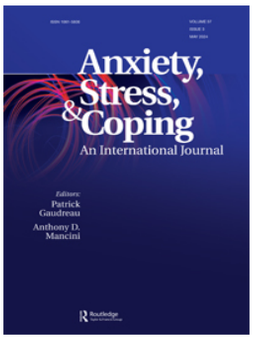

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"I must make the grade!": the role of cognitive appraisals, irrational beliefs, exam anxiety, and affect, in the academic self-concept of undergraduate students

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ABSTRACT

Background and objectives: Examination anxiety is a common occurrence, and is potentially detrimental to student attainment. In recent theorizing, it has been suggested that cognitive appraisals, as put forth in cognitive appraisal theory, and irrational beliefs, as put forth in rational emotive behavior therapy, may interact to predict affectivity. The current research examines the antecedents and associates of examination affect and academic self-concept in undergraduate students.

Design: A preliminary study applied confirmatory factor analysis (CFA) to test the factor structure of an irrational beliefs inventory. Study 1 utilized a cross-sectional and correlational approach to testing core theoretical assumptions. Study 2 took a two-wave longitudinal and path analytical approach to examine temporal effects between target variables.

Method: All self-report data collection took place in the United Kingdom with university students. We recruited $n = 1150$, $n = 362$, $n = 662$ for preliminary, study 1, and study 2, respectively.

Results: Across studies, data indicated that a pattern of adaptive cognitive appraisal was associated with more advantageous affectivity, and better academic self-concept.

Conclusions: Reciprocal temporal relationships were revealed between many variables, supporting an interactive and bidirectional view of how cognition and affect are related pertaining to examination anxiety.

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Emotion; CBT; mood; test anxiety; hedonic balance

Higher education is a place where achievement matters, because undertaking a higher-level qualification presents an opportunity to advance life goals (Pekrun, 2016). As such, against the backdrop of examinations that help to dictate success as a student, higher education is host to high-intensity emotions (Pekrun, 2016). One emotion that has received attention in the extant literature is examination (or test) anxiety, which in the current paper, is defined as an anticipatory achievement outcome emotion (e.g., Pekrun, 2006; Pekrun et al., 2002), and has been linked to poorer academic performance (Cassady & Johnson, 2002). In the present paper, we explore examination anxiety as a habitual and recurring emotion that is experienced in relation to academic examinations (i.e., trait), rather than as a momentary and acute emotional episode (i.e., state; Spielberger & Vagg, 1995). Alongside examination anxiety, a broad gamut of positive affect, such as enjoyment, hope, pride,

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relief, and negative affect such as anger, anxiety, shame, hopelessness, and boredom, have been implicated in the academic outcomes of students (Pekrun et al., 2002). Affect plays an important role in human life (Gray & Watson, 2007), and refers to feelings, preferences, emotions, moods, and affective traits (Díaz-García et al., 2020). In the current study, we consider affect as mental states involving valenced evaluative feelings (e.g., feeling good-bad; Parkinson et al., 1996), with negative affect characterized by subjective distress and unpleasurable engagement, and positive affect by pleasurable engagement (Crawford & Henry, 2004). In the academic attainment literature, studies have linked positive emotions to academic interest and effort, and overall achievement (e.g., Pekrun et al., 2004), and have suggested that negative emotions, particularly anxiety and anger, can damage academic outcomes by hindering cognitive processes important for success (e.g., memory, Owens et al., 2014). However, it is also recognized that negative emotions are not always deleterious and could facilitate cognitive performance in some situations (Valiente et al., 2012). For example, anxiety that one does not have sufficient subject knowledge to pass an upcoming examination may lead to additional effort in revising and preparing for said examination. Indeed, students who are sufficiently regulated may be able to harness emotion-generated energy for task accomplishment (Izard, 2002). Thus, the study of student affect is important because it implicates student motivation, learning, and academic achievement (Pekrun et al., 2002).

Some prominent theory holds that emotions occur via a transactional appraisal process (Scherer et al., 2001), a notion that can help to explain individual differences in emotional responding to stimuli (Lazarus, 1999), such as academic examinations. Since each individual can form their own appraisals concerning examinations, then emotional responding can vary across individuals, since appraisal mediates the emotional impact of situational factors. Studying appraisals is important in part because they can be targeted by educational interventions intended to foster positive emotional development (Pekrun, 2006). As a guiding framework for research, Richard Lazarus' cognitive appraisal theory (CAT; Lazarus, 1991; Lazarus & Folkman, 1984; Smith & Lazarus, 1993) might help explain the occurrence of emotions such as examination anxiety.

In CAT emotions are the result of a transaction between the goals of the individual and the representation of environmental encounters, characterized by primary and secondary cognitive appraisal. Primary appraisals are concerned with the extent to which the encounter is relevant to one's goals (goal relevance; GR), and whether the encounter is congruent with one's goals (goal congruence; GC). Secondary appraisals concern one's options for coping with the encounter and includes problem-focused coping (PFC) potential (evaluations of one's ability to act directly on the situation to bring it in accord with one's goals), and emotion-focused coping (EFC) potential (evaluations of one's ability to psychologically adjust to the situation by altering one's interpretations, desires, or beliefs; Smith & Lazarus, 1993). Lazarus (1999) also posits core relational themes that make it possible to determine the precise emotion generated from a specific constellation of appraisals. For example, anxiety is associated with the core relational theme of uncertain, and existential threat (Lazarus, 1991), where primary appraisals of high GR and low GC combine with secondary appraisals of low EFC (Smith & Lazarus, 1993). Therefore, academic examinations are likely to give rise to anxiety because they are relevant to student goals (GR), stand in the way of students achieving their goals (low GC), and are an uncertain and existential (ego) threat. An appraisal of poor coping potential (PFC, EFC) will also increase anxiety.

The notion of emotion being the result of a transaction between the environment and the individual is also expressed in prominent cognitive–behavioral approaches to psychotherapy (CBTs). Most notably, in rational emotive behavior therapy (REBT; Ellis, 1957), considered to be the first CBT, particular importance is placed upon how human beings appraise events and how this can shape emotion and behavior. In REBT, it is not the event (e.g., an examination) that causes anxiety *alone*, rather, it is the beliefs one has about the event that underpins anxiety. REBT theory, and over 50-years of REBT research, clearly indicates that applying irrational beliefs to events tends to underpin greater negative emotion (see Visla et al., 2015, for a meta-analysis). Irrational beliefs are rigid, extreme, and illogical beliefs concerning the self, others, and the world,

and often comprise demands that things should be as one wants them to be (Ellis, 1994). In REBT, there are four core irrational beliefs, namely demandingness (e.g., "I want to, and so I must, be successful"), awfulizing (e.g., "it is not just bad, it is awful to fail"), low frustration tolerance (e.g., "I cannot stand failing"), and depreciation (e.g., "if I fail, it shows that I am complete failure"). In other words, in REBT, irrational beliefs are dogmatic, over-generalizing and totalistic, and inconsistent with reality (e.g., containing non-sequiturs). Thus, in REBT, irrational beliefs are at the center of emotion as part of the cognitive appraisal process.

