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Article

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Reciprocal Relations between Academic Enjoyment, Boredom, and Achievement over Time

Abstract

The control-value theory (CVT) proposes that achievement emotions and academic achievement show reciprocal effects over time. Previous studies have examined how achievement emotions predict subsequent achievement. However, evidence is limited for whether achievement can also predict achievement emotions. To examine these reciprocal relations, data were collected about two achievement emotions: enjoyment and boredom, and mathematics achievement over four waves in a single school year in primary school students in Years 5 and 6. Results from structural equation modeling supported reciprocal relations between emotions and achievement. Higher enjoyment and lower boredom predicted greater subsequent achievement and, in turn, greater academic achievement predicted subsequent greater enjoyment and lower boredom. Furthermore, the relations between emotions over time were mediated by achievement. These findings build on the evidence base for CVT and further understanding of relations between achievement emotions and academic achievement in younger students.

Keywords: Achievement emotions, enjoyment, boredom, academic achievement, control-value theory

1. Introduction

The aim of this study was to further understand the relationship between academic emotions and academic achievement in children. A number of studies have shown that emotions are not merely a by-product of learning and achievement but, critically, impact on subsequent achievement in tandem with self-system variables such as motivation, learning strategies, and competence beliefs (e.g., Kyttälä & Björn, 2010; Pekrun, Goetz, Daniels, Stupinsky, & Perry, 2010). Hence, understanding the development of children's affect, and how it operates in the school context, offers useful possibilities to impact and positively influence children's learning and achievement.

In particular, we examined relations proposed in control-value theory (CVT) that link emotions and achievement. CVT presents an integrated typology of emotions typically experienced in competence and achievement-based settings, with a cognitive-motivational explanation of the antecedents and outcomes of those emotions (Pekrun, Goetz, Titz, & Perry, 2002; Pekrun 2006; Pekrun, Frenzel, Goetz, & Perry, 2007; Pekrun & Perry, 2014). In CVT, achievement emotions are positioned as an antecedent of academic achievement. However, relations between achievement emotions and academic achievement are not unidirectional. Academic achievements are also thought to influence subsequent emotions. Hence relations are expected to be reciprocal; academic emotions predict subsequent academic achievement and vice versa.

There is substantial empirical evidence that discrete achievement emotions, especially anxiety, can predict subsequent academic achievement (e.g., Mega, Ronconi, & De Beni, 2014; Ranellucci, Hall, & Goetz, 2015; Pekrun, Goetz, Perry, Kramer, Hochstadt, & Molfenter, 2004). Evidence for academic achievement influencing subsequent emotions, or academic achievement and emotions operating reciprocally over time is much more limited (Pekrun, Hall, Goetz, & Perry, 2014; Pinxten, Marsh, De Fraine, Noortgate, & Dame, 2014).

Furthermore, studies examining the relations between achievement emotions and academic achievement have tended to use populations of undergraduate and secondary school students. There is limited evidence for how these relations might operate in younger students. In this study we address these limitations by examining the reciprocal relations between emotion and achievement proposed in CVT, in a sample of primary school children. Specifically, we examine how academic achievement relates to two subsequent academic emotions (enjoyment and boredom), and, in turn, how these emotions relate to subsequent academic achievement.

1.1 Achievement Emotions

Achievement emotions refer to those emotions experienced by students in learning, classroom and testing contexts (Pekrun et al., 2002). These emotions can be distinguished from other affective states and experiences that are experienced during achievement-related settings, such as mood, which are typically less intense, longer lasting, and do not have a specific object focus (Linnenbrink, 2006; Linnenbrink & Pintrich, 2002; Linnenbrink-Garcia & Barger, 2014; Pekrun, 2006). Control-value theory (CVT) differentiates between discrete achievement emotions along dimensions of valence (pleasant vs. non-pleasant), activation (activating vs. deactivating), and object focus (activity vs. outcome) (Pekrun 2006; Pekrun et al., 2002, 2007; Pekrun & Perry, 2014).

In this study, we concentrated solely on two emotions: Enjoyment and boredom. These are two of the most intensely and frequently experienced achievement emotions (e.g., Frenzel, Thrash, Pekrun, & Goetz, 2007; Goetz, Frenkel, Pekrun, Hall, & Lüdtke, 2007) and thus likely to impact on achievement outcomes more strongly than emotions that are experienced infrequently. Enjoyment is defined as a pleasant activating emotion whereas boredom is defined as an unpleasant deactivating emotion.

1.2 Control-value Theory of Achievement Emotions and Academic Achievement

CVT was used in this study as the framework for theorizing the reciprocal relations between activity-focused emotions (enjoyment and boredom) and academic achievement. According to CVT, achievement emotions influence achievement through motivational and cognitive processes (Pekrun et al., 2002, 2007; Pekrun, 2006; Pekrun & Perry, 2014), which in turn should determine qualitative differences in achievement and performance. Positive activating emotions, such as enjoyment, reinforce task activity, focus attention on the task, and facilitate flexible, deep learning strategies. In contrast, negative deactivating emotions, such as boredom, are characterized by a desire to avoid the situation, undermine task incentives and systematic use of learning strategies, and disrupt attentional focus, thus resulting in superficial learning (Kuhbandner & Pekrun, 2010). Accordingly, enjoyment is associated with higher achievement whereas boredom is associated with lower achievement, in both secondary school and undergraduate students (e.g., Ahmed, can der Werf, Kuyper, & Minnaert, 2013; Daniels, Stupnisky, Pekrun, Haynes, Perry, & Newall, 2009; Frenzel, Pekrun, & Goetz, 2007; Goetz et al., 2007; Goetz, Frenzel, Lüdtke, & Hall, 2010; Niculescu, Tempelaar, Dailey-Hebert, Segers, & Gijselaers, 2015; Pekrun, Goetz, Daniels, Stupinsky, & Perry, 2010; Pekrun et al., 2002, 2011; Pekrun et al., 2014; Putwain, Sander, & Larkin, 2013).

