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The role of achievement emotions in primary school mathematics: Control–value antecedents and achievement outcomes

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Background. Appraisals of control and value are proposed as proximal antecedents of achievement emotions, which, in turn, predict achievement. Relatively few studies have investigated how control and value may interact to determine achievement emotions, or subsequent achievement mediated by emotions.

Aim. To examine whether control, value, and their interaction predicted mathematics test score directly, and indirectly, mediated by three salient achievement emotions: enjoyment, boredom, and anxiety.

Method. Data were collected from 1,298 primary schoolchildren. Participants completed self-report measures of control, value (i.e., intrinsic, attainment, and utility), and achievement emotions (i.e., enjoyment, boredom, and anxiety), in the context of mathematics. Participants then undertook a curriculum-based mathematics test in class.

Results. Higher control and value were related to a higher mathematics test score directly, and indirectly, mediated via higher enjoyment and lower anxiety. The interaction of control and intrinsic value predicted mathematics test score directly, and indirectly, mediated via enjoyment.

Conclusion. Intrinsic value amplified the direct positive relation between control and mathematics test score. Intrinsic value also protected mathematics test scores at lower levels of control indirectly, through higher enjoyment. Helping students to maximize control and value will be beneficial for their learning experience and outcomes.

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This study investigated the control–value antecedents and achievement outcomes of three achievement emotions, namely enjoyment, boredom, and anxiety. Achievement emotions are important outcomes in their own right, offering insight into the experience of learning mathematics, and are also important determinants of motivation, engagement, and achievement (Pekrun, 2006; Pekrun & Perry, 2014). It is therefore critical to understand how and why these emotions arise and what consequences they have. Previous studies have shown that appraisals over learning activities and outcomes, such as perceptions of control and value, are the principal proximal determinants of achievement emotions (e.g., Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011), but few studies have investigated how control and value interact (e.g., Goetz, Frenzel, Stoeger, & Hall, 2010). Furthermore, no studies, thus far, have included achievement to examine how control–value appraisals predict achievement, either directly or indirectly, through achievement emotions. The present study aims to address this gap in the literature by testing moderated mediational models of control–value appraisals, achievement emotions, and achievement, in a sample of English primary schoolchildren.

The study focuses on students' emotions in mathematics. Mathematics is widely considered to be an important subject. It provides useful functional skills for adult life, and mastery over basic mathematics skills is a necessary step for higher level courses in the science, technology, engineering, and mathematics fields, thus contributing to national economic prosperity (Kärkkäinen & Vincent-Lancrin, 2013). Mathematics is one of only two subjects compulsorily tested at the end of primary schooling in England (the other being English). Due to the importance of mathematics, it arouses negative emotions and anxiety in many learners (Gottfried, Marcoulides, Gottfried, & Oliver, 2013; Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016). Also, many children fail to acquire basic mathematics proficiency. In 2019, only 79% of English schoolchildren reached expected minimum standards of mathematics at the end of primary schooling (Department for Education, 2019a).

Achievement emotions

Students can experience a range of distinct achievement emotions, defined as 'affective arousal that is tied directly to achievement activities or achievement outcomes' (Pekrun & Perry, 2014, p. 121). Achievement emotions can be differentiated along three principal dimensions: focus (activity-focused vs. outcome-focused), valence (pleasant vs. unpleasant), and physiological activation (activating vs. deactivating; Pekrun, 2006). Outcome-focused emotions can be further differentiated by those with a prospective or a retrospective focus. The present study focused on the three achievement emotions (enjoyment, boredom, and anxiety) that are most commonly experienced in the classroom setting by primary school-age children (Lichtenfeld, Pekrun, Stupnisky, Reiss, & Murayama, 2012). Enjoyment and boredom are activity-focused emotions; enjoyment is pleasant and activating, whereas boredom is unpleasant and deactivating. Anxiety is an unpleasant, activating, and prospective outcome-focused emotion.

Control–value theory

Control–value theory (CVT) is an integrated motivational and information processing model of the antecedents and outcomes of achievement emotions (Pekrun, 2006, 2018; Pekrun & Perry, 2014). Proximal antecedents are cognitive appraisals of control over achievement activities and outcomes, and the value attributed to those activities and outcomes. These can be shaped by features of the learning environment including the motivational milieu of the classroom (e.g., goal structures and autonomy support) and the cognitive quality of the learning tasks (e.g., optimum level of task challenge). Emotions are theorized to influence achievement indirectly through motivation and information processing. For instance, positive emotions, such as enjoyment, are motivating and broaden thought–action repertoires leading to greater academic achievement. Negative emotions, such as anxiety, can reduce motivation and interfere with information processing resources, thus typically leading to lower achievement. A great deal of empirical evidence has found that enjoyment is associated with higher, and boredom and anxiety with lower, achievement in students at all stages of education (e.g., Loderer *et al.*, 2018; Pekrun *et al.*, 2011; Tze, Daniels, & Klassen, 2016; von der Embse, Jester, Roy, & Post, 2018).

Control and value appraisals

As the present study is concerned with proximal antecedents of enjoyment, boredom, and anxiety, we now turn attention to control and value appraisals. Perceived control (henceforth referred to as *control*) consists of action–control expectations and action–outcome expectations that are underpinned by domain-specific self-concepts of ability. Action–control expectations refer to judgements over one's ability to successfully perform behaviour (e.g., that one can complete a set of mathematics problems). Action–outcome expectations refer to expectations that the action will produce the desired outcome (e.g., achievement in mathematics). Students who believe themselves to be good at mathematics will, all things being equal, show greater action–control and action–outcome expectations for mathematics (see Marsh *et al.*, 2019; Muenks, Wigfield, & Eccles, 2018).

