

Expectancy and intrinsic value: Interactions and reciprocal relations with achievement and career aspirations in science

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ABSTRACT

Previous studies show that expectancy and intrinsic value can motivate achievement and aspirations. Studies examining reciprocal relations that also consider how achievement and aspirations can reinforce expectancy and intrinsic value are lacking. The present study examined reciprocal relations between expectancy and intrinsic value, accounting for their interaction, and achievement and aspirations. The sample comprised 1239 students (488 males, mean age of 12.4 years) who, over four waves, self-reported expectancy and intrinsic value twice, and took a science test and reported aspirations twice. Positive reciprocal relations were found between intrinsic value and aspirations; expectancy amplified the relation between intrinsic value and aspirations. Expectancy positively predicted aspirations but not vice versa. Achievement predicted expectancy and intrinsic value beyond prior levels, but not vice versa. Findings imply mutual benefit from interventions to boost expectancy and intrinsic value to benefit subsequent aspirations, and interventions to boost achievement and aspirations with downstream benefits for intrinsic value.

Educational relevance statement: In a sample of early adolescent students, a time when many begin to lose interest in science, we found that viewing science as interesting and enjoyable (intrinsic value) went hand in hand with students' hopes to study higher-level science courses or pursue science-related careers. We found a similar pattern for achievement: doing well in science was linked to intrinsic value and expecting to succeed in the future, although these effects were mostly explained by past performance. This suggests that educators may benefit from supporting both students' intrinsic value of science and their future aspirations at the same time, so each strengthens the other. A similar, though more cautious, conclusion applies to achievement and expectation of future success, which may also reinforce one another over time.

1. Introduction

The present study examines the beliefs that interact to motivate science achievement and aspiration in early secondary education, and how achievement and aspiration in turn can impact subsequent motivational beliefs. While the need for a scientifically literate society has never been greater (e.g., skills shortages, societal challenges, and rapid scientific advances), science motivation declines throughout adolescence for many students (e.g., Gaspard et al., 2015; Wang et al., 2016). From the perspective of Situated Expectancy Value Theory (SEVT: Eccles & Wigfield, 2020; Wigfield & Eccles, 2020), motivational beliefs such as expectancy of success and subjective task value (STV) are key to motivating science achievement and aspirations (e.g., Guo et al., 2015a; Lauermaun et al., 2017; Nagengast et al., 2011).

Studies that consider both science achievement and aspirations (i.e.,

the intention to pursue advanced scientific study and/or a career in science; Archer & DeWitte, 2016) in early adolescence, however, are lacking. Moreover, SEVT proposes that achievement and aspiration would shape subsequent motivational beliefs. Evidence supports reciprocal relations between achievement and motivational beliefs (e.g., Marsh et al., 2022; Vu et al., 2024), but few studies specifically test relations in the domain of science and include intrinsic value alongside expectancy or a proxy such as academic self-concept. We address these limitations to examine reciprocal relations between key motivational beliefs (expectancy of success and intrinsic value, accounting for their interaction) and achievement/aspiration outcomes in a sample of secondary school science students. To situate this investigation theoretically, we next introduce Situated Expectancy-Value Theory (SEVT), which provides the conceptual basis for examining these motivational processes.

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1.1. The Situated Expectancy Value Theory

SEVT is a comprehensive theory of student motivation that combines proximal socio-cognitive determinants of educational choices and achievement with distal socio-cultural determinants (Eccles & Wigfield, 2020; Wigfield & Eccles, 2020). Situatedness was implicit in earlier versions of this model, referred to simply as Expectancy Value Theory (EVT: Eccles et al., 1983; Wigfield & Eccles, 2000). However, to emphasise the dynamic, situated, and recursive nature of the constructs, EVT was renamed SEVT. The present study concerns the proximal socio-cognitive determinants of educational choices and achievement. In SEVT, these are expectancy of success (henceforth referred to as expectancy for brevity) and subjective task value (STV). Next, we set forth definitions of these key terms.

Expectancy refers to one's beliefs about the probability of success on a forthcoming task. Expectancy beliefs, which are time- and task-specific and forward-looking, draw from more stable domain-specific beliefs about one's present ability (Eccles & Wigfield, 2020; Wigfield & Eccles, 2020). All things being equal, students with high expectancy will invest greater effort and persistence in achievement-related tasks, choose more difficult tasks, and show superior task performance (Olivier et al., 2019; Usher et al., 2019).

Subjective task value refers to the worth attached to a particular achievement task (Eccles, 2005, 2009). The *subjective* nature of task values underlines that judgements can and do differ between and within students. Importantly, STVs determine a student's motivation for that task. This can range from micro-level choices (e.g., on-task behaviour during a lesson) to macro-level ones (e.g., choosing to study a particular subject to a higher level in upper secondary or university education). The overall value of a task is determined by intrinsic value (interest), attainment value (importance), utility value (usefulness), and costs (the drawbacks). In the present study, we focus on intrinsic value as arguably the most germane STV to the issue of declining scientific interest in adolescence and to its lasting motivational impact (Renninger & Hidi, 2019). In the following section, we consider evidence to support these propositions alongside the gaps and limitations that we address with our study.

1.2. Evidence for the Situated Expectancy Value Theory

Inspired by EVT and SEVT, numerous studies have shown that expectancy and STVs positively relate to educational choices and achievement (e.g., Kriegbaum et al., 2018; Pinquart & Ebeling, 2020; Vu et al., 2024). Some studies using school-age samples have found that expectancy, or a related proxy such as academic self-concept, is a stronger predictor of mathematics and science achievement than importance (Meece et al., 1990), importance and interest (Simpkins et al., 2006) and total STV (comprising importance, utility, and interest; Bong et al., 2012). Moreover, higher academic self-concept is associated with a greater likelihood of majoring in a STEM field at university than higher interest and importance (Musu-Gillette et al., 2014). Meece et al. (1990) found that importance was a stronger predictor of students' intentions to choose mathematics courses than academic self-concept. In contrast, Simpkins et al. (2006) found that academic self-concept was a stronger predictor of mathematics and science course choice than importance and interest. Additionally, Durik et al. (2006) showed that 4th-grade importance, but not interest or self-concept, predicted 8th-grade literacy achievement; 10th-grade self-concept, interest, and importance all showed similar relations with literacy choices.

Relatively few studies, however, have examined expectancy and STV together in relation to achievement and aspirations or tested for their interaction. This is a significant limitation, as a fundamental proposition of SEVT (Eccles & Wigfield, 2020) is that expectancy and STV interact multiplicatively; the association between expectancy and achievement or aspirations may depend on levels of STV, and vice versa (Trautwein et al., 2012). Moreover, achievement itself may function as a

precondition for science aspirations, with students aligning their aspirations toward subjects or domains in which they are more likely to succeed (Park et al., 2024). As such, it would be advantageous to control for prior levels of achievement and aspiration, along with their correlation, to enable the unique contributions of expectancy and STV to be established. Research has shown that mathematics academic self-concept and interest predict later mathematics achievement, even after accounting for prior performance (e.g., Marsh et al., 2005). However, there is a lack of studies that examine both achievement and aspirations among early adolescents specifically in the context of science.