As we noted earlier, there is a lack of studies of younger students in primary school linking academic achievement with learning-related affect in general, and enjoyment and boredom in particular. Furthermore, with some recent exceptions (e.g., Pekrun et al., 2010, 2014; Pinxten et al., 2014) studies linking enjoyment and boredom with subsequent academic achievement do not typically control for the autoregressive relations with prior achievement. Demonstrating that achievement emotions, such as enjoyment and boredom, can predict achievement over and above the variance accounted for by prior achievement has substantial theoretical and applied importance; emotions are not a mere epiphenomenon of academic achievement and offer credible foci of influence and intervention.

Having established that academic emotions, such as enjoyment and boredom, are related to subsequent academic achievement, what is the rationale for expecting academic achievement to relate to subsequent emotions? To answer this question it is necessary to consider the role of control and value appraisals as proximal antecedents of academic emotions. Enjoyment results from an achievement-based activity (learning or testing) being valued and judged as controllable. Boredom results from an achievement-based activity not being valued and where task demands (learning or testing) are too low or too high. Studies have confirmed that boredom is negatively associated with, and enjoyment positively associated with, academic control and competence beliefs, and intrinsic and extrinsic values, in both undergraduate and secondary school students (e.g., Ahmed et al., 2010; Goetz, Frenzel, Hall, & Pekrun, 2008; Pekrun et al., 2010, Ruthig, Perry, Hladkyj, Hall, Pekrun, & Chipperfield, 2008; for a summary, see Pekrun & Perry, 2014).

The formative and summative assessment of one's learning is likely to directly impact on student's control and value appraisals and, therefore, subsequent emotions. There is substantial evidence that academic achievement positively relates to expectation of success (Zhang, Haddad, Torres, & Chen, 2011) and competence beliefs (such as academic self-concept and academic self-efficacy) while controlling for the autoregressive relations with prior competence beliefs (e.g., Caprara, Vecchione, Alessandri, Gerbino, Barbaranelli, 2011; Marsh, Byrne, & Yeung, 1999; Marsh & Martin, 2011). Furthermore, students may de-value the importance of a particular subject following failure (Loose, Régner, Morin, & Dumas, 2012; Réneger & Loose, 2006). All things being equal, one would expect success to result in greater subsequent enjoyment by strengthening control and value appraisals, whereas failure would result in greater boredom by undermining control and value appraisals.

Few studies have examined the relations of academic achievement with subsequent academic emotions, or the reciprocal relations between academic achievement and academic emotions. Pekrun et al. (2014) showed reciprocal relations between boredom and achievement in undergraduate students, over five measurement occasions each for boredom and testing, controlling for gender, age, and high-school grades. Pixten et al. (2014), in one of the few studies to sample younger children (aged 9 – 14 years), showed reciprocal relations between enjoyment and achievement in mathematics on four out of five testing occasions. Thus, the available evidence to date supports the reciprocal relations between emotion and achievement proposed in CVT. We build on this literature in the present study, by examining the reciprocal relations between achievement, enjoyment, and boredom, in a single study using a sequential panel design with primary school students (see Little, Preacher, Card, & Selig, 2007; Rosel & Lewis, 2008).

1.3 The Model Examined in the Present Study

In the present study, data were collected over four measurement occasions in a single school year. Mathematics achievement data were collected in the first wave (T_1) shortly after the beginning of the school year (September), self-report data for enjoyment and boredom in November at the second wave (T_2), Mathematics achievement data in April at the third wave (T_3) and self-report data for enjoyment and boredom in June at the fourth and final wave (T_4). Figure 1 shows the relations between enjoyment and boredom, and academic achievement tested in this model.

Relations of emotions with subsequent achievement were examined once in this model. Following the rationale in CVT that enjoyment will reinforce, and boredom will undermine, cognitive and motivational processes, we hypothesized that T_2 enjoyment will be positively related to, and T_2 boredom negatively related to, T_3 achievement (H_1). Importantly, we were able to control for prior achievement at T_1. Hence, H_1 tested how enjoyment and boredom predicted subsequent achievement, over and above the variance accounted for by prior achievement.

Relations of academic achievement with subsequent emotions were examined in this model twice. The first occasion was from T_1 mathematics achievement to T_2 enjoyment and boredom. The second occasion was from T_3 mathematics achievement to T_4 enjoyment and boredom. In terms of CVT these represent the under-researched path from academic achievement to achievement emotions. For the first occasion, it was not possible to control for autoregressive relation with prior emotions, thereby offering only a small advance over a cross-sectional design by showing whether relations persist over time. The second occasion, however, offered a powerful test of how achievement relates to subsequent emotion as the autoregressive and cross-lagged relations with prior (T_2) enjoyment and boredom were controlled.