Following Eccles *et al.*'s framework, perceived value (henceforth referred to as *value*) can be differentiated by three types: intrinsic, attainment, and utility (Eccles, 2005; Wigfield & Eccles, 2000). Intrinsic value is when a task is inherently valued in and of itself (e.g., because it is interesting or stimulates curiosity). Attainment value is the perceived importance of task achievement for one's identity or self-worth, and utility value is the perceived instrumental usefulness of the task for one's short- or long-term goals. From a CVT perspective (Pekrun, 2006), attainment and utility value are both forms of extrinsic value (i.e., the learning activity or outcome is used as a means to an end; e.g., to achieve career goals). Different types of values can be important for different achievement emotions. For example, we would expect that extrinsic value appraisals, and especially appraisals of attainment value, would be especially important for students' anxiety (Frenzel, Pekrun, & Goetz, 2007; Pekrun *et al.*, 2011), due to their focus on achievement.

Control–value interactions

CVT predicts that the relations between control and enjoyment or anxiety are moderated by value (e.g., Pekrun, 2006; Pekrun, Frenzel, Goetz, & Perry, 2007). Enjoyment is theorized to result from a learning activity being controllable and valued. Anxiety arises from the combination of uncertain control over a learning outcome that is valued (i.e., avoiding failure is important). In contrast, boredom is principally induced from a lack of value (positive or negative), and either a low level of challenge resulting in very high control or too high a level of challenge resulting in lack of control and rendering task engagement meaningless. Control and value do not necessarily interact in generating boredom. The majority of CVT studies have either examined relations between control–value appraisals using bivariate correlations or including control and value simultaneously in regression analyses, in an additive rather than interactive fashion. Studies have shown higher control to be associated with higher enjoyment, and lower anxiety and boredom, and higher value to be associated with higher enjoyment and anxiety, and lower boredom in Canadian undergraduate (e.g., Pekrun *et al.*, 2011) and German secondary school students (e.g., Frenzel, Pekrun, *et al.*, 2007; Sutter-Brandenberger, Hagenauer, & Hascher, 2018). Studies of how control and value are related to younger, primary-aged students are rare.

There are relatively few studies, however, that have investigated how control and value interact. Our literature search identified only four such studies. In a sample of German undergraduates, Goetz *et al.* (2010) found a positive relation between control and enjoyment that was amplified by value (measured using a single item of undifferentiated task usefulness). In a sample of North American elementary schoolchildren, Lauermann, Eccles, and Pekrun (2017), found that the negative relation between control and anxiety was amplified by high value (intrinsic and utility value). In a sample of upper track secondary school students from Germany, Bieg, Goetz, and Hubbard (2013), found that the negative relation between anxiety and control was amplified by high achievement value (measured using a single item). Although a control–value interaction is not predicted by CVT for boredom, Bieg *et al.* (2013) found a negative control–boredom relation at high value that became positive at low value; the highest level of boredom was found for high control and low value.

In a sample of English primary schoolchildren, Putwain, Pekrun, Nicholson, Symes, Becker, and Marsh (2018), found that the positive relation between control and enjoyment was amplified by high attainment value. Furthermore, similar to Bieg *et al.* (2013), a control–value interaction was shown for boredom. A positive relation between control and boredom was shown for low value, and this was attenuated at high attainment value; the highest boredom was shown for high control and low intrinsic value. The finding that control and value interact to predict boredom is not necessarily contrary to CVT. If a student's capabilities exceed task demands (i.e., low challenge), the task is likely to be non-valued due to a lack of stimulation (hence the higher boredom), and the student is likely to report high control. Although there may be individual and group differences (e.g., culture and gender) in achievement emotions and their underlying appraisals (see Frenzel, Thrash, Pekrun, & Goetz, 2007; Gaspard *et al.*, 2014; Scherer & Brosch, 2009), such differences are not expected to influence the direction and magnitude of the relations between appraisals and emotions, and between emotions and achievement (i.e., these relations are presumed to be universal; see Pekrun, 2009, 2018).

Although findings from these four studies are consistent with CVT, there are two notable limitations. First, these studies have either considered a single achievement emotion (Goetz *et al.*, 2010; Lauermann *et al.*, 2017) or modelled emotions separately where data on more than one emotion were collected (Bieg *et al.*, 2013; Putwain *et al.*, 2018). Given that naturally occurring emotions co-occur during the learning process, it is not clear how control and value may interact when more than one emotion is considered simultaneously. In the present study, we address this limitation by considering three commonly occurring emotions (enjoyment, boredom, and anxiety) simultaneously. Second, although achievement emotions are theorized in CVT as predictors of achievement, and there is much empirical evidence to support this claim (e.g., Pekrun *et al.*, 2011), only one study to date (using a sample of Portuguese secondary school students) has examined both direct relations between control, value, and achievement, and indirect relations mediated via achievement emotions, simultaneously in a single model (Peixoto, Sanches, Mata, & Monteiro, 2016). Peixoto *et al.* (2016), however, did not report coefficients for indirect relations and did not examine for control–value interactions. Thus, it is still not known whether control–value interactions predict achievement, either directly or indirectly through emotions. In the present study, we address this limitation by testing moderated mediational models to examine how control, value, and their interactions may be related to achievement and whether and how these relations are mediated by enjoyment, boredom, and anxiety.

Aim of the present study

The present study aimed to examine how control, value, and their interaction predicted enjoyment, boredom, and anxiety, and how these three achievement emotions, in turn, predicted mathematics achievement on a class test. This also made it possible to examine the role of emotions as mediators in the link between appraisals and achievement. The moderated mediational model tested in our study is diagrammed in Figure 1. Since control–value appraisals, emotions, and achievement are all domain-specific constructs (e.g., Muenks *et al.*, 2018), we focused on a single subject in the present study, namely, mathematics. All students were in Year 5 and following Key Stage 2 of the English National Curriculum. In keeping with the English National Curriculum and its method of assessment, we adopted a curriculum-based paradigm for the class test (Gipps, 2012), to assess the mathematical knowledge and skills in English National Curriculum, covered by students in Year 4 and the early part of Year 5.

We examined the following hypotheses based on CVT.