In a large sample of secondary school students, Guo et al. (2016) showed that global value (intrinsic, attainment, utility, and low cost) amplified the positive relations between academic self-concept in science (a proxy for expectancy) and achievement, effort, and engagement in mathematics. In secondary school students, intrinsic value has specifically been shown to amplify the positive relationships between expectancy and achievement in mathematics and English (Trautwein et al., 2012), in higher-level mathematics courses taken in secondary school (Guo et al., 2015a), and a mathematics-related career attainment (Lauermann et al., 2017). In a large sample of 15-year-old students, enjoyment (a proxy for intrinsic value) amplified the positive relations between academic self-concept in science (a proxy for expectancy) and science extracurricular activities and aspirations (Nagengast et al., 2011). Some studies have shown a compensatory effect, whereby intrinsic value protects against low expectancy (Meyer et al., 2019; Putwain et al., 2019; Song & Chung, 2020). One of the few studies to include both achievement and aspirations found no statistically significant relations with intrinsic value after controlling for academic self-concept (a proxy for expectancy) and utility value in 9th-grade students (Guo et al., 2015b).

These studies' findings of multiplicative expectancy \times STV interactions provide strong support for SEVT. It is notable, however, that studies in the context of science using samples of students in early secondary education are lacking. This is an important omission as early adolescence is a period when educational and career aspirations can become more clearly articulated (Archer et al., 2014), but interest in science declines for many students (e.g., Steidtmann et al., 2023; Wang et al., 2016). This implies that early adolescence could be a critical time to understand the drivers of science aspirations at a time when they are vulnerable to decline (Sheldrake, 2020). Furthermore, in England (the location of our study), students must choose at the end of Year 9 (age 13–14 years) which subjects to study in the latter phase of secondary school for high-stakes exit examinations. Students who do not opt for single science courses have difficulty studying higher-level science courses in upper-secondary education and subsequently at university (Archer & DeWitte, 2016).

Understanding whether the relations among expectancy, achievement, and aspirations vary as a function of STV, and vice versa, has important educational implications (Hall et al., 2024). For educational institutions and educators, such insights may inform decisions about resource allocation (e.g., providing students with additional educational support, such as after-school classes), student ability grouping (e.g., to tailor instruction and optimal challenge to students' achievement level), and access to higher-level science courses (e.g., lowering entry requirements for higher-level courses vs. directing low-achieving students to alternatives).

For students and their families, this understanding may influence school choice (e.g., choosing a school with strong science results or facilities over a closer or more convenient one) and subject selection in upper secondary education and beyond (e.g., mutually supportive subjects, such as mathematics with physics or chemistry). It is critical, therefore, to capture the factors that motivate students' achievement and educational choice in the early years of secondary education before progression routes become closed off. Building on these implications, a key theoretical question concerns the dynamic processes through which motivational beliefs and educational outcomes influence one another

over time.

1.3. Reciprocal relations between motivational beliefs and educational outcomes

SEVT emphasises that the direction of influence from socio-cultural antecedents to motivational beliefs, and from motivational beliefs to educational choices and achievement, is not unidirectional, but dynamic and recursive. The successes and choices of today form the memories and cognitive representations that inform and shape the STVs and competence perceptions of tomorrow; hence, reciprocal relations between expectancy and achievement/aspirations are expected (Van Vu et al., 2022). The theoretical and practical value of examining reciprocal relations lies in determining whether science achievement and aspirations exert downstream effects on students' motivational beliefs and vice versa (Chiu, 2011). This approach helps identify virtuous cycles that can be strengthened and vicious cycles that can be disrupted through interventions targeting achievement (e.g., skill development) and students' motivational beliefs (i.e., self-enhancement).

Expectancy and STV result in greater cognitive (e.g., a repertoire of effective learning and metacognitive processes) and behavioural (e.g., effort, on-task behaviour, and persistence) engagement, which drives learning gains and achievement (Finn & Zimmer, 2012; Putwain et al., 2019; Schunk & DiBenedetto, 2016). In turn, achievement provides a crucial source of feedback about one's competence (Marsh et al., 2022) and can shape expectancy beliefs if attributed to internal causes (Graham & Taylor, 2016; Weiner, 2012).

Similarly, students aspire to higher-level study and careers in subjects they value and believe they can succeed in (Simpkins et al. (2006) and Wang (2012)). Additionally, stronger educational and career aspirations can exert a powerful influence on identity, enhancing the value associated with a particular subject or domain (Black et al., 2010; Verhoeven et al., 2019). Aspirations can also influence the beliefs of key socialisers (e.g., parents and teachers) and the mobilisation of cultural, social, and educational resources in ways that support and reinforce expectations of academic success (Khattab, 2015; Van den Broeck et al., 2020). There is a sound theoretical foundation, therefore, to expect reciprocal effects between motivational beliefs and achievement/aspiration.

There is strong evidence in samples of secondary school students for reciprocal relations between achievement and academic self-concept, which underpins expectancy, in the mathematics and verbal domains (Marsh et al., 2022; Marsh & Craven, 2006), and mathematics interest and achievement (Marsh et al., 2005). Reciprocal relations have also been shown for attainment value and achievement in elementary school students (Li et al., 2021), intrinsic reading motivation and achievement (Hebbecke et al., 2019), and aggregated motivational constructs and achievement (Vu et al., 2024). Longitudinal studies that include aspirations, however, are lacking. Nonetheless, single-wave studies have shown that achievement positively predicts intrinsic value alongside academic self-concept in 13th-grade students for mathematics (Cambria et al., 2017) and 8th-grade students for science (Guo et al., 2017).

One of the few multi-wave studies to include academic self-concept and utility value alongside achievement and educational/career aspirations used a sample of 10th and 11th-grade students (Guo et al., 2015c). After controlling for IQ, non-domain-specific academic self-concept and intrinsic value showed reciprocal relations with achievement. Relations with aspirations were equivocal; academic self-concept and intrinsic value predicted aspirations in some, but not all, waves, while aspirations were unrelated to subsequent academic self-concept or utility value. In Lauermaun et al.'s (2017) study, after controlling for prior cognitive ability and parental education, grade 9 mathematics intrinsic value predicted career plans in grade 12, but not vice versa; achievement in grade 9 predicted intrinsic value in grade, but not vice versa.

1.4. The present study

We surmise that the evidence base for the reciprocal relations theorised by SEVT is lacking, especially in science and during the critical period of early adolescence when motivational decline occurs for many students (primary gaps). Furthermore, the existing limited number of studies often do not model multiple outcomes, such as achievement and aspirations simultaneously, or do not account for the interaction between expectancy and intrinsic value (secondary gaps). Previous studies have shown synergistic (e.g., Trautwein et al., 2012) and compensatory interactions (Song & Chung, 2020). As compensatory effects seem to occur under specific conditions (e.g., ceiling effects for expectancy and STV; Putwain et al., 2019), we reasoned that interactions would likely follow a synergistic pattern. Expectancy is positively related to achievement and aspiration; stronger (amplified) at higher intrinsic value and weaker (attenuated) at lower value. The present study addresses these gaps by testing reciprocal relations (Hypotheses 1 and 2) and expectancy–value interactions (Hypothesis 3).

Data were collected over four waves (T₁ to T₄), with expectancy and intrinsic value measured in the 1st and 3rd waves, separated by approximately five months. Achievement and aspirations were measured in the 2nd and 4th waves, scheduled approximately two weeks after the 1st and 3rd waves, respectively (see Supplementary Materials, Fig. S1). Gender, age, ethnicity, and whether students were eligible for free school meals (FSM), as a proxy for low income, were included as possible demographic covariates. While the gender gap for science subjects on secondary school exit examinations in England is small (female students slightly outperform male students), those from low-income backgrounds typically achieve lower grades (Strand, 2014). Moreover, female students can feel alienated in traditionally male subjects and report lower expectancy, intrinsic value, and science career aspirations (e.g., Mau & Li, 2018; Toh & Watt, 2022); with some exceptions (e.g., medicine), students from ethnic minority backgrounds do not typically aspire to scientific careers (Wong, 2015).