Furthermore, it was theorized that success would increase perceived control and value, and hence increase enjoyment and reduce boredom. Accordingly, we hypothesized that academic achievement will be positively related to subsequent enjoyment and negatively related to subsequent boredom (H_2).

In addition to examining reciprocal relations between emotions and achievement, this analytic model offers the possibility to examine the indirect relations between emotions over time. That is, T_3 mathematics achievement will mediate the relations between T_2 and T_4 emotions. Accordingly, we hypothesized positive indirect paths from T_2 to T_4 enjoyment and from T_2 to T_4 boredom (H_3).

1.4 Aims of the Present Study

The present study sought to examine the reciprocal relations between emotion and achievement proposed in CVT, measuring enjoyment and boredom in a sample of primary school students over the course of one full academic year. Due to the subject-specificity of enjoyment and boredom, and of their relations with achievement (see Goetz et al., 2007, 2010), we chose to focus on a single subject, mathematics. Mathematics education in school has been the focus of international concern to ensure adequate preparation for higher study in science, technology, engineering, and mathematics (STEM) subjects and ensuring a competent STEM workforce (e.g., English, 2016; Kärkkäinen & Vincent-Lancrin, 2013; Wai, Lubinski, Benbow, & Steiger, 2010). As less positive attitudes towards mathematics have generally been reported by female students (e.g., Barkatsas, Kasimatis, & Gialamas, 2009; Watt, 2006) gender was also included as a covariate. Furthermore, as the sample included students from the final two years of primary schooling in England (Years 5 and 6) and self-regulatory abilities can develop during this time (Bronson, 2001), age was also included as a covariate.

2. Method

2.1 Sample and Procedure

Data were collected from participating students over four waves across a single school year. Achievement data at T_1 and T_3 were available for all participants, thus sample size was primarily determined by response rates at T_2 and T_4. The T_2 sample consisted of 1,057 participants (48.6% male, 51.4% female) drawn from 65 classrooms in 25 primary schools in England. Participants were all in the penultimate year (Year 5, 52.4%) or final year (Year 6, 47.6%) of primary school with a mean age of 9.45 years (*SD* = 1.72). The ethnic heritage of participants was primarily Caucasian (77.5%) with smaller numbers from Asian (10.6%), Black (3.8%), or mixed heritage backgrounds (8.1%).

There was attrition at T_4, with 42.9% of the T_2 sample remaining. Attrition was due to individual students exercising their ethical right not to participate, students being absent from school on the day of data collection, or some whole schools not being able to participate due to other commitments (e.g., school visits near the end of the summer term during the week when data was collected). The T_4 sample consisted of 453 participants with similar characteristics to the T_2 sample for gender (48.7% male, 51.3% female), year group (52% Year 5, 48% Year 6), and ethnic heritage (79.3% Caucasian, 13.3% Asian, 3.3% Black, and 4% mixed heritage). Little's test, for all substantive study variables and covariates, confirmed that missing data were completely missing at random (p >.05) and handled in subsequent analyses using full information maximum likelihood (Muthén & Muthén, 2012).

Self-report data were collected from students during lesson time using personal digital assistants, routinely used in participating schools for learning and instruction, by trained class teachers. Responses were uploaded to a database with anonymized student identifiers. Consent was provided by the school Head Teacher, the class teacher and parents/ carers. Assent was provided by students and the opportunity to withdraw data was offered to them.

2.2 Measures

2.2.1 Mathematics enjoyment and boredom. Enjoyment and boredom were measured using the respective scales from the *Achievement Emotions Questionnaire-Mathematics* (Pekrun, Goetz, & Frenzel, 2005). Enjoyment was measured using ten items (e.g., 'I enjoy my maths lessons')[1] and boredom using six items (e.g., 'I think that maths lessons are boring'). Participants responded on a five-point Likert scale (strongly agree = 1, agree = 2, neither agree nor disagree= 3, disagree = 4, strongly disagree = 5). Psychometric properties of scales are reported in Table 1 below.

2.2.2 Mathematics achievement. In the English National Curriculum, student achievement and progress are benchmarked against standardized, criterion-referenced levels of progress (Department of Education, 2014). There are eight levels (1 – 8) of attainment each with three sub-levels (low, mid, and high) resulting in a twenty-four point scale. At the end of primary schooling (Year 6, aged 11 years) children are expected to attain Level 5. Schools are required to monitor and track student progress in order to fulfill requirements of the school inspectorate for accountability purposes (Department for Education, 2016), and we made use of this routinely collected data to assess participants' mathematics achievement. Individual schools have autonomy over the methods used to monitor and track students learning, but typically use data from grades and tests in conjunction with commercially available software to generate reports highlighting whether students are meeting expected levels of progress. In our study, the observed range of National Curriculum Attainment Levels ranged from Level 2 (low) to Level 6 (high) resulting in a fifteen-point scale.

Although it is not possible to establish the reliability of teacher marked classwork and tests directly, Harlen's (2004) systematic review has surmised that teacher assessment of National Curriculum Attainment Levels in primary schools are accurate and close to those of externally marked standardized tests (including *r*s of .77 – .92 for correlations between teacher assessed and externally benchmarked tests in reading and mathematics). Indeed the accurate and reliable assessment of student progress is heavily incentivized in the English educational system. Schools that do not assess student achievement accurately, or track student progress robustly, are subject to heavy sanctions including school closure, wholesale replacement of the school management, and frozen pay and progress for individual teachers (James, 2012; Perryman, 2005, 2006).