H1. Control is positively related to enjoyment and negatively related to anxiety. Value is positively related to enjoyment and anxiety, and negatively related to boredom. Attainment value could be more strongly related to anxiety than intrinsic or utility value.

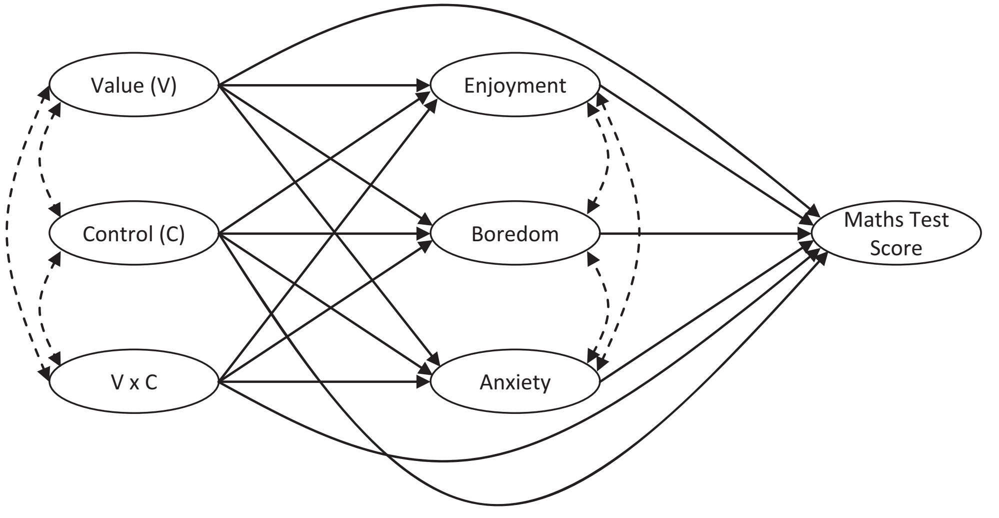

Figure 1. The hypothesized model is how value, control, and their interaction relate to maths test score directly, and indirectly, mediated by achievement emotions. Solid lines represent structural paths, and dotted lines represent correlations. For simplicity, gender was omitted.

H2. The positive relation between control and enjoyment, and the negative relation between control and anxiety are amplified by high value.

H3. Enjoyment is positively related, and anxiety and boredom are negatively related to mathematics test performance.

H4. Control, value, and their interaction will be indirectly related to achievement, mediated by enjoyment, boredom, and anxiety.

Method

Sample

The study used a purposeful sample comprised of 1,298 schoolchildren (male = 658, female = 640; M_{age} = 9.3 years; *SD* = 0.48), drawn from 26 English primary schools. All students were in Year 5, the penultimate year of primary education in England. The ethnic heritage of students was Asian = 344, Black = 52, White = 874, others = 12, and mixed heritage = 29. This is broadly representative of English primary schools. In January 2019 (when data for this project were collected), 65.5% of pupils were from a White British background (Department for Education, 2019b). There was a small amount of missing data (1.65%) that occurred from participants completing the survey but not the mathematics test. Missing data were handled using full information maximum-likelihood (FIML) estimation in *M*plus 8.4.

Measures

Control

Control was measured using three items adapted from Marsh's (1990) *Self-Description Questionnaire II* (see Putwain *et al.*, 2018). Items were adapted to be domain-specific to mathematics and to reflect control over one's learning (e.g., 'I can learn things quickly in maths lessons'). Participants responded to items on a five-point scale (1 = *strongly disagree*, 3 = *neither agree nor disagree*, and 5 = *strongly agree*). Internal consistency was good (McDonald's α = .82, ω = .82).

Task value

Subjective task value was measured using nine items adapted from Eccles *et al.*'s (2005) *Michigan Study of Adolescent Life Transitions* scales (see Putwain *et al.*, 2018). There were three items each for intrinsic value (e.g., 'I am interested in learning maths'), attainment value (e.g., 'Getting a good mark in maths is important to me'), and utility value (e.g., 'Maths is a good skill to have outside of school'). Participants responded to items on a five-point scale (1 = *strongly disagree*, 3 = *neither agree nor disagree*, and 5 = *strongly agree*). Internal consistency for the total measure and subscales was good (intrinsic value: α = .87, ω = .87; attainment value: α = .76, ω = .77; and utility value: α = .70, ω = .70).

Achievement emotions

Achievement emotions were measured using 12 items adapted from the *Achievement Emotions Questionnaire – Elementary School* class-related emotions scales (Lichtenfeld, Pekrun, Stupnisky, Reiss, & Murayama, 2012). Items were adapted to fit with parlance used in English education; items referred to 'maths' rather than 'math', and 'lessons' rather than 'class'. Four items each were used to measure enjoyment (e.g., 'I enjoy maths lessons'), boredom (e.g., 'Maths lessons bore me'), and anxiety (e.g., 'During maths lessons I worry that everything is too difficult for me'). Participants responded to items on a five-point scale (1 = *strongly disagree*, 3 = *neither agree nor disagree*, and 5 = *strongly agree*). Internal consistency was good (enjoyment: α = .92, ω = .92; boredom: α = .91, ω = .91; and anxiety: α = .82, ω = .82).

Mathematics test

A mathematics test was constructed using questions drawn from 2016, 2017, and 2018 English National Curriculum Mathematical Reasoning Tests.[1] These are covering Key Stage 2 of the English National Curriculum (Years 3 to 6). All questions from 2016 to 2018 tests were pooled, and those corresponding to the curriculum for Year 6 or the latter part of Year 5 were discarded. The remaining questions were checked and approved for their suitability by two primary school teachers, unrelated to this project, and a primary school mathematics learning consultant. Questions were randomly selected to create a 19-item test; 18 questions were worth one mark, and one question was worth two marks, resulting in a maximum score of 20. Students were allowed 40 min to complete this test (to be consistent with National Curriculum Mathematical Reasoning Tests) and could use paper and pencil to assist their working out of answers. Internal consistency was good (α = .79, ω = .81).