In light of the SEVT principles and related empirical evidence summarized above, we posit the following three hypotheses, which remain untested specifically in the science context and during early adolescence:

Hypothesis 1. Expectancy (hypothesis 1a) and intrinsic value (hypothesis 1b) will show positive reciprocal relations with achievement.

Hypothesis 2. Intrinsic value will show positive reciprocal relations with aspiration (hypothesis 2a); expectancy will show a positive relation with subsequent aspiration (hypothesis 2b). We tentatively expect to find positive relations from aspiration to subsequent expectancy, but in the absence of supportive empirical findings, we leave this as an open research question.

Hypothesis 3. Intrinsic value will amplify the positive relation between expectancy and achievement (hypothesis 3a) and aspiration (hypothesis 3b).

2. Method

2.1. Participants, procedure, and missing data

The sample comprised 1239 participants drawn from six secondary schools in England. There were 488 males and 700 females (29 participants declined to report their gender, and 22 indicated a non-binary gender). Participants were in Years 7 to 9 (the first three years of secondary education in England) with a mean age of 12.4 years ($SD = 0.90$) and clustered into 64 classes for their science lessons with an average of 19.4 students per class. Economic disadvantage was judged using free school meals (FSM) as a proxy; four hundred and seventeen participants (33.7%) indicated their eligibility. The ethnic heritage of participants was: South Asian/British South Asian ($n = 68$; 5.5%), black/British

black ($n = 130$; 10.5%), British/European white ($n = 813$; 65.7%), Chinese/British Chinese ($n = 42$; 3.4%), and other ($n = 118$; 9.5%). A mixed heritage background was reported by 67 participants (5.5%). In the 2022–23 school year, when the data were collected, 48.7% of secondary school students in England were female, 22.7% were eligible for FSM, and 34.8% were from minority ethnic backgrounds (Department for Education, 2023). Our sample, therefore, contained a slight overrepresentation of female participants resulting from one school being a single-sex girls' school, and students from economically-deprived backgrounds, but was broadly representative in terms of ethnicity.

The study was approved by an institutional research ethics committee (reference: 19/EHC/001). Schools working in partnership with the authors' institution were invited to participate in the study. Written permission was provided by the Head Teacher of the six participating schools, and consent was sought from parents/carers (opt-out) and participants (opt-in). In the 1st and 3rd waves, participants completed an online questionnaire covering expectancy and intrinsic value in school science, along with demographics. To minimise missing data, participants were prompted if they had not answered a question. In the 2nd and 4th waves, participants completed a thirty-minute online science test and survey questions in science aspirations. Data for all waves were collected in school during a science lesson.

Over the four waves, there were 26.7% of the data were missing. Attrition is not uncommon in multi-wave studies (e.g., Gustavson et al., 2012). When there is no systematic identifiable cause of missing data, it is described as Missing Completely at Random (MCAR) and is essentially random (Graham, 2012). Little's omnibus test, $\chi^2(43) = 155.55$, $p < .001$, indicated that MCAR could not be assumed. When the cause of missing data can be identified from one or more observed variables, it is described as Missing Random (MAR) and, somewhat paradoxically, is not truly random (Graham, 2012). To establish if MAR could be assumed, we probed the potential cause(s) of missingness.

Data were more likely to be missing T_3 intrinsic value and expectancy, and T_4 test scores when they were lower in preceding waves ($ps < 0.05$; $ds = -0.10$ to -0.25), if participants were female and were eligible for FSM at wave 3 ($ps < 0.05$; $bs = 0.67$ and 3.07). As missing data could be accounted for in responses at preceding waves, MAR was assumed and handled in subsequent analyses using Full Information Maximum Likelihood (FIML). FIML has been shown to provide accurate estimates under MAR assumptions when the variable(s) responsible for missingness were included in analytic models (Jeličić et al., 2009; Nicholson et al., 2017), even when attrition is substantial (Dong & Peng, 2013).

2.2. Measures

2.2.1. Expectancy of success

Expectancy was measured using four items from the Grade 8 version of the 2019 Trends in International Mathematics and Science Study (TIMSS) *Students' Confidence in Science* scale (International Association for the Evaluation of Educational Achievement, 2018). Participants responded to items (e.g., "I learn things quickly in science") on a five-point scale (1 = "Strongly Disagree", 3 = "Neither", 5 = "Strongly Agree"). Across the countries participating in TIMSS, the longer 7-item scale showed a unidimensional factor, good internal consistency, and predictive validity for achievement (Yin & Fishbein, 2020). In the present study, the internal consistency was good ($\omega_s = 0.82$ and 0.81 for T_1 and T_2 , respectively).

2.2.2. Intrinsic value

Intrinsic value was measured using a four-item scale adapted from the Michigan Study of Adolescent Life Transitions scale (Eccles et al., 2005), with an additional item added and a uniform response scale used for ease of responding (Putwain et al., 2018). Participants responded to items (e.g., "I am interested in learning science") on a five-point scale (1 = "Strongly Disagree", 3 = "Neither", 5 = "Strongly Agree"). The factorial and predictive validity, and internal consistency, of the adapted

4-item version of this intrinsic value measure have been shown in previous studies (e.g., Putwain et al., 2018, 2019). Internal consistency was strong ($\omega_s = 0.91$ and 0.90 , for T_1 and T_2 , respectively).

2.2.3. Science aspirations

Science career aspirations were measured using the four items from the 2006 Programme for International Student Assessment (PISA) survey *Future-Oriented Science Motivation* scale (Organisation for Economic Co-operation and Development, 2009). Participants responded to items (e.g., "I would like to work in a career involving science") on a 4-point scale (1 = "Strongly Disagree" to 4 = "Strongly Agree"). This scale showed a good fit to the data and good internal consistency in the participating countries (Organisation for Economic Co-operation and Development, 2009). In the present study, the internal consistency for science aspirations was good ($\omega_s = 0.89$ and 0.90 , for T_1 and T_2 , respectively).

2.2.4. Science achievement

Science achievement was measured using items from Key Stage 3 (KS3) National Curriculum Tests (NCTs¹) designed for students in Years 7 to 9 (the focal sample in the present study). The questions chosen for the achievement test included all three science domains (biology, chemistry and physics) and focused upon thinking scientifically. This enabled participants to access the questions on their disciplinary knowledge and understanding (i.e., knowledge of how scientific knowledge is generated and grows) rather than their substantive knowledge and understanding (i.e., curriculum-based knowledge of concepts, models, laws and theories). The tests comprised seven questions created from a random pool of items from previous KS3 NCTs. Each question was worth a maximum of five to eight marks, depending on its complexity, resulting in a score ranging from 0 to 41. Previous studies have shown NCTs to show excellent internal consistency (Newton, 2009). In the present study, the internal consistency was strong ($\omega_s = 0.88$ and 0.90 , for T_1 and T_2 , respectively).

2.2.5. Socio-demographic covariates

Participants self-reported gender (male, female, other, or non-binary), age (in years), FSM (0 = not eligible, 1 = eligible), and ethnic heritage (South Asian/British South Asian, black/British black, British/European white, Chinese/British Chinese, or 'other'). For analysis, gender was coded as (male = 0, female = 1); non-binary and prefer not to say responses were recoded as missing data, as there were insufficient responses to warrant inclusion. Similarly, ethnicity was recoded as 0 = British/European white, and 1 = people from ethnic minority backgrounds, as there were insufficient numbers of persons from South Asian/British South Asian, black/British black, or Chinese/British Chinese, or mixed heritage backgrounds to warrant their inclusion as specific dummy variables.