3. Results

3.1 Descriptive Statistics

Descriptive statistics are reported in Table 1. Enjoyment (at both T_2 and T_4) showed a negatively skewed, and boredom (at both T_2 and T_4) a positively skewed distribution. Acceptable reliability coefficients (Cronbach's $\alpha > .70$) were observed for all variables. Intra-class correlations (ICC_1) showed the between-class variance was notable in all variables (>.04) and substantial in T_2 enjoyment and boredom ($ICC_1 \geq .21$) as well as both September and April mathematics achievement ($ICC_1 \geq .20$). Factor loadings, reported from a confirmatory analysis described below, were all satisfactory ($\lambda > .4$). Subsequent modeling of data must account for the non-normal distribution of emotion variables and the clustering of participants within classes.

3.2 Preliminary Analyses

A measurement model was built for mathematics achievement at T_1 and T_3 and enjoyment and boredom at T_2 and T_4. Mathematics achievement at each time point was treated as a single-indicator latent variable. The single achievement indicator was not assumed to offer perfect measurement (i.e., $\lambda = 1$). Based on estimates from the literature (e.g., Hoy, Tarter, & Hoy, 2006; Watkins, Lei, & Canivez, 2007), factor loadings for both T_1 and T_3 mathematics achievement were fixed at $\lambda = .9$ ($\sigma_\varepsilon = .1$). Following the procedure adopted for the AEQ (e.g., Pekrun et al., 2011), the residual variances for enjoyment and boredom items that refer to the same setting (classroom learning, testing) were allowed to correlate at each measurement occasion. Furthermore, the residual variances for T_2 and T_4 enjoyment and boredom items were allowed to correlate over time.

A confirmatory factor analysis was used to examine the measurement model in M*plus* version 7.3 (Muthén & Muthén, 2012). The maximum-likelihood estimator with robust standard errors (MLR) was used to adjust standard errors for the non-normal distribution of data, and the ‘complex’ and ‘cluster’ commands to account for the clustering of participants in classes. To evaluate model fit, we used the root mean square error of approximation (RMSEA), standardized root means square residual (SRMR), comparative fit index (CFI), and the Tucker-Lewis index (TLI). Although various thresholds have been proposed to guide model fit (e.g., RMSEA and SRMR values $\leq .05$, and CFI and TLI values $\geq .95$, are indicative of a good model fit), the rigid application of these values has been criticized (Marsh, Hau, & Grayson, 2005; Marsh, Hau, & Wen, 2004) and may be overly ambitious for complex data (Heene, Hilbert, Draxler, Ziegler, & Bühner, 2011).

The measurement model showed an excellent fit to the data: $\chi^2(440) = 705.90$, $p < .001$; RMSEA = .024, SRMR = .044; CFI = .976, and TLI = .970. When gender (0 = male, 1 = female) and age were added to the model, the fit was $\chi^2(497) = 804.41$, $p < .001$; RMSEA = .024, SRMR = .043; CFI = .974, and TLI = .967. The latent bivariate correlations from this model are shown in Table 2. Enjoyment and boredom were strongly and negatively intercorrelated at T_2 and T_4. For interpreting these correlations, it should be noted that they are corrected for measurement error and represent the highest estimates possible for the relations between these emotions in the current dataset. Mathematics achievement at T_1 and T_3 correlated positively with enjoyment and negatively with boredom at both T_2 and T_4. Female students reported higher boredom and older students reported lower enjoyment. Although mathematics achievement correlated positively and significantly with age, the size of these correlations was negligible.

3.3 Structural Equation Modeling

A structural equation model (SEM) was used to examine the paths specified in Figure 1. In addition to the substantive variables, gender (0 = male, 1 = female) and age were entered as covariates. Analyses were performed in M*plus* version 7.3 and, like the measurement model, used the MLR estimator and controlled for class clustering effects. This reciprocal relations model was tested competitively against: (1) a baseline model in which all paths linking emotion and achievement were fixed to zero, (2) a unidirectional achievement effects model estimating effects of achievement on emotion but fixing effects of emotion on achievement to zero (unidirectional model A), and (3) a unidirectional emotion effects model estimating effects of emotion on achievement while fixing effects of achievement to zero (unidirectional model B).

Nested models were compared to the reciprocal effects model using the Satorra–Bentler scaled χ^2 difference test (TRd), appropriate for the MLR estimator (Bryant & Satorra, 2012; Satorra, 2000), and one relative fit index: the Akaike Information Criterion (AIC). A lower AIC value indicates a better fitting model (Hix-Small, Duncan, Duncan, & Okut, 2004), and an increase of AIC > 10 suggests a worse fitting and essentially unacceptable model (Burnham & Anderson, 2002). Model fit indices are reported in Table 3.