Procedure

After invitation letters to the school head teachers, a project recruitment event was held in two local authorities. The project was approved by an institutional research ethics committee at Liverpool John Moores University. Gatekeeper consent was provided by the school head. Opt-in parental consent was sought for all participants and verbal assent sought from participants at the point of data collection. Data were collected on school premises over a 2-week period, using an online survey tool for self-report measures and a custom-designed website to host the mathematics tests. Surveys and tests were administered by the regular class teacher.

Schools set aside two periods of the timetable during this fortnight for data collection, one period each for the survey and the test. The survey was scheduled for the period before the test, to avoid the possibility that experiences of the test may exert a proximal influence on the survey responses. For each period of data collection, it was emphasized to participants that participation was voluntary and that they could stop whenever they wanted to. Teachers were asked to write the survey and test URL on the class whiteboard, and ask all students to log onto the website. Teachers then read out loud to participants the instructions. For the survey, teachers read through each item slowly as participants answered them online. The survey tool required all questions to be completed; hence, there were no missing data.

[1] *Papers and mark schemes can be found at https://www.gov.uk/government/collections/national-curriculum-assessments-practice-materials.*

Analytic plan

In preliminary analyses, the distributional characteristics of data were checked through descriptive statistics and intraclass correlation coefficients (ρ_I), and a measurement model was assessed through a confirmatory factor analysis (that was also used to generate latent bivariate interactions). To assess interactions between control and value, the main analyses used the unconstrained approach to latent interaction structural equation modelling (LI-SEM: Marsh, Wen, & Hau, 2004, 2006). Achievement emotions (enjoyment, boredom, and anxiety) were regressed onto first-order latent variables for control and value, and a latent control × value interaction variable. Mathematics test scores were regressed onto the three achievement emotions, control, value, and their interaction. Gender was included as a covariate for all variables. Separate LI-SEMs were estimated for intrinsic, attainment, and utility value, due to the high collinearity between variables. The shared variance, resulting from including all three variables in a single model, would severely limit the predictive power of value (Winship & Western, 2016).

Results

Preliminary analyses

Descriptive statistics are shown in Table 1. Attainment value, utility value, and enjoyment were negatively skewed, and boredom and anxiety were positively skewed. Furthermore, attainment and utility value showed leptokurtic distributions. The proportion of variance attributable to the school level was relatively small ($\rho_I \leq .07$), with the exception of mathematics test score ($\rho_I = .13$). Factor loadings, from measurement models described below, were good (λs > .62). In order to generate latent bivariate correlations, a measurement model was built that contained control, intrinsic value, attainment value, and utility value (each construct represented by three indicators), and enjoyment, boredom, and anxiety (each construct represented by four indicators). Mathematics test score and gender were represented as single-item latent variables. To acknowledge the possibility of measurement error, mathematics test score was modelled as a one-indicator latent variable with $\lambda = .9$ ($\varepsilon = .1$), based on estimates reported in the educational psychology literature (Hoy *et al.*, 2006; Watkins, Lei, & Canivez, 2007).

This measurement model and all other subsequent latent variable models were estimated using the M*plus* 8.3 (Muthén & Muthén, 2017). The maximum-likelihood estimator with robust standard errors (MLR) was used to account for the non-normal

Table 1. Descriptive statistics for control, value, achievement emotions (enjoyment, boredom, and anxiety), and mathematics test score

	Range	Mean	*SD*	Skewness	Kurtosis	ρ_I	Factor loadings
Control	4–20	16.63	3.54	−0.50	−0.14	.05	.76–.79
Intrinsic value	3–15	12.16	3.04	−1.03	0.37	.06	.79–.86
Attainment value	3–15	13.43	2.32	−1.77	3.12	.03	.67–.78
Utility value	3–15	12.76	2.45	−1.21	1.21	.03	.62–.69
Enjoyment	4–20	16.24	4.48	−1.11	0.27	.07	.85–.88
Boredom	4–20	7.87	4.81	1.14	0.22	.04	.79–.88
Anxiety	4–20	8.30	4.38	1.01	0.23	.03	.70–.75
Mathematics test score	0–20	4.64	3.67	0.95	0.45	.13	–

Note. Factor loadings represent loadings on latent variables in measurement model.

distribution of variables (see Table 1), and the 'type = complex' command was used to adjust standard errors for the clustering of data within schools. Models were assessed using the following fit indices: root-mean-square error of approximation (RMSEA), standardized root-mean-square residual (SRMR), comparative fit index (CFI), and the Tucker–Lewis index (TLI). Simulation studies have indicated that a good fitting model is indicated by RMSEA $\leq .08$, SRMR $\leq .06$, and CFI/TLI $\geq .95$ (Hu & Bentler, 1999). These values, however, are intended as interpretive guidance rather than strict cut-points and may be overly stringent for naturalistic data (e.g., Heene, Hilbert, Draxler, Ziegler, & Bühner, 2011; Marsh, Hau, & Grayson, 2005).

The measurement model showed a good fit to the data, $\chi^2(265) = 452.06, p < .001$, RMSEA = .023, SRMR = .027, CFI = .986, and TLI = .983. Bivariate correlations are shown in Table 2. Control and value correlated positively with enjoyment and negatively with boredom and anxiety. Enjoyment related positively to the mathematics test score, and boredom and anxiety related negatively to these scores.

Latent interaction structural equation models

Three separate LI-SEMs were estimated, one each for intrinsic, attainment, and utility value. The latent interaction variable consisted of three indicators; each was the product of paired control and value indicators. Data were grand-mean-centred prior to estimation. The means of the latent control and value variables were fixed to zero, and the means of the latent interaction variables were fixed to equal the covariance of the control and value variables, as suggested by Marsh *et al.* (2004, 2006). Gender was included as covariate. These models showed a good fit to the data (see Table 3). Standardized path coefficients are reported in Table 4 and Figure 2. Standardized indirect effects from value and control to mathematics test score, mediated by achievement emotions, are shown in Table 5.