2.3. Analytic strategy

First, a preliminary analysis, we tested longitudinal measurement invariance of expectancy, intrinsic value, and aspirations (i.e., equality of factor loadings, intercepts, and residual variance over time; see Putnick & Bornstein, 2016). Equality of intercepts is a precondition for testing relations over time (Widaman et al., 2010). Having established residual invariance (see Supplementary Materials Table S1), we tested a confirmatory factor analysis (CFA) for all latent variables and included

¹ KS3 refers to the English National Curriculum Years 7 to 9. KS3 NCTs were statutory tests taken by students at the end of Year 9 for school accountability purposes. KS3 NCTs were withdrawn in 2008 following concerns, about over-testing of students in secondary education. Despite their withdrawal, KS3 NCT questions remain widely used by English schools in a non-statutory fashion to measure student understanding.

correlated residual invariance for corresponding items over time. Having established a good-fitting CFA, we then added science test scores and socio-demographic covariates to estimate bivariate correlations.

Second, we then tested two structural equation models (SEMs), one without expectancy \times intrinsic value interactions, and the second with. Interactions were specified using the unconstrained approach (Marsh et al., 2004, 2006). Expectancy and intrinsic value items were mean-centred, randomly paired (separately for T₁ and T₃), and multiplied to create four indicators for each latent interaction. The means of expectancy and intrinsic value were fixed to zero, and the mean of the expectancy \times intrinsic value interaction was fixed to equal the covariance of expectancy and intrinsic value. We chose this approach as it has the advantage over the latent moderated structural equation approach (Klein & Moosbrugger, 2000) of estimating model fit indices while performing just as well (Little et al., 2006; Marsh et al., 2007; Steinmetz et al., 2011). Binary demographic variables were included as predictors of all variables.

A priori sample size, estimated using a Monte Carlo simulation algorithm (Westland, 2010), showed that a minimum of 744 participants is required to detect small effects ($r = 0.15$, $p < .05$, power = 0.8) for the SEM, including interactions, as the most complex model estimated. The present sample was therefore sufficient to detect small effects. All models were conducted in Mplus v8.11 (Muthén & Muthén, 2017) using the type = "complex" command and the maximum likelihood estimator with robust standard errors (MLR). The type = "complex" command adjusts standard errors for clustering in the data (i.e., participants in the same science class), and MLR is the default estimator for this command. The fit of measurement models was evaluated using the Root Mean Error of Approximation (RMSEA), Standardized Root Mean Residual (SRMR), Confirmatory Fit Index (CFI), and Tucker-Lewis index (TLI). Model fit was judged using Hu and Bentler's (1999) criteria, whereby RMSEA \approx 0.05, SRMR \approx 0.06, and CFI and TLI \approx 0.95 are indicative of a good-fitting model.

2.4. Transparency and openness

Data were collected as part of a larger project on relations among students' motivational beliefs, science achievement and aspirations, and teacher enthusiasm, messaging and self-efficacy. All data, materials, and analytic code have been made publicly available at the Open Science Framework and can be accessed at [https://www.osf.io/s4tbd/?view_only=2ec3df87b72f489d8eb57d0df38e3887]. The study was not preregistered, and two other papers have been published from this project (Putwain et al., 2024, 2026).

3. Results

3.1. Descriptive statistics, measurement model and bivariate correlations

Descriptive statistics are presented in Table 1. The distribution of all variables was within ± 1 skewness and kurtosis, and factor loadings from the measurement model of latent constructs were strong ($\lambda_s \geq 0.64$). CFAs for a measurement model of latent constructs only, and a second measurement model with achievement and socio-demographic covariates added as manifest constructs to estimate bivariate correlations, showed a good model fit (see Table 2). Bivariate correlations are reported in Table 3. Expectancy and intrinsic value were positively correlated with science achievement and aspirations. Female students reported lower T₁/T₃ expectancy, lower intrinsic value at T₃, and higher achievement at T₄. Students eligible for FSM showed lower T₂/T₄ achievement. Students from ethnic minority backgrounds showed lower T₁/T₃ expectancy, lower intrinsic value at T₁, lower T₂/T₄ aspirations, and higher achievement at T₄.

3.2. Structural equation modelling

We tested two SEMs. The first was a fully forward model to examine reciprocal relations between expectancy/intrinsic value and achievement/aspirations. Gender, FSM, and ethnicity were included as demographic covariates. We excluded age as no statistically significant correlations were shown with substantive variables. The second SEM added latent interactions. Both SEMs showed a good model fit (see Table 2), and coefficients for substantive variables are presented in Table 4. For comparative purposes, the coefficients for both SEMs are included. Coefficients for sociodemographic covariates are shown in Table 5.

3.3. Reciprocal relations between expectancy/intrinsic value and aspirations/achievement

T₁ expectancy ($\beta_s = 0.23$) and intrinsic value ($\beta_s = 0.15$ and 0.19) predicted T₂ achievement. T₂ achievement in turn predicted T₃ expectancy ($\beta_s = 0.10$) and intrinsic value ($\beta_s = 0.12$ and 0.14). T₃ expectancy and intrinsic value were not statistically significant predictors of T₄ achievement. Thus, reciprocal relations were shown to the extent that expectancy and intrinsic value only predicted subsequent achievement when prior achievement was not accounted for, thereby partially supporting Hypothesis 1a and b.

T₁ expectancy ($\beta_s = 0.17$ and 0.18) and intrinsic value ($\beta_s = 0.53$ and 0.57) predicted T₂ aspirations. T₂ aspirations, in turn, predicted T₃ intrinsic value ($\beta_s = 0.23$ and 0.24), but not expectancy. T₃ expectancy ($\beta_s = 0.34$ and 0.37) and intrinsic value ($\beta_s = 0.23$ and 0.24) predicted T₄ aspirations. Thus, reciprocal relations were shown between intrinsic value and aspirations, strongly supporting Hypothesis 2a and b. Relations are depicted in Fig. 1.

3.4. Expectancy \times intrinsic value interactions on aspirations/achievement

T₁/T₃ expectancy and intrinsic value interacted to predict T₂/T₄ aspirations, respectively ($\beta_s = 0.13$ and 0.08) and probed with simple slopes at ± 1 standard deviations for intrinsic value.² T₁ expectancy was positively related to T₂ aspirations ($B = 0.17$, $SE = 0.06$); the positive relation strengthened at +1SD intrinsic value ($B = 0.28$, $SE = 0.07$) and weakened at -1SD ($B = 0.06$, $SE = 0.07$) intrinsic value. T₃ expectancy was positively related to T₄ aspirations ($B = 0.39$, $SE = 0.15$); the positive relation strengthened at +1SD intrinsic value ($B = 0.47$, $SE = 0.15$) and weakened at -1SD intrinsic value ($B = 0.32$, $SE = 0.15$). T₁ expectancy and intrinsic value interacted to predict T₂ achievement. T₁ expectancy was positively related to T₂ achievement ($B = 2.58$, $SE = 0.75$); the positive relation strengthened at +1SD intrinsic value ($B = 3.85$, $SE = 0.70$) and weakened at -1SD intrinsic value ($B = 1.30$, $SE = 0.96$). T₃ expectancy and intrinsic value were not significant predictors of T₄ achievement. Simple slopes are graphed in Fig. 2 and show that high intrinsic value amplified (i.e., strengthened) achievement and aspiration. These findings offer partial support for Hypothesis 3a and strong support for Hypothesis 3b.