The reciprocal effects model showed a good fit to the data, $\chi^2(496) = 800.45$, $p < .001$; RMSEA = .024, SRMR = .043; CFI = .974, TLI = .967; AIC = 59,683.92. By comparison the baseline model, TRd (8) = 66.30, $p < .001$ (ΔAIC > .10), unidirectional model A, TRd (2) = 36.70, $p < .001$ (ΔAIC > .10), and unidirectional model B, TRd (6) = 82.47, $p < .001$ (ΔAIC > .10), all showed a statistically significant decline in model fit and increases in AIC indices. The reciprocal relations model would, therefore, seem preferable to the baseline or unidirectional effects models. Standardized path coefficients (βs) are reported in Table 4. Statistically significant βs for paths and Pearson's *r* coefficients for covariances are shown in Figure 2.

3.3.1 Relations between T_1 achievement, T_2 emotions, and T_3 achievement. T_1 achievement was a positive predictor of T_2 enjoyment ($\beta = .27$, $p < .001$) and a negative predictor of T_2 boredom ($\beta = -.36$, $p < .001$). Despite substantial autoregressive effect of T_1 achievement on T_3 achievement ($\beta = .73$, $p < .001$), T_2 enjoyment was a positive predictor ($\beta = .12$, $p = .03$), and T_2 boredom a negative predictor ($\beta = -.07$, $p = .04$), of T_3 achievement[2].

3.3.2 Relations between T_3 achievement and T_4 emotions, controlling for T_1 achievement and T_2 emotions. T_3 achievement was a positive predictor of T_4 enjoyment ($\beta = .30$, $p = .02$) having controlled for the autoregressive effect of T_2 enjoyment ($\beta = .44$, $p < .001$), the cross-lagged effect of T_2 boredom ($\beta = -.15$, $p = .02$), and the impact of T_1 achievement ($\beta = -.32$, $p = .003$)[3]. T_3 achievement was a negative predictor of T_4 boredom ($\beta = -.31$, $p = .002$) having controlled for the autoregressive effect of T_2 boredom ($\beta = .30$, $p < .001$), the cross-lagged effect of T_2 enjoyment ($\beta = -.10$, $p = .25$), and the impact of T_1

achievement ($\beta = .10$, $p = .34$). In terms of covariates, girls reported higher T_2 boredom ($\beta = .08$, $p = .008$)[4]. Relations of gender and age with all other variables were not statistically significant (*p*s >.05).

3.3.3 Comparing the size of reciprocal relations from T_2 to T_3 and from T_3 to T_4. The size of the standardized regression coefficients from T_2 emotions to T_3 achievement, and from T_3 achievement to T_4 emotions, was compared using a *Z* transformation (Clogg, Petkova, & Haritou, 1995). The relationship from T_3 achievement to T_4 enjoyment ($\beta = .30$) was significantly larger ($Z = 2.01$, $p = .02$) than from T_2 enjoyment to T_3 achievement ($\beta = .12$). Similarly, the relationship from T_3 achievement to T_4 boredom ($\beta = -.31$) was significantly larger ($Z = 2.45$, $p = .007$) than the relationship from T_2 boredom to T_3 achievement ($\beta = -.07$).

3.3.4 Estimates of indirect (mediated) paths. Indirect paths were examined from T_1 to T_3 achievement, T_2 to T_4 enjoyment, and T_2 to T_4 boredom. Mediating effects were assessed by creating 95% confidence intervals around the estimate of the indirect effect. Confidence intervals that do not cross zero indicate a statistically significant indirect effect ($p < .05$). The effect of T_2 on T_4 enjoyment was mediated by T_3 achievement, $\beta = .035$, $SE = .019$, 95% CIs [.003, .067]. The effect of T_2 on T_4 boredom was also mediated by T_3 achievement, $\beta = .021$, $SE = .012$, 95% CIs [.002, .041]. The effect of T_1 to T_3 achievement was mediated by T_2 enjoyment, $\beta = .032$, $SE = .016$, 95% CIs [.006, .058], and T_2 boredom, $\beta = .023$, $SE = .012$, 95% CIs [.003, .044, with a total indirect effect of $\beta = .055$, $SE = .018$, 95% CIs [.026, .085].

4. Discussion

The aim of the present study was to examine the reciprocal relations between achievement and two key achievement emotions (achievement and boredom). There already exists a substantial body of literature examining how emotions relate to subsequent achievement. The relations of achievement with subsequent emotions are comparatively under-researched. Data were collected from a sample of primary school students in Years 5 and 6 over the course of one full school year. Mathematics achievement data were collected at the first (T_1) and third (T_3) waves. Enjoyment and boredom were measured at the second (T_2) and fourth (T_4) waves. Data were analyzed using latent variable modeling in a structural equation model.

The hypothesis that T_2 emotions would be related to subsequent mathematics achievement (H_1) was supported. Higher T_2 enjoyment, and lower T_2 boredom, predicted greater T_3 mathematics achievement over and above the autoregressive effect of prior (T_1) mathematics achievement. The hypothesis that mathematics achievement would be positively related to subsequent emotions (H_2) was also supported. Higher T_1 mathematics achievement predicted greater T_2 enjoyment and lower T_2 boredom. Furthermore, higher T_3 mathematics achievement predicted greater T_4 enjoyment and lower T_4 boredom, over and above the autoregressive effects of prior (T_2) enjoyment and boredom. The hypothesis that T_3 mathematics achievement would mediate relations between T_2 and T_4 emotions (H_3) was also supported. Indirect paths were shown from T_2 to T_4 enjoyment, and from T_2 to T_4 boredom, mediated by T_3 mathematics achievement. Thus relations between enjoyment/ boredom and achievement are not unidirectional; rather, emotions and achievement interact reciprocally over time.

