self-Handicapping will underperform. Since Bonus has only a small share in the total score, it is not visible for QM I performance. For a more detailed overview of each's variable contribution in each of the four performance outcomes, the relations between these variables are provided in the equations below (coefficients for each independent variable are expressed in standardized betas):

MathPerfomance = 0.32*AcademicControl + 0.06*Enjoyment – 0.10*Hopelessness

StatsPerfomance = 0.27*AcademicControl – 0.10*Enjoyment – 0.13*Hopelessness

BonusPerfomance = 0.24*AcademicControl + 0.09*Enjoyment – 0.16*SelfHandicapping

QM1Perfomance = 0.33*AcademicControl – 0.13*Hopelessness

4. Discussion

Recent work suggests that learning-related emotions (LREs) play a crucial role in performance especially in the first year of university, a period of transition for most students; however, additional research is needed to show how these emotions emerge. To explain this classical problem, we developed a framework which links two types of antecedents of LREs: 1) the course-contextualized academic control in the Control Value Theory of Achievement Emotions (Pekrun, 2006) as a direct antecedent and 2) the generic adaptive and maladaptive cognitions and behaviors from the Motivation and Engagement Wheel framework (Martin,

2007) as distal antecedents. We used this framework to predict learning achievements in a mathematics and statistics course.

The main findings of this study bring forth the emergence of four distinct LREs (Enjoyment, Anxiety, Boredom and Hopelessness) and the fact that they standalone from students' individual performance. Such findings are reassuring: although LREs are important, they are not blocking students to perform academically. More importantly, the relations between LREs and performance are rather weak when taking into account their antecedents. Especially, in the mediational model comprising Academic Control, LREs and performance, we see that Academic Control plays a central role in the development of the four LREs investigated in our study as well as for what regards the performance outcomes in the course. The direct relationship between appraisals and performance strongly dominates the indirect relationship through LREs. Next, Academic Control has a strong effect on all of the four LREs with the strongest impact observed for Hopelessness and secondary, for Anxiety. The model explaining the four LREs is again of mediational type. Beyond the indirect effect through the control appraisal, there are direct effects from the four second order motivation and engagement factors to the LREs. In this part of the model, direct and indirect effects rather well balance in size.

Academic Control, on one hand, builds on contributions from adaptive and mal-adaptive cognitions solely, where the main impact is explained by the Uncertain Control dimension of impending cognitions. On the other hand, adaptive cognitions have a positive impact on Enjoyment and a negative one on Boredom. Where impeding cognitions confirm the hypotheses of positive relationship with the negative emotions, surprisingly though, the maladaptive behaviours impact the LREs positively for Enjoyment and negatively for Anxiety. It seems that amongst students scoring high on maladaptive behaviour (amongst them an over-representation of male students), there exists a dislike of the learning activities (increased levels of Boredom), but not of the learning content: high Enjoyment, low Anxiety. With respect to the implications on performance outcomes, the most consistent role is played by Academic Control; this is followed by Hopelessness (with the exception played for Bonus as detailed earlier). At last, an important role is also played by Enjoyment: it has opposite impact for Math (positive) and Stats (negative) performance.

Our findings are consistent with earlier research on the central role of control appraisals in the emergence of achievement emotions (Pekrun et al., 2002; Perry et al., 2001) as well predicting performance at the course level (Hall et al., 2006). This study also provides support for the positive relations between impeding cognitions and negative emotions (Martin & Marsh, 2006). Conversely, it extends such evidence by showing maladaptive behaviours influencing positively Enjoyment and negatively Anxiety. We therefore extend on the Control Value Theory of Achievement Emotions (Pekrun, 2006) by integrating the distal antecedents of emotions from the Motivation and Engagement Wheel framework (Martin, 2007). Most notably, to the knowledge of the authors, the study is the first of its kind in using an integrated framework to ultimately explain achievement outcomes in the first year at university. We have provided a new approach to understand students' emotional experiences when they first enter a university study. In this respect, the two theories are complementary: on one side our results are an empirical validation of the CVTAE; on the other side, the concepts operating in the MES could provide practical solutions on how to facilitate educational change in the classroom by using the influence these variables have in the experience of emotions.