3.5. Sociodemographic covariates

Socio-demographic covariates are shown in Table 5. Girls reported lower T₁ expectancy ($\beta_s = -0.16$ and -0.17) and T₃ intrinsic value ($\beta_s = -0.10$) and showed higher T₄ achievement ($\beta_s = 0.11$). Students eligible for FSM showed lower T₁ expectancy ($\beta_s = -0.08$) and T₂ achievement ($\beta_s = -0.16$). Students from an ethnic minority background showed lower T₁ expectancy ($\beta_s = -0.12$ and -0.13) and intrinsic value ($\beta_s = -0.10$), and lower T₂ aspirations ($\beta_s = -0.08$ and -0.09).

² Mplus only estimates unstandardised coefficients for simple slopes.

Table 1
Descriptive statistics for study variables.

Variable	Scale	Mean	SD	ω	Skewness	Kurtosis	Factor Loadings
T ₁ expectancy	4–20	12.33	3.62	0.82	–0.06	–0.50	0.67–0.76
T ₁ intrinsic value	4–20	14.65	4.09	0.91	–0.37	0.26	0.78–0.89
T ₂ achievement	0–30	22.57	8.37	0.88	–0.14	–0.67	–
T ₂ aspirations	4–16	9.31	3.08	0.89	0.26	–0.47	0.77–0.85
T ₃ expectancy	4–20	12.27	3.53	0.81	–0.21	–0.36	0.64–0.79
T ₃ intrinsic value	4–20	14.24	4.20	0.90	–0.53	–0.41	0.75–0.88
T ₄ achievement	0–30	21.97	5.65	0.90	–0.14	–0.67	–
T ₄ aspirations	4–16	9.37	3.24	0.90	0.17	0.64	0.77–0.86

Table 2
Model fit of the confirmatory factor analyses and structural equation models.

	χ^2 (df)	RMSEA	SRMR	CFI	TLI
<i>Confirmatory factor analyses</i>					
Latent constructs	537.44 (225)	0.031	0.041	0.974	0.967
Latent constructs, achievement, and demographic variables	877.24 (345)	0.033	0.088	0.958	0.946
<i>Structural equation models</i>					
No interactions	684.77 (315)	0.030	0.040	0.968	0.959
With interactions	1291.37 (584)	0.031	0.050	0.945	0.935

Note. χ^2 of all models $p < .001$.

4. Discussion

The aim of this study was twofold. First, to examine reciprocal relations between expectancy/intrinsic value and achievement/aspirations. Second, to examine the interactions between expectancy and intrinsic value on achievement and aspiration. Concerning the first aim, intrinsic value and aspirations showed positive reciprocal relations. That is, intrinsic value was positively related to subsequent aspirations, and aspirations, in turn, were positively related to subsequent intrinsic value. Expectancy and aspirations showed unidirectional relations; expectancy was positively related to subsequent aspirations, but not vice versa. Intrinsic value and expectancy showed partial reciprocal relations with achievement; expectancy and intrinsic value were reciprocally related to achievement only at early time points (T₁ → T₂, T₂ → T₃); in a later time interval (T₃ → T₄), this relationship lost significance when prior achievement was controlled. Concerning the second aim, high intrinsic value strengthened the positive relation between expectancy and aspirations (T₁ → T₂, T₃ → T₄) and achievement (T₁ → T₂ only).

4.1. Reciprocal relations between expectancy/intrinsic value and aspirations/achievement

As predicted by SEVT (Eccles & Wigfield, 2020; Wigfield & Eccles, 2020), we found positive bidirectional relations between intrinsic value

and aspirations, and expectancy/intrinsic value and achievement up to the 3rd wave. This is consistent with prior research in science (e.g., Andersen & Chen, 2015; Simpkins et al., 2006) and other subject areas (e.g., Meece et al., 1990; Meyer et al., 2019). Students are more inclined to study higher-level science courses at school and university, and work in scientific careers when they find science interesting and enjoyable and expect to succeed (e.g., Wang, 2012). Interest, enjoyment, and a belief in one's ability also result in greater effort and persistence in one's studies, leading to higher achievement (e.g., Putwain et al., 2019; Wang & Eccles, 2013).

The role of achievement and aspirations in maintaining or boosting intrinsic value is less well studied. Higher aspirations involve a degree of belongingness with a subject and personal investment that can shape intrinsic value (Kontkanen et al., 2025; Stets et al., 2017) as well as other STVs (Jones et al., 2021). Aspirations are also intimately bound with familial, social, and cultural identities and supports, in ways that can affirm the value of science (Archer & DeWitte, 2016; Aschbacher et al., 2010; Kontkanen et al., 2025). Achievement can strengthen intrinsic value directly or indirectly by enhancing competence beliefs (Van Vu et al., 2022; Vu et al., 2024) and provides key feedback about competence that shapes expectancy beliefs (Marsh et al., 2022), with its impact depending on how individuals attribute their successes and failures (Graham & Taylor, 2016).

Our findings build on studies showing links from achievement and aspiration to intrinsic value in mathematics (e.g., Cambria et al., 2017; Guo et al., 2017), partial support for reciprocal relations between intrinsic value and achievement/aspirations in science (Guo et al., 2016) and mathematics (Lauermann et al., 2017), and well-established links from academic self-concept and achievement in mathematics and reading (e.g., Marsh et al., 2022; Marsh & Craven, 2006). There is clear evidence for a positive cyclical link. Relations between expectancy and aspirations were unidirectional. Our finding that expectancy predicted aspirations, but not vice versa, is consistent with Guo et al. (2015c). They showed in a sample of participants starting in late adolescence that academic self-concept predicted aspirations, but relations were not reciprocal.

While our findings, along with those of Guo et al. (2015b), challenge the SEVT claim that processes are recursive, we suggest that the idea

Table 3
Latent bivariate correlations between science value, cost, expectancy, aspiration, achievement and socio-demographic variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. T ₁ expectancy	–	0.70	0.34	0.56	0.78	0.53	0.35	0.47	–0.19	–0.01	–0.01	–0.14
2. T ₁ intrinsic value		–	0.32	0.65	0.57	0.74	0.28	0.55	–0.06	0.04	0.07	–0.11
3. T ₂ achievement			–	0.25	0.36	0.35	0.25	0.29	0.06	–0.19	0.05	0.08
4. T ₂ aspirations				–	0.46	0.60	0.43	0.72	–0.05	0.03	0.05	–0.17
5. T ₃ expectancy					–	0.70	0.39	0.59	–0.20	–0.02	–0.01	–0.15
6. T ₃ intrinsic value						–	0.30	0.66	–0.15	0.03	0.08	–0.06
7. T ₄ achievement							–	0.66	0.13	–0.22	0.07	0.11
8. T ₄ aspirations								–	–0.07	0.05	0.05	–0.15
9. Gender									–	–0.08	–0.13	0.04
10. FSM										–	0.11	–0.14
11. Age											–	–0.09
12. Ethnicity												–

Note. **Bold** coefficients: $p < .05$. FSM = free school meals. T₁ to T₄ = waves 1 to 4 of data collection.

Table 4
Standardised coefficients from the SEMs.