Intrinsic value model

Higher intrinsic value and control were related to higher enjoyment, qualified by an intrinsic value × control interaction, and lower boredom and anxiety. Higher intrinsic value and control were indirectly related to a higher mathematics test score via higher enjoyment and lower anxiety. The indirect relations, via enjoyment, were qualified by the intrinsic value × control interaction. Simple slopes for the relation between control and enjoyment, the relation between control and achievement, and the conditional indirect relation between control and achievement mediated by enjoyment, at different levels of intrinsic value (±1SD), are plotted in Figure 3. Control showed a stronger positive relation with enjoyment at lower levels (−1SD) of intrinsic value ($B = .47, p = .02$) that became weaker at mean value ($B = .11, p = .01$), and negative, albeit non-significant at higher levels (+1 *SD*) of intrinsic value ($B = -.24, p = .14$). Control showed a stronger positive relation with achievement at higher levels (+1 *SD*) of intrinsic value ($B = 2.98, p < .001$) than at mean ($B = 1.47, p < .001$) and lower levels (−1 *SD*) of intrinsic value ($B = -0.05$, $p = .93$). Control showed a positive indirect relation with achievement, mediated by enjoyment, at mean intrinsic value, $B = 0.13$, $SE = .04$, 95% CIs [.02, .24]. This relation became stronger at lower levels (−1 *SD*) of intrinsic value: $B = 0.55$, $SE = .20$, 95% CIs [.22, .88], and it became negative at higher levels (+1 *SD*) of intrinsic value, $B = -0.29$, $SE = .07$, 95% CIs [−.04, −.53].

Table 2. Latent bivariate correlations of control, value, achievement emotions, mathematics test scores, and gender

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Control	–	.70***	.41***	.54***	.66***	−.35***	−.32***	−.33***	−.16***
2. Intrinsic value		–	.48***	.69***	.88***	−.61***	−.36***	.23***	−.17***
3. Attainment value			–	.63***	.41***	−.29***	−.17***	.17***	.03
4. Utility value				–	.55***	−.39***	−.27***	.22***	−.03
5. Enjoyment					–	−.69***	−.37***	.16***	−.16***
6. Boredom						–	.65***	−.17***	.05
7. Anxiety							–	−.31***	.10**
8. Mathematics test score								–	−.10**
9. Gender									–

Note. Gender is coded as 0 = male; 1 = female.
**p < .01; ***p < .001.

Table 3. Fit indices for unconstrained LI-SEMs

	χ^2	RMSEA	SRMR	CFI	TLI
Intrinsic value	499.98	.034	.030	.975	.969
Attainment value	512.46	.034	.031	.968	.960
Utility value	371.50	.025	.028	.982	.978

Note. χ^2 of models statistically significant at $p < .001$ with 204 df.

Table 4. Standardized path coefficients from the LI-SEMs

	Enjoyment	Boredom	Anxiety	Mathematics test score	Gender
Intrinsic value LI-SEM					
Intrinsic value	.76***	−.71***	−.18**	.22*	−.16***
Control	.10*	−.18*	−.21**	.31***	−.16***
Intrinsic value × control	−.09*	.06	.03	.10*	.04
Enjoyment				.29*	−.01
Boredom				−.01	−.04
Anxiety				−.24***	.04
Mathematics Test Score					−.03
Attainment Value LI-SEM					
Attainment Value	.19*	−.20***	−.07	.14	.02
Control	.57***	−.24***	−.32***	.32***	−.16***
Attainment value × control	.01	−.01	−.04	.10	−.04
Enjoyment				.19*	−.07**
Boredom				−.03	.01
Anxiety				−.23***	.05
Mathematics test score					−.05
Utility value LI-SEM					
Utility value	.27***	−.29***	−.12*	.09*	−.04
Control	.48***	−.15*	−.29***	.32***	−.16***
Utility value × control	−.06	.06	−.03	.10	−.04
Enjoyment				.21**	−.07**
Boredom				−.03	.02
Anxiety				−.23***	.05
Mathematics test score					−.05

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

Attainment value model

Higher control was related to higher enjoyment, and lower anxiety and boredom. Higher value was related to higher enjoyment and lower boredom. Higher control showed statistically significant indirect relations with higher mathematics test score through higher enjoyment and lower anxiety.

Utility value model

Higher utility value and control were related to higher enjoyment, and lower boredom and anxiety. Higher utility value and control were indirectly related to a higher mathematics test score via higher enjoyment and lower anxiety.