Given the similarities between the core ideas of Lazarus' cognitive appraisal theory and Ellis' REBT, it is perhaps unsurprising that the two theories have been compared by both Lazarus (1989) and Ellis (1994), whose common progenitor is Magda Arnold who first conceptualized cognitive appraisal formally (1960). Both Ellis and Lazarus were pioneers of a cognitive approach to emotion (Ellis, 1957, Lazarus, 1966) who produced somewhat overlapping theories, Lazarus in academia, and Ellis in psychotherapy (Lazarus, 1989). Both Ellis and Lazarus regarded emotion "as a response to personal meaning, which comes down to judgements about oneself and the world" (Lazarus, 1989, p. 49). As such, different judgements beget different emotional qualities and intensities. Lazarus focused less on core beliefs compared to Ellis, favoring situational appraisals, but did recognize that general beliefs about the self and world play an antecedent role in emotion (Lazarus, 1999). Lazarus places a larger emphasis on coping potential as part of appraisal compared to Ellis, who focused on disputation and cognitive change as a coping strategy. Also, Ellis used a Goals-Adversity-Beliefs-Consequences framework (Ellis, 1962, 1994) to capture what Lazarus posited in his appraisal components. Cognitive appraisals are thoroughly couched in, and interconnected with, beliefs as represented in the Goals-Adversity-Beliefs-Consequences framework (Ziegler, 2001). In the Goals-Adversity-Beliefs-Consequences framework, individuals face Adversity that impedes their Goals, which set the scene for negative emotional and behavioral Consequences. If the individual applies irrational Beliefs to the goal impediment, greater and more maladaptive negative Consequences will arise.

However, it is possible to bring cognitive appraisal theory and REBT together to enable to greater understanding of how events can lead to anxiety (e.g., Turner, 2022). For example, a student is anticipating the start of a final exam (reflecting Goals in the REBT model, and high GR in cognitive appraisal theory). The student has not taken an exam of this difficulty before, and they are not sure whether they will perform well (reflecting A in the REBT model, and uncertain, existential threat, and low GC in cognitive appraisal theory). The student cannot change the situation now (low PFC), and does not have the ability to psychologically adjust (low EFC). The student also believes that "I want to and therefore I must reach my important goals in life, and not doing so would make me a complete failure" (reflecting irrational beliefs in the REBT model). This constellation of cognitive appraisals (including irrational beliefs) is conducive to heightened anxiety, which might be unpleasant, but also may not be ideal for examination performance. Indeed, related to the irrational beliefs proposed within REBT, cognitive distortions (faulty, illogical beliefs) and have been shown to be a mediating factor in the relationship between examination anxiety and academic attainment, whereby worry and bodily symptoms (anxiety) were positive predictors of cognitive distortions which were, in turn, an inverse predictor of GCSE achievement (Putwain et al., 2010).

The confluence of cognitive appraisal theory and REBT has been considered in previous research (David et al., 2002; David et al., 2005), which examined the role of cognitive appraisal theory components and irrational beliefs in a range of emotions. Results indicated particular patterns of appraisal across the emotions. For example, in David et al. (2002) anxiety was best predicted by high GR, low GC, and high irrational beliefs, and in David et al. (2005) anxiety was best predicted by high GR, low GC, low EFC, and high irrational beliefs. Previous work has revealed some promising convergence between cognitive appraisal theory and REBT, but has been limited in sample size ($n = 60$–120; David et al., 2002). Also, the regression analyses conducted in past studies of this nature limit the ability to encapsulate the interaction between appraisal components, and their indirect effects on multiple affective outcomes. Therefore, in the present study, we replicate and build upon David et al.'s work by employing path analyses with a larger sample of university students.

Furthermore, in the present study, rather than assess general anxiety symptoms, we focus on examination anxiety as a more contextual assessment of this emotion. Our assessment of cognitive appraisals is also geared toward examinations, offering a more specific exploration of theory with regards to actual emotionally evocative events.

In sum, in seeking to understand examination anxiety, an exploration into cognitive appraisal as posited in cognitive appraisal theory and REBT may shed some light onto how examination anxiety occurs. Rather than viewing cognitive appraisal theory and REBT as separable transactional explanations for emotion, we can begin to integrate these prominent theories to enable a more comprehensive study of emotion etiology and regulation. The present paper comprises three studies in which we seek to answer the question: what are the cognitive appraisals that underpin examination anxiety and affect in a sample of university students, and how do cognitive appraisals, examination anxiety and affect relate to academic self-concept of ability? We include affect here because academic contexts are enriched with emotional diversity, so it is important to capture a broad range of affect experienced by students in addition to specific examination anxiety. Indeed, whilst evidence indicates that examination anxiety can influence attainment, there is also evidence that broader affect can influence academic outcomes too (Pekrun et al., 2004). In this paper, we operationalize the academic self-concept of ability, referred hitherto as "ASC", as a student's self-assessment about what they can and cannot do in academic contexts (e.g., Bong & Skaalvik, 2003; Gorges & Hollmann, 2019; Trautwein et al., 2006), and use self-reported information concerning student's exam performances to indicate ASC.

In a preliminary study, we test the factor structure of a self-report measure assessing irrational performance beliefs that we have adjusted to fit the academic context more apparently. Then, in study 1, informed by cognitive appraisal theory and REBT, we examine the underpinning cognitive appraisals and irrational beliefs of examination anxiety, affect, and ASC in a sample of U.K. undergraduate students. We seek to replicate and build upon David et al. (2002; 2005) by studying the confluence between cognitive appraisal theory and REBT in relation to the specific context of university examinations. In study 2, we extend study 1 by incorporating additional cognitive appraisal components outlined in cognitive appraisal theory, namely challenge and threat, which are markers of adaptive (challenge) and maladaptive (threat) cognitive appraisal. Challenge and threat were not considered by David et al. in their research, but are considered to be important appraisal components within the wider literature (e.g., Meijen et al., 2020). Indeed, the extant challenge and threat research indicate its relevance across various performance domains such as aviation (Vine et al., 2015), surgery (Moore et al., 2014), sport (Turner et al., 2013), and public speaking (Trotman et al., 2018). Study 1 is extended by study 2 by the inclusion of challenge and threat, in order to examine the role of challenge and threat as part of the cognitive appraisal theory and REBT confluence. In study 2, we also take a longitudinal approach to explore the relationships between cognitive appraisals, irrational beliefs, examination anxiety and affect, in order to capture the temporal dynamics of exam relevant cognition and affect.