Path	SEM without EX × IV interactions		SEM With EX × IV Interactions	
	β	SE	β	SE
<i>Autoregressive paths</i>				
T ₁ EX → T ₃ EX	0.73	0.07	0.73	0.07
T ₁ IV → T ₃ IV	0.58	0.06	0.55	0.06
T ₂ ACH → T ₄ ACH	0.55	0.05	0.54	0.05
T ₂ ASP → T ₄ ASP	0.55	0.07	0.53	0.07
<i>EX & IV → ACH & ASP</i>				
T ₁ EX → T ₂ ACH	0.23	0.07	0.23	0.07
T ₁ EX → T ₄ ACH	0.04	0.13	0.04	0.13
T ₃ EX → T ₄ ACH	0.17	0.11	0.16	0.11
T ₁ IV → T ₂ ACH	0.15	0.08	0.19	0.08
T ₁ IV → T ₄ ACH	-0.13	0.10	-0.13	0.10
T ₃ IV → T ₄ ACH	0.17	0.13	0.17	0.12
T ₁ EX → T ₂ ASP	0.18	0.06	0.17	0.06
T ₁ EX → T ₄ ASP	-0.24	0.15	-0.21	0.16
T ₃ EX → T ₄ ASP	0.34	0.14	0.37	0.14
T ₁ IV → T ₂ ASP	0.53	0.06	0.57	0.05
T ₁ IV → T ₄ ASP	-0.01	0.15	-0.02	0.11
T ₃ IV → T ₄ ASP	0.24	0.11	0.23	0.11
<i>ACH & ASP → EX & IV</i>				
T ₂ ACH → T ₃ EX	0.10	0.04	0.10	0.04
T ₂ ACH → T ₃ IV	0.12	0.04	0.14	0.04
T ₂ ASP → T ₃ EX	0.04	0.07	0.07	0.07
T ₂ ASP → T ₃ IV	0.23	0.07	0.24	0.06
<i>Cross-lagged paths</i>				
T ₁ EX → T ₃ IV	-0.04	0.06	-0.05	0.06
T ₁ IV → T ₃ EX	0.01	0.07	-0.03	0.07
T ₂ ACH → T ₄ ASP	0.04	0.05	0.03	0.05
T ₂ ASP → T ₃ ACH	-0.01	0.06	-0.01	0.06
<i>Interactions</i>				
T ₁ EX × T ₁ IV → T ₂ ACH			0.14	0.04
T ₁ EX × T ₁ IV → T ₂ ASP			0.13	0.04
T ₃ EX × T ₁ IV → T ₄ ACH			-0.01	0.03
T ₃ EX × T ₁ IV → T ₄ ASP			0.09	0.04

Note. **Bold** coefficients: $p < .05$. EX = expectancy, IV = intrinsic value, ACH = achievement, and ASP = aspirations. T₁ to T₄ = waves 1 to 4 of data collection.

that aspirations can influence later expectancy remains plausible. Aspirations may provide additional motivation to engage in study (Black et al., 2010), which, when supported by skill development and learning opportunities (Khattab, 2015; Van den Broeck et al., 2020), can lead to learning gains. These gains, in turn, could reasonably be expected to improve expectancy over time. Furthermore, identity-related factors linked to students' social and cultural capital, such as access to resources, peer support, role models, and guidance, may shape both their confidence in achieving learning gains and their willingness to invest effort in

Table 5
Standardised coefficients from the SEMs with and without interactions for demographic covariates.

Variable	T ₁ EX	T ₁ IV	T ₂ ACH	T ₂ ASP	T ₃ EX	T ₃ IV	T ₄ ACH	T ₄ ASP
<i>Model without interactions</i>								
Gender	-0.16 (0.04)	-0.04 (0.04)	0.03 (0.05)	0.02 (0.03)	-0.05 (0.04)	-0.10 (0.03)	0.11 (0.04)	0.01 (0.04)
FSM	-0.08 (0.03)	-0.04 (0.04)	-0.16 (0.04)	-0.01 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.08 (0.05)	0.01 (0.04)
Ethnicity	-0.12 (0.04)	-0.10 (0.04)	0.07 (0.04)	-0.09 (0.03)	-0.03 (0.03)	0.06 (0.03)	0.04 (0.03)	-0.02 (0.03)
<i>Model with interactions</i>								
Gender	-0.17 (0.04)	-0.04 (0.04)	0.03 (0.05)	0.02 (0.03)	-0.05 (0.04)	-0.10 (0.03)	0.11 (0.04)	0.02 (0.04)
FSM	-0.08 (0.03)	-0.04 (0.04)	-0.16 (0.04)	0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.08 (0.05)	0.01 (0.04)
Ethnicity	-0.13 (0.04)	-0.10 (0.04)	0.04 (0.03)	-0.08 (0.03)	-0.03 (0.03)	0.06 (0.03)	0.04 (0.03)	-0.02 (0.03)

Note. Standard errors in parentheses and **bold** coefficients: $p < .05$. EX = expectancy, IV = intrinsic value, ACH = achievement, ASP = aspirations, and FSM = free school meals. T₁ to T₄ = waves 1 to 4 of data collection.

science, particularly for students from disadvantaged backgrounds (Archer et al., 2012). In short, unmeasured factors in our study may either strengthen this relationship (e.g., social and cultural capital) or enable it to develop over time (e.g., effort and learning gains).

4.2. *Expectancy × intrinsic value interactions, achievement and aspirations*

Studies have supported the expectancy and STV interactions proposed in SEVT for expectancy and aggregated value on mathematics achievement (Guo et al., 2016), expectancy and intrinsic value for mathematics and English achievement (Trautwein et al., 2012), higher-level mathematics courses taken in secondary school (Guo et al., 2015a), mathematics-related career attainment (Lauermann et al., 2017), and science extracurricular activities and aspirations (Nagengast et al., 2011). Our findings extend this body of work to show that expectancy and intrinsic value interact to drive science aspirations and achievement (T₁ → T₂ only). These are notable results as studies of science expectancy and intrinsic value interactions in early adolescent students are generally lacking. Interactions followed a ‘classic’ SEVT pattern whereby the lowest achievement and aspiration was found when both expectancy and intrinsic value were low. The rate at which expectancy boosted achievement and aspirations depended on intrinsic value; it was weaker when intrinsic value was low and stronger when intrinsic value was higher. Supporting SEVT, the highest achievement and aspiration were found when both expectancy and achievement were high.

4.3. *The curious case of T₄ achievement*

It was notable that when prior achievement was controlled (i.e., the autoregressive path from T₂ → T₄ achievement), neither T₃ expectancy, intrinsic value, nor their interaction predicted T₄ achievement. Our findings support the short-term predictive role of motivational beliefs on science achievement (i.e., T₁ → T₂), but they also indicate that in predicting long-term academic progress, pre-existing achievement (the autoregressive relation) may be a much stronger determinant. This could suggest that motivation interventions need to be conducted in parallel with strengthening the student's existing knowledge base.