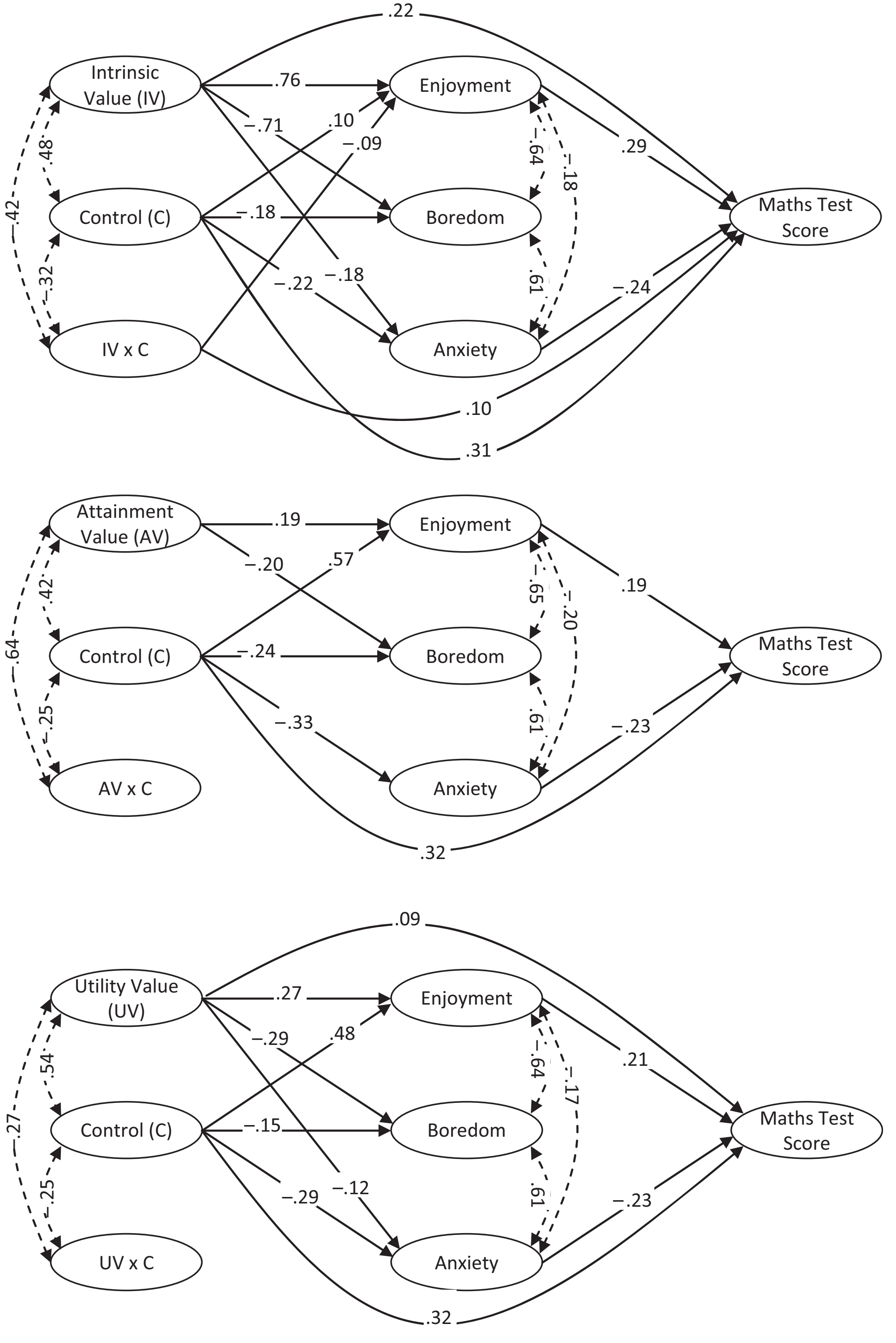

Figure 2. LI-SEMs to show how intrinsic value, control, and the intrinsic value × control interactions relate to achievement emotions and maths test scores. Solid lines represent structural paths and dotted lines correlations. Gender was omitted for clarity.

Table 5. Standardized indirect effects from value and control to mathematics test score, mediated by achievement emotions

	Enjoyment			Boredom			Anxiety		
	β	*SE*	95% CIs	β	*SE*	95% CIs	β	*SE*	95% CIs
Intrinsic value (IV)	.22	.11	.04, .40	.01	.06	−.08, .10	.04	.02	.01, .08
Control	.03	.01	.02, .24	.01	.01	−.08, .10	.31	.04	.11, .38
IV × C	.03	.01	.01, .04	.01	.01	−.01, .01	−.01	.01	−.03. .01
Attainment Value (AV)	.04	.03	−.01, .08	.01	.02	−.02, .03	.01	.02	−.02, .04
Control (C)	.11	.05	.03, .16	.01	.02	.02, .09	.08	.02	.09, .14
AV × C	−.01	.02	−.03, .03	.01	.01	−.01, .01	.01	.01	−.01, .02
Utility Value (UV)	.06	.04	.01, .10	.01	.02	−.03, .05	.03	.01	.01, .05
Control (C)	.10	.04	.03, .14	.01	.01	−.02, .02	.12	.02	.08, .16
UV × C	.01	.01	−.01, .03	−.01	.01	−.01, .01	.01	.01	−.01, .02

Discussion

The aim of this study was to examine how control–value interactions may predict achievement on a mathematics test indirectly through three commonly experienced achievement emotions: enjoyment, boredom, and anxiety. Three moderated mediational LI-SEMs were tested, one each for intrinsic, attainment, and utility value, in a sample of English primary schoolchildren. Results offered partial support for the model. Control, intrinsic value, and utility value showed direct and indirect links, mediated by enjoyment and anxiety, to mathematics test scores. Furthermore, control and intrinsic value interacted to predict enjoyment and mathematics test score. Control showed a negative (Figure 3c) indirect relation with mathematics test score, mediated by enjoyment, at higher levels of intrinsic value. At lower levels of intrinsic value, this indirect relation became positive/stronger. Boredom was unrelated to mathematics test score, and attainment value showed no direct or indirect links to mathematics test score.

The relations between control, value, and achievement emotions were largely as predicted by CVT (Pekrun, 2006; Pekrun & Perry, 2014). Control was positively related to enjoyment and negatively related to boredom and anxiety; intrinsic, attainment, and utility value were positively related to enjoyment and negatively related to boredom, consistent with earlier findings (e.g., Frenzel, Pekrun, *et al.*, 2007; Pekrun *et al.*, 2011). CVT proposes that anxiety would result from higher attainment value, specifically the perceived importance of avoiding failure, and this has been found in studies of older students (e.g., Frenzel, Pekrun, *et al.*, 2007; Pekrun *et al.*, 2011). In direct contradiction to the first hypothesis, anxiety was unrelated to attainment value; however, it should be noted that we did not differentiate between the value of success and failure in this study, which may explain the overall zero relation. In addition, we found that intrinsic and utility value were negatively relatively related to anxiety. This is possibly because it is difficult to positively value a task that is anxiety-provoking due to its adverse experiential, motivational, and cognitive effects (Sutter-Brandenberger *et al.*, 2018). From this perspective, the negative relation represents anxiety as the antecedent of low positive value, rather than vice versa. This is not inconsistent with CVT, where emotions link back to antecedents to form a cyclical feedback loop. However, as control–value antecedents were measured at the same point in the present study, we cannot disentangle the directionality of value–anxiety relations.