Preliminary study

The purpose of this preliminary study was to test the factor structure of the irrational performance beliefs inventory (iPBI; Turner et al., 2018a) for use with university students. The iPBI was originally developed and validated within an occupational sample, although it has been used frequently in a range of samples including athletes (Michel-Kröhler & Turner, 2022; Turner & Allen, 2018), exercisers (Miller et al., 2023), and students (Turner et al., 2018b). However, given the importance of accurate measurement, but the absence of a student-specific irrational beliefs measure in the literature, we adjusted some of the iPBI items in order to fit the university student context. The 28-item iPBI measures primary irrational beliefs: PIB (e.g., "I have to be respected by the people on my course"), frustration intolerance: FI (e.g., "I can't stand not reaching my goals"), awfulizing: AWF ("It's terrible if the members of my course do not respect me"), and depreciation: DEP ("I am a

loser if I do not succeed in things that matter to me"). A total iPBI score indicates the level of endorsement of irrational belief, and responses are made on a five-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In the current study, questions 4, 11, 14 and 17 of the iPBI were altered to focus specifically on academic achievement; for example, question four was changed from, "I need my manager/coach to act respectfully towards me," to "I need my lecturer to act respectfully towards me."

In order to ensure that this student iteration of the iPBI was valid for psychometric usage in the current study, we conducted confirmatory factor analysis (CFA). In order to complete CFA, we recruited $n = 1150$ university students ($M_{age} = 22.22$, $SD_{age} = 6.00$; female = 503, male = 575, did not disclose = 72) studying in the U.K. to take part in a single wave of data collection ($n = 362$ also completed measures for use in study 1), using convenience and snowball sampling. In the current study, we wanted to provide a sample size that could be considered excellent ($n > 1000$; Boateng et al., 2018; Osborne & Costello, 2004) because on the basis of the CFA, changes to the iPBI might occur and we wanted to be sure that these changes were based on more than sufficient data.

Prior to CFA, missing data (0–.04%) were replaced using SPSS expectation maximization, and outliers (standardized z values > 3.29; Hahs-Vaughn, 2016) were Winsorized ($n = 7$ from 41,400 cases = .02%; Kwak & Kim, 2017). Goodness of fit was assessed using the χ^2 statistic, the comparative fit index (CFI), the Tucker–Lewis Index (TLI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). Values below .06–.08 for the RMSEA (Awang, 2012; Brown, 2015) and .08 for the SRMR (Byrne, 1994) are indicative of an acceptable model fit, as are values between .90 and .95 for the CFI and TLI (Byrne, 1994; Hu & Bentler, 1998; Marsh et al., 2004; Schumacker & Lomax, 2004). We then computed internal reliability coefficients (Cronbach's α) for each irrational belief subscale; α > .70 indicates good reliability (Nunnally & Bernstein, 1994; for a critique of coefficient α, see McNeish, 2018).

Full standardized factor loadings, error variances, and coefficient α estimates for the 28-item and 23-item versions are reported in file 1 of supplementary materials. The initial CFA produced a somewhat unacceptable fit to the theoretically expected four-factor structure, $\chi^2(232) = 1769.663$, $p < .001$, CFI = .85, TLI = .83, SRMR = .075, RMSEA = .084 (90% CI: .078, .083). We explored whether the removal of potential problem items would improve statistical fit. Items were selected for removal based on modification indices (> 20), standardized factor loadings and error variances. A 23-item measure produced a more acceptable fit to the theoretically expected four-factor structure, $\chi^2(236) = 1105.399$, $p < .001$, CFI = .94, TLI = .92, SRMR = .067, RMSEA = .061 (90% CI: .057, .064). Coefficients α and ω estimates were similar for the 23-item and 28-item versions of the iPBI (see Table 1). On the basis of the CFA results, and the internal consistency results, the 23-item iPBI-Student was used in all subsequent analyses.

Study 1

In study 1, we examine the underpinning cognitive appraisals of examination anxiety, affect, and ASC in a sample of undergraduate students in the United Kingdom (U.K.). Based on past research (e.g.,

Table 1. Cronbach's α and ω for 28-item version and 23-item version of the IPBI subscales for the Preliminary Study, and at wave 1 and wave 2 for Study 2.

	Preliminary study				Study 2			
	28-item		23-item		Wave 1		Wave 2	
	α	ω	α	Ω	α	ω	α	ω
PIB	.81	.81	.73	.73	.69	.70	.67	.69
FI	.87	.87	.88	.88	.80	.81	.83	.83
AWF	.84	.84	.84	.84	.87	.87	.81	.81
DEP	.90	.90	.90	.90	.90	.90	.88	.88
Total	.93	.92	.92	.91	.91	.91	.91	.90

David et al., 2002), and theory (e.g., cognitive appraisal theory and REBT), it is hypothesized that students who report greater anxiety and more negative (and less positive) affect, will report greater negative appraisals characterized by higher GR, lower GC, lower PFC and EFC (i.e., poorer coping), and higher irrational beliefs. It is also hypothesized that greater negative appraisals, greater anxiety and more negative (and less positive) affect, will be associated with poorer student ASC. That is, those with a more positive ASC would have a more adaptive psychological approach to exams, where "adaptive" reflects a more positive appraisal, lower irrational beliefs, and lower negative affect (including less exam anxiety).

Method

Participants

A total of 362 participants (female = 159, male = 195, did not disclose = 8; M_{age} = 21.95, SD = 5.69; first year = 3.3%, second year = 20%, third year = 47.80%) from two universities in the United Kingdom (Staffordshire = 307, Salford = 55) studying BSc sport science and psychology courses, completed measures of irrational beliefs, cognitive appraisal, examination anxiety, affect, and examination attainment. Sample size was determined using GPower 3.0 (Faul et al., 2007). To detect the recommended "minimum effect size representing a practically significant effect" (RMPE) for social science research (R^2 = .04 [f^2 = .043]; Ferguson, 2009), with statistical power set at .80 and an alpha error probability of .05, in a regression-type model with 7 predictors, the sample size required is 341. Only students enrolled on courses in which assessment was undertaken using examinations were recruited. Questionnaires were completed either online using Qualtrics (online survey provider), or physically in person using paper surveys. The questionnaires took no longer than 15-minutes to complete. University ethical approval was gained from each institution prior to participant recruitment and all participants completed informed consent prior to taking part.