We speculate that the collinearity between T₃ expectancy and intrinsic value ($r = 0.60$), when combined with prior achievement, limited their unique predictive influence. It is also plausible that the nature and timing of the T₂ and T₄ tests played a role. As tests of scientific knowledge and understanding, they would be less sensitive to student progress over four months than teacher-assigned grades. While this had the advantage of allowing us to use a standard test across multiple schools and age groups, this type of test may not have been sufficiently sensitive to detect progression in student learning of curriculum goals and standards, thereby emphasising the impact of prior test scores over motivational beliefs. Teacher-assigned grades, however, can be influenced by students' engagement (Kaiser et al., 2013) and differ by school or district grading policy (Cheng et al., 2020). The best

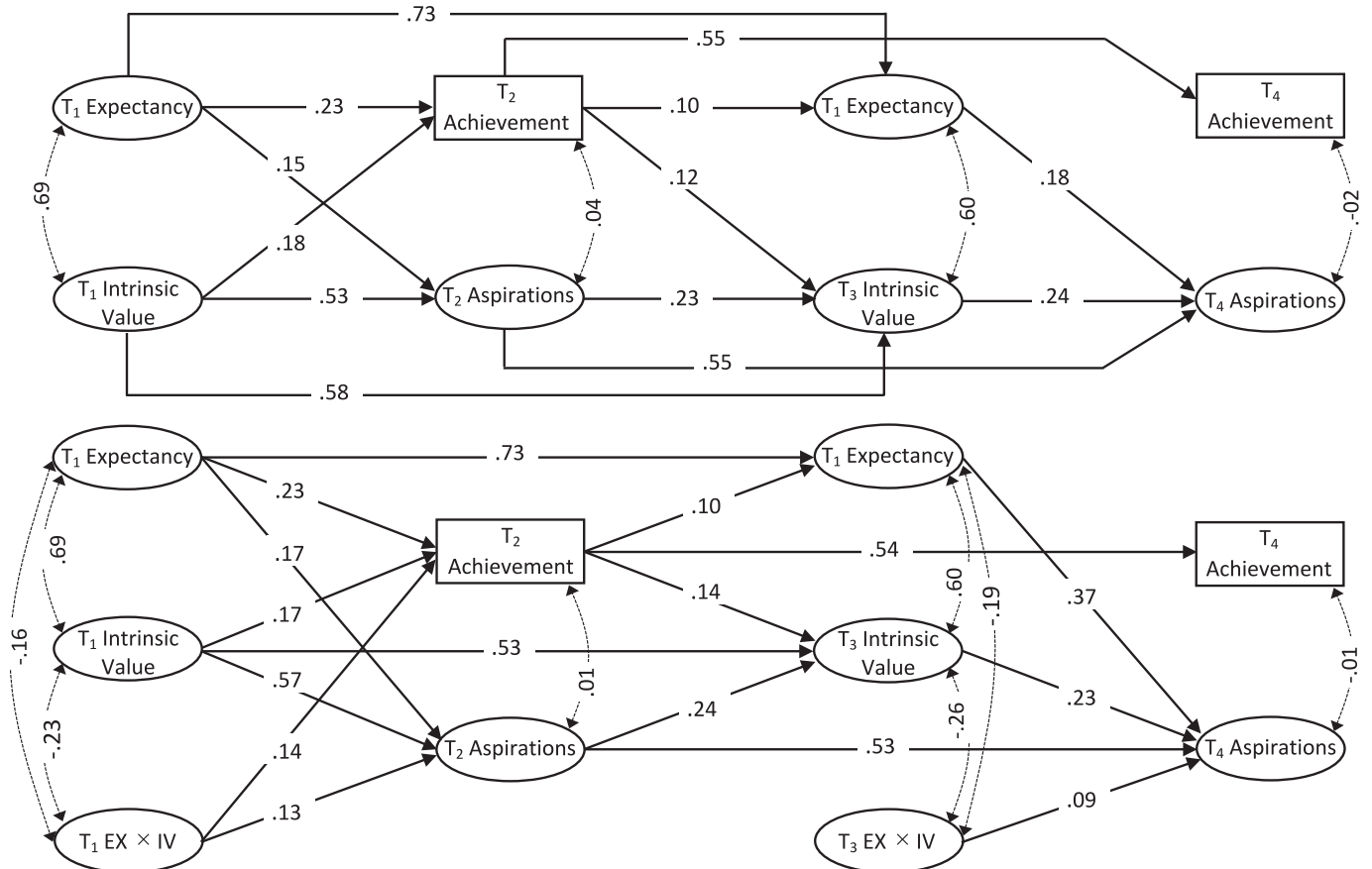


Fig. 1. Statistically standardised coefficients from SEMs with (lower) and without (upper) expectancy × intrinsic value interactions. Note. Dashed lines are correlations, and unbroken lines are directional paths.

solution may lie in a combination of the two approaches.

4.4. Implications for intervention and classroom practice

Over the past decade, studies have shown that interventions designed to enhance utility value can positively influence students' decisions to pursue higher-level courses in the later stages of secondary education and beyond (e.g., Gaspard et al., 2015; Hulleman & Harackiewicz, 2009). Notably, such interventions can also increase students' intrinsic value (e.g., Hulleman et al., 2010; Priniski et al., 2019), further supporting their engagement and course choices. Nonetheless, our findings, like others (e.g., Rosenzweig et al., 2022), suggest there are also benefits to intrinsic value interventions. One promising avenue to promote the intrinsic value of science is through outreach activities offered by higher education institutions. Outreach activities involve extra-curricular science classes designed and run by staff (e.g., higher education researchers) with specialist expertise and access to equipment not readily available in secondary schools, enabling learning experiences that promote curiosity, enquiry, and enjoyment of science in ways that dovetail, but are not constrained by, the school curriculum. Such outreach programmes have been shown to enhance aspirations to study science at university, especially in learners from deprived socio-economic backgrounds (Mujtaba et al., 2020; Simon et al., 2020).

Moreover, expectancy and intrinsic value appear to operate in positive feedback loops with achievement and aspirations. Interventions designed to boost achievement and raise interest and awareness in science careers may, in turn, boost subsequent intrinsic value and achievement. In this respect, improving expectancy or intrinsic value without also raising achievement and aspirations or raising achievement and aspirations without also boosting expectancy or intrinsic value, may

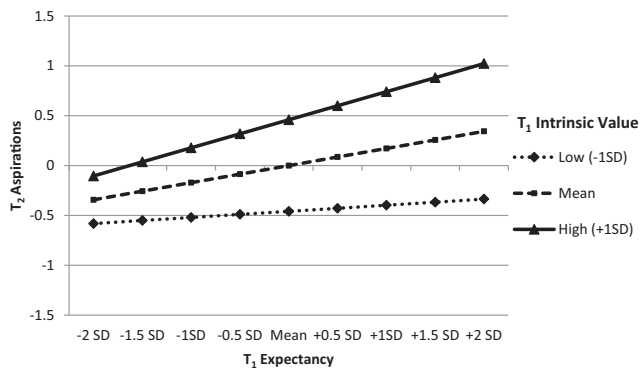
only result in short-lived effects (see Marsh & Craven, 2006). Classroom-based interventions should therefore be designed to address motivational beliefs and educational outcomes concurrently. Importantly, our finding that expectancy and intrinsic value interact suggests that multicomponent interventions, for example, those that simultaneously strengthen expectancy (e.g., Haynes-Stewart et al., 2011; Martens & Witt, 2004) and intrinsic value, may be more effective than single-component approaches.

The most effective components of expectancy- and value-based interventions could be embedded within regular classroom instruction, rather than delivered as a stand-alone programme. Feedback on students' work could, for example, emphasise strategies (e.g., learning, scientific reasoning) and attribution of marks or grades to strategy and effort rather than ability to boost expectancy (Engelmann et al., 2016; Ziegler & Stoeger, 2004). Inquiry-based learning, connecting the school science curriculum to local real-life issues, such as river pollution, can promote interest, curiosity, and STV (Högström et al., 2024; Potvin et al., 2017; Schoenherr, 2024). Educational psychologists are therefore well positioned to play a key role in translating evidence from motivational research into practice, informing policy and supporting the initial education and continuing professional development of teachers. We believe there is considerable untapped potential of educational psychology to arrest, or even reverse, the decline of interest in science during adolescence, and the attendant issues of science literacy and skills in the wider population.