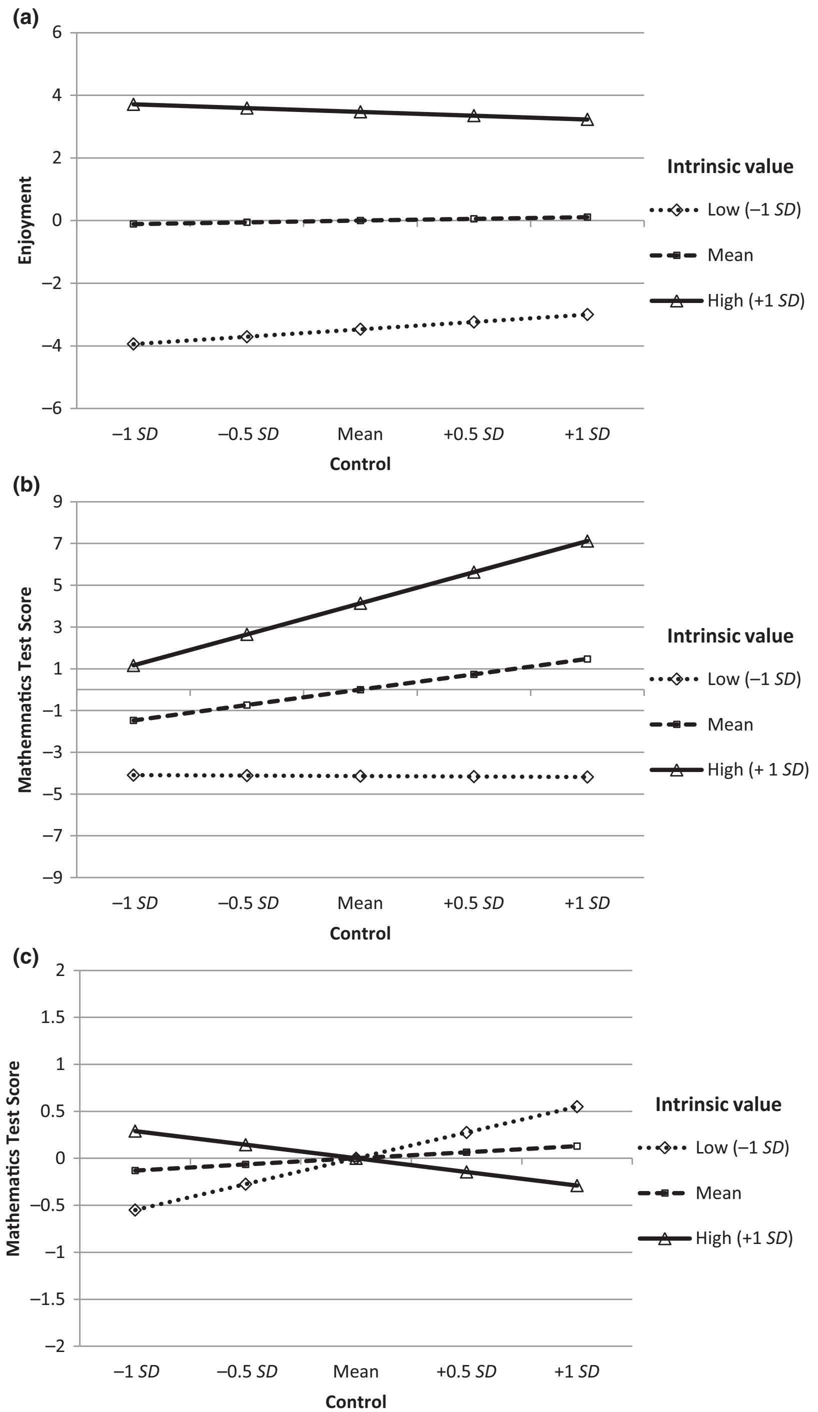

Figure 3. (a) Model-implied simple slopes between control and enjoyment at ±1 *SD* intrinsic value. (b) Model-implied simple slopes between control and mathematics test score at ±1 *SD* intrinsic value. (c) Model-implied conditional indirect slopes between control and mathematics test score (mediated by enjoyment) at ±1 *SD* intrinsic value.

The relation between control and enjoyment was amplified by low intrinsic value. This is similar to interactions shown in studies of expectancy–value theory (Guo, Marsh, Parker, Morin, & Yeung, 2015; Putwain, Nicholson, Pekrun, Becker, & Symes, 2019), whereby higher value shows a protective role at low control that diminishes at higher levels of control. The protective role of high intrinsic value on enjoyment at lower control is harder to discern in the present study, due to the large first-order effect of intrinsic value.

Control did not interact with utility or attainment value to predict enjoyment. Putwain *et al.* (2018) proposed that context may influence the strength with which value interacts with control. Attainment value may be more prominent in high-stakes testing settings and intrinsic value more so in classroom learning settings. The findings in our study support this proposition. Although students undertook a test, this was a low-stakes setting, taken in a classroom, and ultimately one that students could choose to participate in or not. Control did not, however, interact with any form of value to predict anxiety. This runs contrary to previous findings (Bieg *et al.*, 2013; Lauermann *et al.*, 2017) where anxiety is heightened at high value and low control. This is most likely a result of the zero relation shown between anxiety and attainment value, and negative relations between anxiety and intrinsic and utility value; the hypothesized interaction rests on negative anxiety–control relations and positive value–anxiety relations. Taken together, these findings offer partial support for *H1* and *H2*.

The relations between achievement emotions and mathematics test score were as predicted by CVT and consistent with previous studies (e.g., Loderer *et al.*, 2018; Pekrun *et al.*, 2011; von der Embse *et al.*, 2018); enjoyment predicted a higher test score, and anxiety predicted a lower test score. Boredom did not emerge as a unique predictor after the shared variance with enjoyment and anxiety was accounted for. This may be due to the measure used in this study not differentiating between types of academic boredom which may be more or less damaging for achievement. Indifferent or apathetic boredom, characterized by low arousal, may be more damaging for achievement than searching or reactant boredom, where the student is searching for meaningful activities (Goetz & Hall, 2014).