Measures

Irrational beliefs

On the basis of the CFA and internal consistency results in the preliminary study, the 23-item iPBI-Student was used. A total iPBI score indicates level of endorsement of irrational belief, such that higher scores reflect stronger irrational beliefs. Responses are made on a five-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Cognitive appraisal

The primary and secondary cognitive appraisals were assessed with five single-item questions used in previous research (Chadha et al., 2019; David et al., 2002), modified from Smith and Lazarus (1993). The primary appraisal comprises of goal relevance (GR; "How important is your next exam to you?"), goal congruence (GC; "Think about what you WANT in your next exam. To what extent will these DESIRABLE elements be present in your next exam?"), and goal incongruence (GI; Think about what you DON'T WANT in your next exam. To what extent do you think these UNDESIRABLE elements will be present in your next exam?), and the secondary appraisal comprises of problem-focused coping potential (PFC; "When you take your next exam, how certain are you that you will be able to influence things to make (or keep) the situation the way you want it to be?") and emotion-focused coping potential (EFC; "Thinking about your next exam, how certain are you that you will be able to deal emotionally with what will be happening in the exam?"). The single-item questions were answered on a 11-point Likert-scale ranging from 1 (*not at all*) to 11 (*extremely*). To assess the relative goal congruence of the next exam, GI scores were subtracted from GC (GI-GC) scores to produce a congruence discrepancy score. Relative goal congruence (RGC) indicates the

extent to which participants anticipate the presence of desirable elements *relative to* the presence of undesirable elements. Higher congruence discrepancy scores indicate greater RGC.

Examination anxiety

The Westside test anxiety scale (Driscoll, 2007) was used to assess examination anxiety, which comprises 10-items scored on a 5-point Likert-scale between 1 (*not at all or never true*) to 5 (*extremely or always true*). Participants are asked to indicate how true each items is for them, including statements such as "The closer I am to a major exam, the harder it is for me to concentrate on the material", "I worry so much before a major exam that I am too worn out to do my best on the exam", and "I feel out of sorts or not really myself when I take important exams". A total score is calculated by summing the item scores, and higher scores reflect greater anxiety. The scale specifically measures anxiety impairments, with most items asking about worry and/or performance impairment. In the current sample, Cronbach's $\alpha = .89$.

Affect

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) incorporates two 10-item subscales based on a bi-dimensional theory of affect. Individuals can experience a mixture of positive affect (interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, active) and negative affect (distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, afraid) during a specific period of time (Watson & Tellegen, 1985). The items are scored on a 5-point Likert-scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). In order to orient responses to the PANAS towards exams, participants were asked to indicate to what extent they felt each item with regards to their next upcoming exam. Cronbach's α in the current sample was .82 for the positive affect, and .85 for the negative affect. In the current study, we conceptualize positive and negative emotions as hedonic balance (the relative amount of positive emotion to negative emotion), because it is considered a more suitable index of subjective well-being than measures of positive and negative affect when model predictions target the overall affective experience (Allen et al., 2017). Higher hedonic balance scores indicate a greater tendency to experience positive affect, and in the current paper for brevity and ease of comprehension, we refer to hedonic balance simply as "affect".

Academic self-concept

To indicate the academic self-concept (ASC) for participants, we used a set of self-report questions pertaining to past, typical, and future examination performance: What grade did you get in your last exam? What grade do you typically get in exams? What grade do you think you will get in your next exam? We selected these questions in order to provide an overall sense of how well participants perform in examinations, such that higher scores in each question indicate a more positive ASC. We wanted to get a sense of how participants perform in exams above and beyond a single exam grade which would reflect a singular and momentary data point. Also, we did not have, nor did we request, access to student records. Pearson's correlation coefficients ($r = .48–.59$, $p < .001$), inter-item correlation (.48–.61), Cronbach's alpha ($\alpha = .78$), and McDonald's omega ($\omega = .79$) indicated agreement across the three questions, and therefore we formed a composite score to indicate ASC, which amalgamates recent, typical, and potential future, examination attainment. Grades were coded on a 1–5 scale where 1 = lowest grade (i.e., fail at University level), 2 = third class, 3 = lower second class (2:2), 4 = upper second class (2:1), and 5 = the highest grade (first class at University). Higher scores indicate a more positive ASC.

Transparency and openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study, and we follow JARS (Kazak, 2018). All research materials are available on

request from the first author, and data available at https://osf.io/6f9ap/?view_only = 8767daaa29544aecbada7abf2ad62206. This study's design and its analysis were not pre-registered.

Analytic strategy

Participant data ($n = 362$) were screened for missing values and full information maximum likelihood information (FIML) data imputation was applied in SPSS AMOS to the target variables in the dataset to provide a complete dataset for analyses. Data were screened for outliers (standardized z values > 3.29; Hahs-Vaughn, 2016), and outliers were Winsorized ($n = 16$ from 29,684 cases = .06%; Kwak & Kim, 2017). In order to test correlational hypotheses, we calculated Pearson's bivariate correlation coefficients across target variables, which can be found in table 2.

Results

Pearson's bivariate correlation coefficients revealed that irrational beliefs were negatively related to RGC ($r = -.26$, $p < .001$), EFC ($r = -.16$, $p < .001$), affect ($r = -.24$, $p < .001$), and ASC ($r = -.13$, $p = .009$), and positively related to anxiety ($r = .31$, $p < .001$). GR was positively related to EFC ($r = .12$, $p = .022$) and ASC ($r = .16$, $p = .002$). RGC was positively related to PFC ($r = .16$, $p = .002$), EFC ($r = .22$, $p < .001$), affect ($r = .36$, $p < .001$), and ASC ($r = .17$, $p = .001$), and negatively related to anxiety ($r = -.31$, $p < .001$). PFC was positively related to EFC ($r = .51$, $p < .001$) and affect ($r = .15$ $p = .006$), and negatively related to anxiety ($r = -.12$, $p < .023$). EFC was positively related to affect ($r = .35$, $p < .001$) and ASC ($r = .20$, $p < .001$), and negatively related to anxiety ($r = -.28$, $p < .001$). Anxiety was negatively related to affect ($r = -.56$, $p < .001$) and ASC ($r = -.32$, $p < .001$). Finally, affect was positively related to ASC ($r = .42$, $p < .001$).

Discussion

We hypothesized that students who report greater anxiety and more negative (and less positive) affect, would report greater negative appraisals characterized by higher GR, lower GC, lower PFC and EFC (i.e., poorer coping), and higher irrational beliefs. In line with this hypothesis, data analyses indicate that less adaptive affective states, characterized by higher anxiety and less positive affect, are associated with a more negative cognitive appraisal profile, characterized by lower GR, RGC, EFC, PFC, and higher irrational beliefs. We also hypothesized that a more negative appraisal profile, greater anxiety and more negative (and less positive) affect, would be associated with poorer student academic self-concept. In line with this hypothesis, we found that poorer ASC was related to lower GR, RGC, EFC, less positive (more negative) affect, and higher irrational beliefs and anxiety.