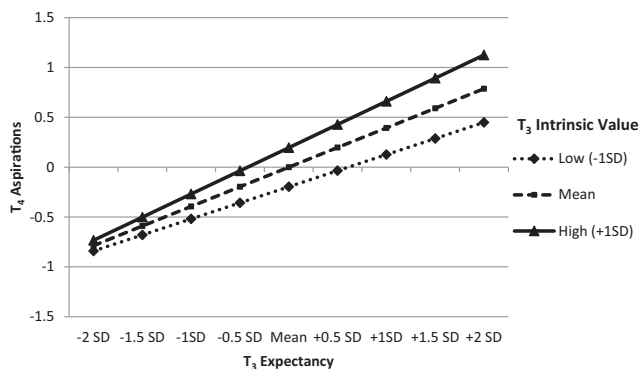
4.5. Limitations and directions for future research

The present study contributes to the literature by examining reciprocal relations between expectancy/intrinsic value and achievement/

Panel A: T₁ Expectancy × Intrinsic Value Interaction on T₂ Aspirations



Panel B: T₃ Expectancy × Intrinsic Value Interaction on T₄ Aspirations



Panel C: T₁ Expectancy × Intrinsic Value Interaction on T₂ Achievement

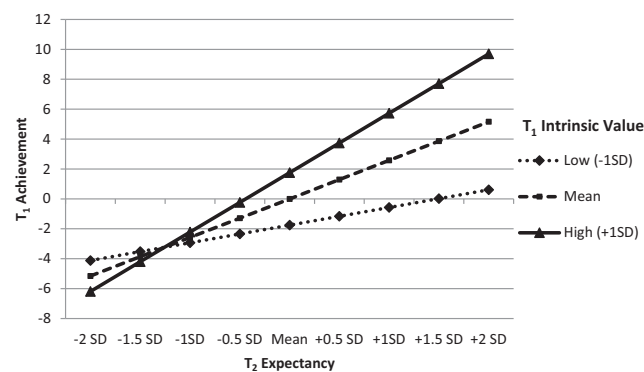


Fig. 2. Expectancy × intrinsic value interactions on aspirations and achievement.

Panel A: T₁ expectancy × intrinsic value interaction on T₂ aspirations.

Panel B: T₃ expectancy × intrinsic value interaction on T₄ aspirations.

Panel C: T₁ expectancy × intrinsic value interaction on T₂ achievement.

aspirations, while accounting for the expectancy × intrinsic value interaction, in a sample of students in the early years of secondary education. Despite this contribution, there are four limitations to highlight. First, our study design was sufficient to show how short-term directional relations from expectancy and intrinsic value to subsequent achievement and aspirations; the gap was two weeks. It is not clear whether these relations would persist over time, especially beyond those of prior achievement. Over longer time spans, a range of ecological factors, such as increased academic difficulty, shifts in teaching toward exam preparation, and family influences on educational and career aspirations, may reduce the predictive power of expectancy, intrinsic value, and

their interaction. Future research should therefore examine both short- and long-term outcomes.

Relatedly, we measured “typical” expectancy and intrinsic value and, as such, we found strong stability over the four-month gap from T₁ → T₃. This may have assisted the estimation of relations from T₂ achievement and aspirations to T₃ expectancy and intrinsic value, but a more temporally sensitive measure of expectancy and intrinsic value may have been more appropriate as proximal antecedents (e.g., the instructions could have been modified to “in the past week”). Future research should carefully consider the choice of time lags used to infer directionality, ensuring that these intervals are appropriate given the temporal sensitivity of the measures and theoretical expectations regarding how long effects are expected to persist (Dormann & Griffin, 2015; Dormann & van de Ven, 2014).

Second, we focused on intrinsic value as the sole STV. It is not unusual in the literature for studies to focus on a single STV (Nagengast et al., 2011). There are good reasons for this choice. Intrinsic value can be a precursor for other STVs (Arens et al., 2019) and conceptually may provide a more direct indicator of immediate task motivation than other STVs and costs, as it is less influenced by future goals, identity, or emotional burden (Eccles, 2009; Wigfield & Eccles, 2000). Our study does not, however, provide a full account of the STVs and costs proposed in SEVT. The importance of performance standards for identity may enhance the salience of attainment value for achievement (Putwain et al., 2019), and utility value may promote aspirations in students who did not previously consider taking higher-level science courses or careers (Rosenzweig et al., 2022). Future studies could include other STVs (e.g., attainment and utility value, and cost).

Third, many of the explanations reciprocally linking science motivational beliefs and achievement outcomes draw on understandings of student identity, belongingness, and sociocultural resources that were not explored in the present study. There is a rich seam of research drawing ‘science capital’ frameworks to explore how the subjective identity positions offered by intersections of gender, ethnic heritage, and economic deprivation influence achievement and educational choice (e.g., Archer et al., 2012; Moote et al., 2021). There are useful insights to be drawn from the science capital research for SEVT, as indeed there are for SEVT insights to be utilised by science capital researchers. It would be exciting for future studies to explore the possible synergies, inconsistencies, and contradictions of these different approaches to understanding student achievement and choice in science.

Fourth, and finally, gender and ethnic heritage were not originally measured as binary constructs but were dichotomised for analysis due to insufficient data to model all response categories. The gender categories “non-binary” and “prefer not to say” were treated as missing data, as combining them with either the male or female categories would constitute a category error and could lead to spurious conclusions. This decision, however, limits insight into how non-binary gender relates to achievement, aspirations, and motivational beliefs (see Fenaughty et al., 2019). Similarly, participants from non-White ethnic backgrounds were combined into a single category. This aggregation reflects shared experiences of potential discrimination and unequal access to educational resources, rather than assumptions of cultural similarity (Makarova & Birman, 2016). Consequently, this approach does not capture the distinct achievements, aspirations, and motivational beliefs of students from specific ethnic backgrounds. Future research in which socio-demographic variables are central theoretical constructs, rather than covariates, will require larger samples and targeted sampling strategies to ensure adequate representation of diverse groups.

4.6. Conclusion

Our study examined how expectancy and intrinsic value interact to motivate science achievement and aspiration, and how science achievement and aspiration in turn can impact subsequent expectancy and intrinsic value. Broadly, our findings support two key SEVT

propositions in a sample of secondary education students aged 11 to 14 years. First, science achievement and aspirations also shape subsequent expectancy and intrinsic value judgements. The predictive value of expectancy and intrinsic value on subsequent achievement, however, may be limited when prior achievement is accounted for. Second, to motivate science achievement and aspiration, both expectancy and STV are needed; the absence of one cannot be compensated for by the other. These findings highlight the potential value of intrinsic value interventions (e.g., science outreach) to enhance science interest, aspirations, and achievement, as well as the importance of integrating motivational principles into classroom instruction.

CRedit authorship contribution statement

David W. Putwain: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Andrea Mallaburn:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

We have no known conflict of interest to disclose. The study was not preregistered. This project was funded by an award made to both authors by the British Academy (SRG22\220016).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.lindif.2026.102912>.

Data availability

All data, materials, and analytic code, have been made publicly available at the Open Science Framework and can be accessed at: <https://osf.io/s4tbd/>.

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