There already exists an impressive and substantial body of work, inspired by CVT, showing that enjoyment and boredom can predict achievement. Enjoyment positively correlates with, and boredom negatively correlates with, academic achievement (e.g., Ahmed et al.2013; Daniels et al., 2009; Frenzel et al., 2007; Goetz et al., 2007, 2010; Niculescu et al., 2015; Pekrun, 2010, 2011; Putwain, et al., 2013). Our findings confirm and build on this body of work. Importantly we offer a robust test of the link from emotions to achievement, by controlling for prior achievement as well as students' gender and age. Furthermore, most of the existing studies are conducted on samples of undergraduate or school aged populations. This study shows that the relations of emotion with subsequent achievement also apply to younger aged students in primary school settings. From the perspective of CVT, students who enjoy their mathematics lessons and tests are more cognitively engaged with their work, make more use of learning strategies, and are more motivated, hence achievement is higher (e.g., Kuhbandner & Pekrun, 2010; Pekrun, 2006; Pekrun & Perry, 2014). In contrast, students who are bored with their mathematics lessons and tests are less cognitively engaged, make less use of learning strategies, and are less motivated, hence achievement is lower.

In comparison, the relations of achievement with subsequent emotions, such as enjoyment and boredom, have not been as thoroughly researched. . Notable exceptions include Pekrun et al. (2014) for boredom in undergraduate students and Pixten et al. (2014) for enjoyment in primary school students. Our findings provide clear evidence that achievement positively predicts subsequent enjoyment and negatively predicts subsequent boredom in primary school students while controlling for prior enjoyment, boredom, and demographic variables. The likely mechanism is that children who perform well in their mathematics lessons and tests strengthen their control and value beliefs that underpin enjoyment and reduce boredom (e.g., Pekrun et al., 2010). Notably, the standardized coefficients were substantially stronger for the relations of achievement with subsequent emotions than for the relations of emotions with subsequent achievement. This is possibly due the multiplicity of competing and interacting factors that impact on achievement in addition to, and in conjunction with, emotion. In contrast, there are fewer influences on the control and value appraisals that underpin emotions, allowing a greater role for feedback on learning and achievement in shaping the development of emotions.

Few studies have examined reciprocal relations between emotions and achievement. The studies by Pekrun et al. (2014) and Pixten et al (2014), highlighted above, also found evidence for reciprocal relations between boredom and enjoyment respectively. Our findings extend this nascent literature examining the reciprocal relations between emotion and achievement proposed in CVT. While the studies by Pekrun et al. (2014) and Pixten et al (2014) included only a single emotion variable, it is noteworthy in the present study that reciprocal relations with achievement were shown when both enjoyment and boredom were included in a single analytic model. Enjoyment and boredom are conceptualized in CVT to have distinct control and value antecedents, and therefore represent distinct emotions, rather than opposing extremes of a single emotion. The findings of this study support the conceptualization of enjoyment and boredom as discrete emotions: despite the strong correlations shown between enjoyment and boredom at both T_2 and T_4, reciprocal relations with achievement remained.

Although in relative terms the size of the indirect paths was small, this is not unusual for naturalistic studies that control for autoregressive effects (Collie, Martin, Malmberg, Hall, & Ginns, 2015). Indeed, large indirect effects are typically found in complex naturalistic datasets only when autoregressive effects have not been controlled for (Martin, 2011). Furthermore, the distribution of scores for emotions assessed at T_2 would serve to constrain the size of indirect paths; there was little room for further increases in enjoyment or decreases in boredom.

The implications are nonetheless important. Emotions can interact with achievement over time in a cyclic fashion. Greater enjoyment could result in an upward spiral of greater achievement, followed by greater enjoyment and so on (referred to in CVT as feedback loops). Sadly, a downward spiral could also be expected for greater boredom. As such, intervention to increase enjoyment or reduce boredom should result in educational gains over time. This could be achieved through curriculum planning and lesson delivery designed to promote interest (e.g., Durik & Harackiewicz, 2007), mastery experience through optimal challenge (e.g., Turner, Christensen, Kackar-Cam, Trucano, & Fulmer, 2014), or activities designed to enhance value and control appraisals (e.g., Gaspard et al., 2015) that underpin high enjoyment and low boredom.

4.1 Limitations and Suggestions for Future Research

Although this study has gone some way towards evidencing the reciprocal relations between emotion and achievement in younger students, there are a number of limitations to highlight. First, with four measurement occasions it was only possible to test the relations of achievement with subsequent emotion, and of emotion with subsequent achievement, once each (while controlling for autoregressive effects) due to restrictions imposed by participating schools. A more formal test of the feedback loop between emotions and achievement, proposed in CVT, would require two or more succeeding time intervals. It is also important to highlight that although this panel design allowed for the control of autoregressive relationships, it is not a sufficient basis on which to establish causality (e.g., Rogosa, 1980). There could be third variables, not controlled for in the present study, that are a cause of both lower achievement and learning-related emotions.