Table 2. Bivariate Pearson's correlation coefficients for irrational beliefs, cognitive appraisal, exam anxiety, affect, and academic self-concept in study 1.

	2.	3.	4.	5.	6.	7.	8.
1. IBs	.01	−.26**	−.06	−.16**	.31**	−.24**	−.13*
2. GR	–	.01	.10	.12*	.04	.10	.16**
3. RGC		–	.16**	.22**	−.31**	.36**	.17**
4. PFC			–	.51**	−.12*	.15**	.09
5. EFC				–	−.28**	.35**	.20**
6. Anxiety					–	−.56**	−.32**
7. Affect						–	.42**
8. ASC							–

Notes: IBs, total irrational beliefs; GR, goal relevance; RGC, relative goal congruence; PFC, problem focussed coping; EFC, emotion focussed coping; ASC, academic self-concept.

*$p < .05$.

**$p < .001$.

Thus, it was apparent that a more adaptive affective state was related to student ASC. In sum, with regards to exam anxiety, lower RGC, PFC, EFC, more negative affect, and higher irrational beliefs were related to greater anxiety. In other words, those who reported that they anticipated desirable outcomes of their exams, who expressed an ability to apply coping to exams and their emotions, who reported more positive (less negative) affect, and endorsed lower irrational beliefs, were less anxious about exams. Regarding ASC, higher GR, RGC, EFC, more positive affect, and lower irrational beliefs and anxiety were related to more positive ASC. In other words, those who reported that exams are important to them, who anticipated desirable outcomes of their exams, and expressed an ability to apply coping to their emotions, who reported more positive (less negative) affect and lower anxiety, and endorsed lower irrational beliefs, reported a more positive ASC. The findings of study 1 align with the chief stimulus for the study, namely David et al. (2002), who found that anxiety in university students was best predicted by high GR, low GC, and high irrational beliefs, and David et al. (2005) in which anxiety was additionally predicted low EFC. Broadly, the results of study 1 support the confluence of CAT and REBT constructs in the context of affect as proffered in theory (Ellis, 1994; Turner, 2022), in the context of examinations and ASC.

Importantly in study 1, irrational beliefs data collected using the 23-item iPBI-Student was related to outcomes in ways that we would expect for an accurate measure of irrational beliefs. This finding, and the prior instantiation of the iPBI-Student in the preliminary study, offer added value beyond the current paper. It is possible for researchers studying irrational beliefs, and more broadly REBT, to use the iPBI-Student in their data collection (iPBI-Student is available on request from the first author). Whilst study 1 offers some enlightening findings with regard to the role of cognitive appraisal and irrational beliefs in affectivity and attainment, a purely cross-sectional approach to study design and analyses has some limitations. We cannot rule out that the results of study 1 are specific to the cohort sampled, and we cannot imply, for example, that cognitive appraisals and irrational beliefs predicted affective states in a directional manner.

Study 2

In study 2, we sought to replicate and build upon the findings of study 1. The stimulus for study 1 was David et al. (2002; 2005) and as such theoretically we stayed close to their approach. But David et al. (2002; 2005) omit an important cognitive appraisal component put forth by Lazarus (1999), namely challenge and threat. Challenge and threat are indicators of cognitive appraisal outcome, whereby a more positive appraisal profile is likely to be reflected in challenge, and a more negative appraisal profile is likely to be reflected in threat (Lazarus, 1999). Challenge is considered to be adaptive for human functioning, whereas threat is considered to be maladaptive for human functioning (Blascovich, 2008; Blascovich & Mendes, 2000; Jones et al., 2009; Seery, 2011). Indeed, drawing on the work of Putwain (2007), an Office of Qualifications and Examinations Regulation (Ofqual) report (Howard, 2020) recognizes the role of challenge and threat in exam anxiety and performance, noting that "if the stressor is perceived as a threat, this causes anxiety, can disrupt cognitive function (for instance, going blank in an exam), and as a result, can reduce performance" (p. 7).

Therefore, in study 2, we include challenge and threat to advanced theory toward a more comprehensive portrayal of cognitive appraisal as it pertains to examination anxiety. The inclusion of challenge and threat is in line with recent theorizing, where cognitive appraisals goal relevance (GR), goal congruence (GC), goal incongruence (GI), problem-focused coping potential (PFC), and emotion-focused coping potential (EFC) are proposed to relate to challenge and threat alongside irrational beliefs (e.g., Meijen et al., 2020). Some data supports this proposal, whereby more negative appraisal (higher GR and GI, and lower coping) and higher irrational beliefs have been associated with greater threat (Chadha et al., 2019; 2023). Other research has found that greater irrational beliefs contribute to greater threat (Dixon et al., 2017; Evans et al., 2018; Mansel, 2021), and increased irrational beliefs are related to increased burnout (Turner & Moore, 2016). Chadha et al. (2023)

studied the temporal effects of irrational beliefs on cognitive appraisal and affective outcomes in elite golfers, finding that increases in irrational beliefs over a week were associated with a shift toward more negative cognitive appraisal, increased threat and increased competitive anxiety. Thus, there may be important temporal dynamics involved in the relationships between irrational beliefs, cognitive appraisal, and affective states.

Study 2 advances the methodology of study 1 by employing a temporal study design to overcome the limitations of the atemporal design used in study 1. Specifically, in study 2 we recruit a separate cohort of U.K. university students and employ a two-wave (six-months apart) longitudinal design to investigate cognitive appraisals, irrational beliefs, challenge and threat, affectivity, and ASC. We investigate how changes in cognitive appraisal, irrational beliefs, and challenge and threat, relate to changes in affectivity and ASC. Based on study 1, on theory (Meijen et al., 2020), and on past research (Chadha et al., 2019; 2023), it is hypothesized that students who report increased anxiety and worsening (more negative) affect, will report increased negative appraisals characterized by decreased RGC (i.e., lower congruence relative to incongruence), decreased PFC and EFC (i.e., poorer coping), increased threat, and decreased challenge, and will report increased irrational beliefs. It is also hypothesized that increased negative appraisals, increased irrational beliefs, and increased anxiety, and worsening (more negative) affect, will be associated with a decline in ASC.

Again longitudinally, but using cross-lagged panel analysis, it is hypothesized that that greater negative appraisals and higher irrational beliefs at wave 1 would be associated with greater anxiety and worse affect at wave 2. Also, greater anxiety and worse affect at wave 1 would be related to poorer student ASC at wave 2. In all, our aim was to examine the temporal associations between target variables in line with theory.