When considered simultaneously with anxiety and enjoyment, however, boredom is a less powerful predictor than enjoyment and anxiety. An interaction was shown between intrinsic value and enjoyment, whereby high intrinsic value amplified the relation between control and mathematics test score. These findings offer partial support for *H3*.

Control and value were directly, and indirectly, positively related to greater achievement, mediated through higher enjoyment and lower anxiety. The finding that control and value were directly, as well as indirectly, related to mathematics test score builds on Peixoto *et al.* (2016) whilst providing estimations of the sizes of indirect effects. These ranged from negligible to large, depending on the emotion and on which type of value was paired with control. For instance, control showed a larger indirect relation with anxiety when paired with intrinsic value than when paired with attainment or utility value. It is likely that control and value impact on achievement-related behaviours and cognitions (e.g., effort, persistence, and attention: Martin, 2012; Reschley, & Christenson, 2012; Skinner, Pitzer, & Steele, 2016), in addition to emotions. Conditional indirect effects showed that the indirect relations from control to mathematics test score, mediated by enjoyment, differed at high and low intrinsic value. At low control, mathematics achievement was partially compensated by high intrinsic value through higher enjoyment. As control increased, the protective role of intrinsic value diminished. At high control, the achievement of students with high intrinsic motivation is lower than that of students with low intrinsic motivation. For students with high control and intrinsic value, work may not be sufficiently challenging to be enjoyable due to low mastery experience and hence the lower mathematics achievement. These findings offer partial support for *H4*.

Limitations and future directions

The principal limitation of this study was that control–value appraisals and emotions were measured at the same point in time. Although this may be justifiable, and possibly beneficial, when measuring proximal antecedents of emotions, it does place limits on the extent to which directionality can be understood. This was most pertinent in our consideration of anxiety, whereby the negative relation with value may represent an outcome rather than antecedent of emotion. It would be beneficial for future studies, where practical circumstances permit, to build in a temporal separation, albeit a short one for proximal antecedents, between assessment of control–value appraisals and emotions (Maxwell, Cole, & Mitchell, 2011). A second limitation concerns the range of emotions studied. The present study focused on three key emotions, enjoyment, boredom, and anxiety; however, there are other important emotions, such as pride, shame, frustration, and anger, that have not been widely studied in relation to younger students or in relation to control–value interactions. Future studies should consider whether to broaden the range of emotions, although this may not permit all emotions to be analysed in a single model, or consider different emotions to those that have been widely studied thus far. It should also be noted that, although we attempted to select test questions that matched the children's level of education, the mean performance in the current sample was relatively low. This suggests that the items were difficult for the participants or that some participants were not highly motivated, possibly as a consequence of the low-stakes research situation. However, importantly for the present analysis, there was nevertheless sufficient variance in the performance scores.

Educational implications

Our study showed that control and value appraisals are beneficial for achievement emotions and mathematics test scores. The implication is that helping students to maximize control and value will be beneficial for their learning experience and outcomes, and that educators and practitioner psychologists, who are seeking to understand why students may not be achieving their potential, may find value and control useful constructs to consider. Control and value are inherently malleable and, when enhanced, can have downstream benefits for achievement. Instructional material showing the utility of a particular science (Harackiewicz, Canning, Tibbetts, Priniski, & Hyde, 2016), imagining a future high-achieving self (Oyserman & James, 2009), and learning activities designed to develop curiosity (Durik & Harackiewicz, 2007), are all ways of boosting different aspects of value. Teachers can also build attributional principles into feedback (e.g., attributing effort to strategy rather than ability) and provide strategies for students to improve their future work to help students build control (e.g., Perry, Chipperfield, Hladkyj, Pekrun, & Hamm, 2014). Specifically, it is important for educators to ensure that students with high perceived control and intrinsic value in mathematics are sufficiently challenged to avoid lower enjoyment and any subsequent negative effects on achievement.

The findings of this study also have implications for interventions designed to boost positive emotions and/or reduce negative emotions. Enhanced control and value appraisals play a central mechanism in achieving this outcome and so would be plausible foci for intervention. In the educational psychology literature, there has been discussion over the key mechanisms of intervention that are common to, and span across, different theoretical perspectives (e.g., Brandenberger, Hagenauer & Hascher, 2018; Hulleman & Barron, 2016; Pekrun, 2013). Given the potential benefits of boosted control and value appraisals not only for achievement emotions, but also for motivation and achievement (e.g., Harackiewicz *et al.*, 2016; Hulleman & Barron, 2016), control and value could be two such mechanisms.

Conclusion

This study has shown that control and value appraisals do relate to subsequent mathematics test scores indirectly, through emotions (namely enjoyment and anxiety), but that control, value, enjoyment, and anxiety also relate to achievement directly. The size of the indirect paths varied, depending on the emotion and the control–value pairing. In some cases (e.g., intrinsic value mediated by enjoyment and control mediated by anxiety), they are of a similar strength to those of direct paths. High intrinsic value amplified direct control–mathematics test score relations and, indirectly, protected mathematics test score at low control through higher enjoyment. The protective role of high intrinsic value diminishes at higher levels of control. The lower mathematics test scores, shown for students with the combination of high control and high intrinsic value, may be due to a lack of challenge lowering enjoyment.

Conflicts of interest

All authors declare no conflict of interest.

Author contribution

David William Putwain, PhD (Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Writing – original draft; Writing – review & editing) Eva A. Schmitz (Formal analysis; Writing – original draft; Writing – review & editing) Peter Wood (Conceptualization; Funding acquisition; Investigation; Methodology; Project administration; Writing – original draft; Writing – review & editing) Reinhard Pekrun (Conceptualization; Methodology; Writing – original draft; Writing – review & editing).

Data availability statement

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

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