Second, our test of the relations between emotion and achievement was limited to enjoyment and boredom. A number of other emotions, positive and negative, activating, and deactivating, are commonly reported by students including hope, pride, anger, and hopelessness (Pekrun et al., 2002) as well as epistemic emotions occurring during knowledge-generating activities (Pekrun, Vogl, Muis, & Sinatra, 2016). In comparison to anxiety, and more recently enjoyment and boredom, these emotions remain under-researched. Future research should extend the study of the emotion and achievement to include these emotions.

For future research, one possible solution to these limitations is, within practical and logistical constraints, to use repeated measurements with a shorter duration between each data collection time point, and shorter measures of emotions (e.g., see Gogol, et al., 2014). For instance, emotions and achievement could be studied more intensively over shorter (e.g., one or two weeks) or longer (e.g., one term) durations as temporal dynamics might unfold. The use of personal digital assistants can make demands of data matching across different waves more straightforward.

Finally, although evidence was provided for the reciprocal relations between emotion and achievement, the mechanisms underpinning these relations were not examined. According to CVT, emotions would influence achievement via various cognitive and motivational mechanisms, and achievement would in turn impact on subsequent learning-related emotions by influencing control and value appraisals potentially as a function of the learning environment (e.g. cognitive or motivational quality of the lessons or tasks). Perceived success would be expected to strengthen, and perceived failure weaken, control and value appraisals. A more nuanced examination of the emotion and achievement feedback loop would be to include measurements of these mediating mechanisms.

4.2 Conclusion

This study examined reciprocal relations between achievement and two achievement emotions, enjoyment and boredom, proposed in CVT. Evidence was provided for both forward- and backward facing paths as well as the entire loop. Emotions predicted achievement, and achievement in turn predicted emotion. Thus, emotions are not solely an outcome or epiphenomenon of academic achievement but can, and do, influence one's subsequent learning. These findings build on the evidence base for CVT, and further understanding of enjoyment and boredom in primary aged students.

Endnotes:

[1] In the UK, mathematics is colloquially referred to as maths.

[2] As the β coefficient for T_2 boredom to T_3 achievement was small, we tested an alternative model in which this path was set to zero. The fit of the alternative model was $\chi^2(497) = 803.18$, $p < .001$, RMSEA = .024, SRMR = .043, CFI = .974, TLI = .967, and AIC = 59681.93. The reciprocal effects model showed a significantly better fit than the alternative model: TRd(1) = 4.49, *p* = 03.

[3] The sign of this coefficient is the opposite of what would be predicted by theory and the Pearson's *r* coefficient (*r* = .14) shown in Table 2. This likely is an artifact of statistical suppression arising from the subsequent change in mathematics achievement from T_1 to T_3 (see Maassen & Bakker, 2001). Substantive interpretation of this coefficient to represent change, although not the focus of this analysis, would require using a mathematical procedure that involves a reversal of this sign (Kessler & Greenberg, 1981).

[4] As the β coefficient for the relation from gender to T_2 boredom was small, we tested an alternative model in which this path was set to zero: $\chi^2(497) = 805.82$, $p < .001$, RMSEA = .025, SRMR = .044, CFI = .973, TLI = .966. The reciprocal effects model showed a significantly better fit than the alternative model: TRd(1) = 6.22, *p* = .01.

5.0 References

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Table 1
Descriptive Statistics for Activity-Focused Emotions (at T_1 and T_3) and Mathematics Achievement (T_2 and T_4).

	Mean	SD	α	ICC_1	Skewness	Kurtosis	Factor Loadings
T_2 Enjoyment	4.12	0.73	.89	.21	-1.12	1.45	.49 – .77
T_2 Boredom	1.88	1.05	.92	.22	1.32	0.96	.76 – .87
T_4 Enjoyment	4.09	0.78	.91	.12	-1.00	0.65	.56 – .79
T_4 Boredom	1.87	0.98	.91	.08	1.18	0.68	.73 – .85
T_1 Mathematics achievement	6.59	1.92	—	.20	0.07	-0.08	—
T_3 Mathematics achievement	7.43	1.90	—	.21	0.15	-0.18	—

Table 2

Latent Bivariate Correlations between T_1 and T_3 Mathematics Achievement, T_2 and T_4 Enjoyment and Boredom, and Gender and Age

	1.	2.	3.	4.	5.	6.	7.	8.
1. T_2 Enjoyment	—	-.71***	.63***	-.41***	.31***	.42***	.07	-.04
2. T_2 Boredom		—	-.49***	.48***	-.27***	-.42***	.08*	.02
3. T_4 Enjoyment			—	-.61***	.14*	.31***	.05	-.13*
4. T_4 Boredom				—	-.29***	-.40***	.10*	.14
5. T_1 Mathematics achievement					—	.80***	-.02	.04*
6. T_3 Mathematics achievement						—	-.07	.04*
7.Gender							—	—
8. Age								—

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 3

Model fit indices for the nested SEMs

	χ^2 (df)	RMSEA	SRMR	CFI	TLI	AIC	BIC
Reciprocal effects model	800.45 (496)***	.024	.043	.974	.967	59683.92	60675.92
Baseline model	897.58 (504)***	.028	.084	.966	.958	59783.01	60735.53
Unidirectional model A	826.47 (498)***	.025	.047	.972	.964	59709.86	60691.99
Unidirectional model B	865.34 (502)***	.027	.070	.969	.961	59748.85	60711.25

$^{***}p < .001$.