Method

Participants

We recruited $n = 662$ university students ($M_{age} = 23.16$, $SD_{age} = 7.00$; female = 359, male = 242, did not disclose = 61; Asian = 5.5%, Black = 5.0%, Mixed = 2.1%, White = 85.9%, did not disclose = 1.5%; first year = 43.5%, second year = 37.1%, third year = 19.1%, did not disclose = 0.2%) studying in the U.K. (BSc biology = 6.6%, BA education = 29.4%, BSc psychology = 12.8%, BSc/BA sport = 51.3%) at two universities (Staffordshire, and Salford) to take part in two waves of data collection, using convenience and snowball sampling. Only students enrolled on courses in which assessment was undertaken using examinations were recruited. Questionnaires were completed either online using Qualtrics, or physically in person using paper surveys. The questionnaires took no longer than 15-min to complete. University ethical approval was gained prior to participant recruitment and all participants completed informed consent.

Design

We adopted a two-wave longitudinal study design, allowing us to complete longitudinal cross-lagged, and change, analyses. Wave 1 data collection occurred in October 2018, and wave 2 data collection took place in April 2019.

Measures

In study 2, we assessed irrational beliefs using the 23-item iPBI-Student derived in study 1. In order to confirm the validity of this 23-item version, we ran CFA, which revealed a χ^2 value of 545.539 (df = 220, $p < .001$), with goodness-of-fit indices: CFI = .94, SRMR = .05, RMSEA = .05 (CI: .048, .059). These data demonstrated that the 23-item iPBI-Student provided an acceptable fit to the four-factor model.

Standardized factor loadings, error variances, and coefficient α estimates are reported in File 2 of supplementary materials. In addition, for the iPBI subscales α's and ω for wave 1 and 2 can we found in Table 1.

We also assessed cognitive appraisals (Chadha et al., 2019), examination anxiety (Driscoll, 2007; $\alpha = .89$ at wave 1, and .90 at wave 2), affect (Watson et al., 1988; positive affect: $\alpha = .89$ at wave 1, and .98 at wave 2; negative affect: $\alpha = .89$ at wave 1, and .90 at wave 2), and student ASC. For student ASC, at wave 1 Pearson's correlation coefficients ($r = .39–.65$, $p < .001$), inter-item correlation (.39–.65), and Cronbach's alpha ($\alpha = .76$) indicated agreement across the three questions, and at wave 2 Pearson's correlation coefficients ($r = .48–.60$, $p < .001$), inter-item correlation (.48–.60), and Cronbach's alpha ($\alpha = .77$) indicated agreement across the three questions. From these data, we formed a composite score to indicate a Mean student ASC score, as we did in study 1.

In addition, in line with the aims of study 2, we assessed challenge and threat evaluations using the Cognitive Appraisal Scale (CAS; Skinner & Brewer, 2002). The CAS is an 18-item Likert-type scale in which item responses range from 1 (*strongly disagree*) to 6 (*strongly agree*) and participants were asked to indicate the extent to which they agreed with each statement. Eight items make up the Challenge subscale (e.g., "I tend to focus on the positive aspects of any situation" and "In general I anticipate being successful at my chosen pursuits, rather than expecting to fail"). Ten items make up the Threat subscale (e.g., "I am concerned that others will find fault with me", and "I am concerned that others will not approve of me"). The Challenge appraisal subscale had a Cronbach's α coefficient of .83 at wave 1 and .84 at wave 2, whereas the Threat appraisal subscale had an α coefficient of .94 at wave 1, and .93 at wave 2.

Transparency and openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study, and we follow JARS (Kazak, 2018). All research materials are available on request from the first author, and data available at https://osf.io/6f9ap/?view_only = 8767daaa29544aecbada7abf2ad62206. This study's design and its analysis were not pre-registered.

Analytic strategy

Of the 662 participants, $n = 517$ completed wave 1, $n = 273$ of whom also completed wave 2, and $n = 145$ completed wave 2 only. Participants who *only* completed wave 2 were excluded from analyses. Thus, $n = 517$ participants' data were screened for missing values and full information maximum likelihood information (FIML) data imputation was applied in SPSS AMOS to the dataset to provide a complete dataset for all analyses. Data were then screened for outliers (standardized z values > 3.29; Hahs-Vaughn, 2016), and outliers were Winsorized ($n = 148$ from 134,386 cases = .11%; Kwak & Kim, 2017). In order to document atemporal correlational hypotheses, we calculated Pearson's correlation coefficients across target variables.

Using wave 1 to wave 2 unstandardized residualized change scores (Zumbo, 1999), we completed path analysis with bootstrapping procedures using SPSS AMOS version 27 (e.g., Chadha et al., 2019). Residualized change scores are preferable to the simple change scores approach as it eliminates auto-correlated errors and regression toward the mean effects (e.g., Cheval et al., 2021). A positive residualized change score indicates an increase from wave one to wave two, and a negative score indicates a decrease. In line with recommendations for path analyses (Browne & Cudek, 1993; Hu & Bentler, 1998; Kline, 2005; Vandenbergh & Lance, 2000) model fit was evaluated using the chi-square statistic (χ^2 $p > .05$ = good fit), CFI and TLI (between .90 and .95 = good fit), RMSEA (< .08 is acceptable), and SRMR (< .08 is acceptable).

We also completed hierarchical multiple regression analyses using the unstandardized residual change scores. Variables were entered in line with the path analyses, but because regression

allows only for a single outcome, we ran three separate models. In models 1 and 2, anxiety and affect were the respective outcomes, with irrational beliefs entered at step 1, cognitive appraisals (GR, RGC, EFC, and PFC) entered at step 2, and challenge and threat entered at step 3. In model 3, with student ASC as the outcome, steps 1–3 were the same as models 1 and 2, but at step 4 anxiety and affect were added.

Finally, we conducted cross-lagged panel analysis for observed variables with cross-lagged and autoregressive paths (e.g., Curran et al., 2016) between wave 1 and wave 2. This allowed us to assess temporal direct effects between all variables at wave 1, and all variables at wave 2, whilst accounting for autoregressive effects.

Results

Atemporal effects

Correlations at wave 1 and wave 2, and between wave 1 and wave 2, can be seen in Tables 3 and 4.

Temporal effects

Path analysis

Path analysis revealed that the hypothesized model demonstrated an acceptable fit to the data $\chi^2(8) = 35.016$, $p < .001$, CFI = .97, TLI = .84, SRMR = .041, RMSEA = .080 (CI: .055, .109). The significant standardized path coefficients (*direct effects*) for each individual path are displayed in Figure 1. Overall, change in cognitive appraisals and change in irrational beliefs accounted for 17% of the total variance in change in challenge, and 25% in change in threat. Cognitive appraisals, irrational beliefs, challenge, and threat, accounted for 38% of total variance in anxiety, and 33% in affect. With regards to change in student ASC, change variables accounted for 5% of the variance.