4.1. Additional findings

Although not the main focus of this study, we find interesting gender patterns and effects of prior education. They are described separately. First, in our descriptive analysis, we find gender patterns that match earlier research (Martin, 2007). Females score significantly higher on all adaptive dimensions, with one exception: Self-Belief, where no significant difference is found. Statistical significance of gender differences is however inflated by the large sample size; effect sizes are in the .2 to .4 range, therefore, small in size. With regard to the maladaptive dimension, we find the same pattern as described by Martin (2007): maladaptivity expresses itself stronger in the form of impeding cognitions in females, but in the form of maladaptive behaviours in males. The gender effect in Anxiety is not only significant, but also medium in size, again in line with previous research (Preckel, Goetz, Pekrun, & Kleine, 2008). This divide between the

cognitive and behavioural aspects of maladaptivity repeats itself in the LREs. It is in Boredom, the behavioural aspect of neutral emotions (see Pekrun et al., 2002), that males score higher than females, and in the cognitive aspects of the negative LREs, Anxiety and Hopelessness, that females score higher. The last gender effect refers to Academic Control, where male students score higher than female students, in line with outcomes of self- concept research (Frenzel et al., 2007).

The second effect we investigated refers to prior education: having been educated in high school in an advanced, rather than a basic mathematics track. The impact on the generic dimensions of motivation and engagement are quite small, as to be expected. Students from the advanced track are higher in Self-Belief, but lower in Study-Management and Anxiety; effect sizes are however very small. These findings contrast the impact of prior education on the LREs and Academic Control: the largest effect size, .6, is observed for Hopelessness; in rest we find medium size effects. These effects point in the direction that students from the advanced track are higher in Enjoyment and Academic Control and lower in Anxiety, Hopelessness, and Boredom.

4.2. Limitations

Using a large sample, our study proposed a framework linking control appraisals (as direct predecessor) with motivation and engagement concepts (as distal predecessors) in an attempt to better explain the emerge and consequences of LREs in a first year undergraduate mathematics and statistics course. However, we point out two limitations.

First of all, our LREs measures (assessed through self-reports) rely heavily on retrospective beliefs about emotions, which make them subject to the same biases as the self-appraisals (Robinson & Clore, 2002). At the same time, self-reports still remain the most reliable measure (Zeidner, 1998) and, for that reason - the most extensively used approach, which is able to capture in a non-invasive manner students' emotional experiences in an educational setting.

Second, while in the present study we tried to answer how emotions emerge in an introductory course, an important question for future studies remains: how students' emotions change over different courses in the first year at university. Future work should employ the use of a longitudinal design, over a period of time and different course subject which could cover ideally an entire year of study.

4.3. Recommendations for further research

Some general recommendations should be outlined. First, our results showed that amongst students scoring high on maladaptive behaviour, there is a dislike of the learning activities (increased levels of Boredom), but not of the learning content: high Enjoyment, low Anxiety. We propose that they solve this tension by designing their own learning trajectories, participating at a lower level in homework and quizzes (as evident from the role of Self-handicapping in explaining the bonus performance), and prepare independently for the exam.

We mentioned earlier that the evidence gained in our study could potentially inform the design of educational interventions to improve academic achievement while, at the same time, support building emotionally sound learning environments. In this respect, a first aspect to consider would be that any educational interventions in the classroom should foster students' sense of competency towards the specific learning activities required in a mathematics and statistics course. If such progress is acquired, then reinforcing – by means of feedback – the certainty of control over the activities and outcomes in which students engage is key. Increasing students enjoyment and decreasing their hopelessness seems intuitive, still these measures should be regarded in context together with the factors from which they emerge, the maladaptive behaviours. If emotions are more difficult, and less desirable, to influence directly, addressing students maladaptive behaviours could be a reasonable solution.

4.4. Conclusion

It can be concluded from our study that next to personal factors that bring their contribution (especially in the development of Academic Control), it is the contextual experience in a course that shapes students' emotional experiences and performance. Besides all other known factors, emotions seem to play a central role in any learning process as an input and as a major educational outcome next to academic performance (Pekrun, Frenzel, Goetz, & Perry, 2007). Therefore, learning about the factors that play a role in how these emotions develop – and how, in turn, they further influence academic outcomes – is crucial. Good education should also care about how students feel and not only how well they can perform academically.

Keypoints

- Academic control impacts strongest learning hopelessness
- Adaptive cognitions impact both learning enjoyment and boredom
- Maladaptive behaviours impact learning enjoyment and anxiety
- Achievement outcomes are mainly predicted by academic control and learning hopelessness

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