Table 4

Standardised Path Coefficients from the SEM

	T_1 Mathematics Achievement	T_2 Enjoyment	T_2 Boredom	T_3 Mathematics Achievement	T_4 Enjoyment	T_4 Boredom
T_1 Mathematics Achievement		$.27^{***}$	$-.36^{***}$	$.73^{***}$	$-.32^{**}$	.10
T_2 Enjoyment				$.12^{*}$	$.44^{***}$	-.10
T_2 Boredom				$-.07^{*}$	$-.15^{*}$	$.30^{***}$
T_3 Mathematics Achievement					$.30^{*}$	$-.31^{**}$
Gender	-.01	.05	$.08^{**}$	-.05	.05	.06
Age	.04	-.05	.04	.02	-.11	.13

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

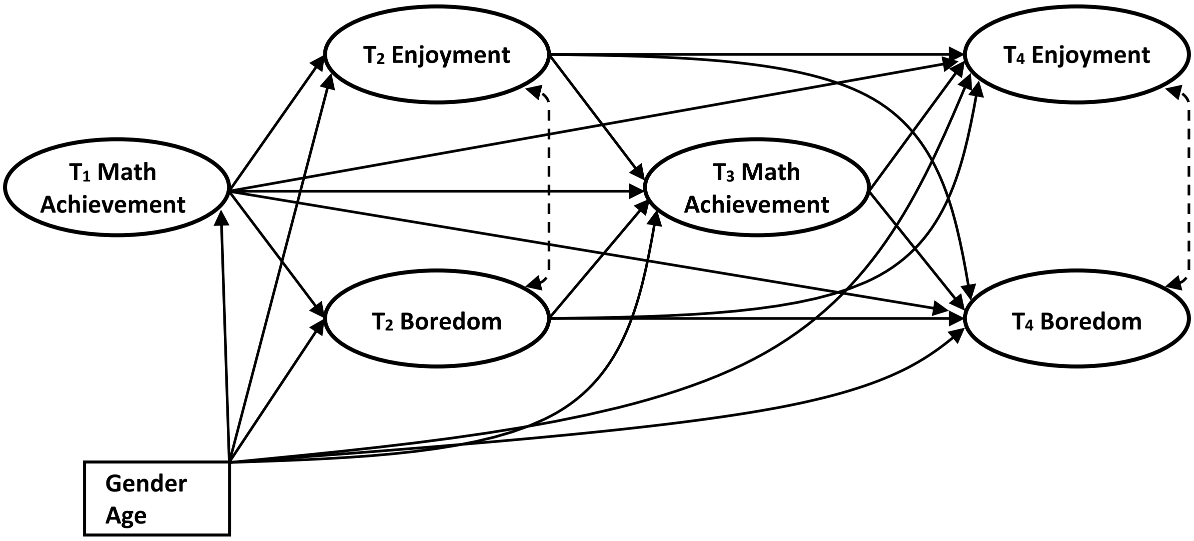

Figure 1. Model examining reciprocal linkages between mathematics achievement and activity-focused emotions (enjoyment and boredom) controlling for age and gender. Structural paths are represented as solid black lines and covariances as dotted lines.

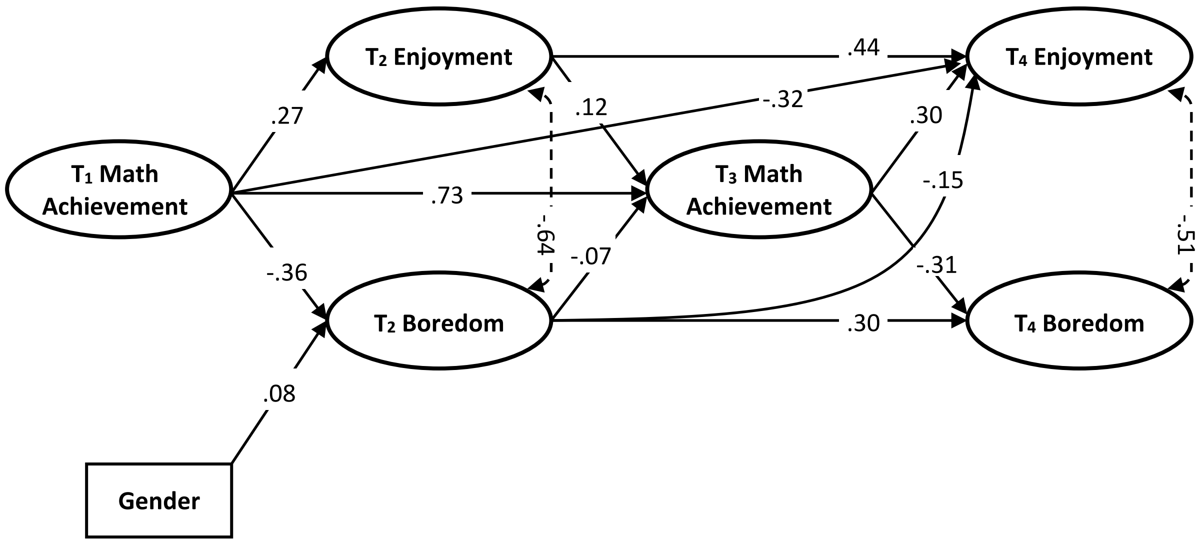

Figure 2. Statistically significant paths (solid black lines) and covariances (dotted lines) from the SEM.