Results of *indirect effects* revealed that change in EFC was negatively related to change in anxiety ($\beta = -.13$, $p = .004$), positively to change in affect ($\beta = .16$, $p = .004$), and positively to change in ASC ($\beta = .05$, $p = .009$). Change in RGC was negatively related to change in change in anxiety ($\beta = -.09$, $p = .021$), and positively related to change in affect ($\beta = .09$, $p = .006$) and change in ASC ($\beta = .05$, $p = .004$). Change in GR was positively related to change in anxiety ($\beta = .08$, $p = .018$). Change in irrational beliefs was positively related to the change in anxiety ($\beta = .11$, $p = .004$) and negatively related to change in affect ($\beta = -.15$, $p = .004$). Change in challenge was positively related to change in ASC ($\beta = .05$, $p = .004$). Change in threat was negatively related to change in affect ($\beta = -.10$, $p = .004$) and change in ASC ($\beta = -.05$, $p = .044$). Change in anxiety was negatively related to change in ASC ($\beta = -.07$, $p = .007$).

Table 3. Study 2 bivariate Pearson's correlation coefficients for irrational beliefs, cognitive appraisal, challenge and threat, exam anxiety, affect, and academic self-concept at waves 1 (upper section) and 2 (lower section).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. IBs	–	.15**	−.23**	−.10*	−.24**	−.20	.56**	.47**	−.29**	.02
2. GR	.06	–	.02	.11*	.06	.27**	.12**	.05	.09	.04
3. RGC	−.13**	.16**	–	.36**	.30**	.34**	−.26**	−.37**	.42**	.15**
4. PFC	−.10*	.18**	.28**	–	.51**	.31**	−.15**	−.27**	.31**	.11*
5. EFC	−.14**	.09*	.17**	.52**	–	.35**	−.32**	−.43**	.38**	.09
6. Challenge	−.02	.24**	.25**	.27**	.37**	–	−.23**	−.26**	.44**	.12**
7. Threat	.45**	.12**	−.18**	−.19**	−.32**	−.15**	–	.57**	−.41**	−.03
8. Anxiety	.45**	.08	−.26**	−.26**	−.34**	−.21**	.58**	–	−.57**	−.10*
9. Affect	−.21**	.23**	.31**	.31**	.33**	.41**	−.32**	−.45**	–	−.02
10. ASC	−.01	.13**	.28**	.28**	.27**	.33**	−.14**	−.15**	.30**	–

Notes: IBs, total irrational beliefs; GR, goal relevance; RGC, relative goal congruence; PFC, problem focussed coping; EFC, emotion focussed coping; ASC, academic self-concept.

*$p < .05$.

**$p < .001$.

Table 4. Study 2 bivariate Pearson's correlation coefficients for irrational beliefs, cognitive appraisal, challenge and threat, exam anxiety, affect, and academic self-concept between waves 1 and 2.

	Wave 2									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Wave 1	1. IBs	.72**	.04	−.05	−.08	−.10*	.02	.21**	.21**	−.13**	.02
	2. GR	.07	.21**	.06	−.01	.04	.12**	−.02	−.01	.12**	.10*
	3. RGC	−.19**	.04	.08	.10*	.05	.15**	−.13**	−.15**	.18**	.10*
	4. PFC	−.15**	.03	−.03	.10*	.07	.07	−.16**	−.20**	.17**	.14**
	5. EFC	−.22**	.03	.02	.13**	.19**	.14*	−.19**	−.20**	.23**	.15**
	6. Challenge	−.08	.10	−.08	−.11**	−.14**	.36**	−.15**	−.17**	.25**	.21**
	7. Threat	.49**	.11*	.14**	.14**	.11*	−.11*	.43**	.27**	−.19**	−.05
	8. Anxiety	.39**	−.01	−.13**	−.12**	−.16**	−.12**	.34**	.37**	−.28**	−.12**
	9. Affect	−.27**	.10*	.09*	.12**	.10*	.19**	−.18**	−.19**	.34**	.10*
	10. ASC	.01	.04	.06	.17**	.16**	.15**	−.08	−.09*	.17**	.40**

Notes: IBs, total irrational beliefs; GR, goal relevance; RGC, relative goal congruence; PFC, problem focussed coping; EFC, emotion focussed coping; ASC, academic self-concept.
*$p < .05$.
**$p < .001$.

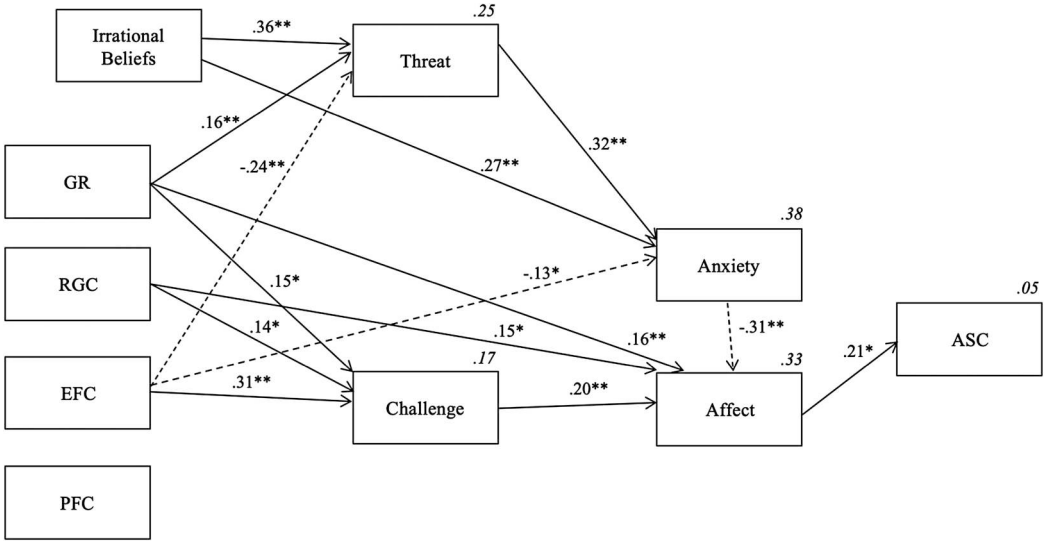

Figure 1. Path model for residualized scores from wave 1 to wave 2 (IBs, total irrational beliefs; GR, goal relevance; RGC, relative goal congruence; PFC, problem focussed coping; EFC, emotion focussed coping; ASC, academic self-concept). Only significant (**$p < .01$, *$p < .05$) paths are shown. Dotted line indicates negative relationship.

In sum, regarding the explained variance in exam anxiety, path analysis using residualized change scores indicated that, decreased EFC and increased irrational beliefs directly and indirectly through threat, were related to increased exam anxiety. Also, increased GR, and decreased RGC indirectly through threat, were related to increased exam anxiety. Overall, change in threat appeared to be particularly important in explaining the variance in exam anxiety, such that increases in threat were related to increases in anxiety.

Regarding the explained variance in affect, increased GR and RGC, directly and indirectly through challenge, were related to increased positive affect. Increased irrational beliefs indirectly through threat and anxiety, and change in threat indirectly through anxiety, were related to decreased positive affect. Also, increased EFC was directly associated with increased positive affect. Overall, challenge and anxiety appeared to be particularly important in explaining the variance in affect, such that increased challenge and decreased anxiety were related to increases in positive affect.

Finally, regarding the explained variance in ASC, increased RGC and EFC indirectly through challenge, threat, anxiety, and affect, were related to increased ASC. Increased challenge and decreased threat indirectly through anxiety and affect were related to increased ASC. Also, decreased anxiety indirectly through affect was related to increased ASC. Overall, affect appeared to be particularly important in explaining the variance in ASC, such that increased affect was related to increased ASC.

Cross-lagged panel analysis from wave 1 to wave 2

The results of the cross-lagged path analysis can be seen in File 3 of supplementary materials. Proportion of explained variance for each variable at wave 2 was: irrational beliefs = 54% ($p = .021$), GR = 6% ($p = .249$), RGC = 5% ($p = .365$), EFC = 7% ($p = .174$), PFC = 6% ($p = .295$), challenge = 15% ($p = .071$), threat = 23% ($p = .075$), anxiety = 16% ($p = .066$), affect = 17% ($p = .053$), ASC = 20% ($p = .038$). With autoregressive paths as statistical controls, significant ($p < .05$) temporal effects emerged. GR at wave 1 predicted more positive affect ($\beta = .34$, $p = .041$) at wave 2. PFC at wave 1 predicted lower anxiety ($\beta = -.04$, $p = .031$) at wave 2. Threat at wave 1 predicted higher irrational beliefs at wave 2 ($\beta = .04$, $p = .005$). Challenge at wave 1 predicted higher ASC ($\beta = .07$, $p = .015$) and higher RGC ($\beta = .29$, $p = .024$) at wave 2. Anxiety at wave 1 predicted higher threat ($\beta = .16$, $p = .007$), and lower RGC ($\beta = -.31$, $p = .015$) at wave 2. Finally, ASC at wave 1 predicted higher EFC ($\beta = .34$, $p = .004$), higher PFC ($\beta = .34$, $p = .004$), higher challenge ($\beta = .09$, $p = .006$), and higher affect ($\beta = 1.693$, $p = .004$) at wave 2. The remaining temporal effects were nonsignificant.

Regressing change on change

Change in anxiety

Steps 1 (change in irrational beliefs; $R^2 = .19$, $p < .001$), 2 (change in cognitive appraisals; $R^2 = .11$, $p < .001$), and 3 (change in challenge and threat; $R^2 = .08$, $p < .001$) accounted for a significant proportion of variance in anxiety change. In the final model (step 3; $R^2 = .38$, $F(7,509) = 45.49$, $p < .001$), change in irrational beliefs ($\beta = .27$, $p < .001$), change in GR ($\beta = .09$, $p = .018$), change in RGC ($\beta = -.10$, $p = .008$), change in EFC ($\beta = -.13$, $p = .003$), and change in threat ($\beta = .32$, $p < .001$) were related to changes in anxiety, such that increases in irrational beliefs, GR, and threat were associated with increases in anxiety, whilst decreases in RGC and EFC were associated with increases in anxiety.

Change in affect

Steps 1 (change in irrational beliefs; $R^2 = .03$, $p < .001$), 2 (change in cognitive appraisals; $R^2 = .18$, $p < .001$), and 3 (change in challenge and threat; $R^2 = .07$, $p = .001$) accounted for a significant proportion of variance in anxiety change. In the final model (step 3; $R^2 = .26$, $F(7,509) = 26.73$, $p < .001$), change in GR ($\beta = .13$, $p = .001$), change in RGC ($\beta = .18$, $p < .001$), change in PFC ($\beta = .09$, $p = .049$), change in challenge ($\beta = .22$, $p < .001$), and change in threat ($\beta = -.19$, $p < .001$) were related to change in affect, such that increases in GR, RGC, PFC, and challenge, and decreases in threat, were associated with increases in affect.

Change in ASC

Step 1 (change in irrational beliefs; $R^2 = .00$, $p = .390$) and 4 (change in anxiety and affect; $R^2 = .01$, $p = .147$) did not account for a significant proportion of variance in ASC change. However, steps 2 (change in cognitive appraisals; $R^2 = .07$, $p < .001$), and 3 (change in challenge and threat; $R^2 = .03$, $p < .001$), did account for a significant proportion of variance in ASC change. In the final model (step 4; $R^2 = .10$, $F(9,507) = 7.00$, $p < .001$), change in PFC ($\beta = .12$, $p = .021$), and change in challenge ($\beta = .16$, $p < .001$), and change in affect ($\beta = .10$, $p = .05$) was positively related to change in student ASC, such that increases in PFC, challenge, and affect were associated with an increase in ASC.

Discussion

Study 2 extends study 1 by including challenge and threat, thus offering a more comprehensive portrayal of cognitive appraisal as it pertains to examination anxiety and its concomitants. The atemporal results of study 2 are in line with study 1 and support theory (Meijen et al., 2020) and previous research (Chadha et al., 2019) in that more adaptive affective states, characterized by lower anxiety and more positive affect, were associated with a more positive cognitive appraisal profile, characterized by greater EFC, GR, and RGC, less threat, and more challenge, and lower irrational beliefs. But findings regarding the extent to which ASC could be determined by this constellation of appraisal and affective indicators were less clear. To expand, a more positive appraisal and more positive affect appeared to be particularly important in explaining the variance in ASC. Data indicate that participants with a positive approach to exams, including greater coping, higher challenge, less anxiety, and more positive affect, reported a more positive ASC. These effects, however, do appear to be reciprocal rather than predictive or unidirectional. The idea that more positive affect may aid examination performance is in line with extant literature (Pekrun et al., 2004), but this should be viewed reciprocally. It might be that as my ASC improves, I experience greater positive affect due to that improvement, rather than my ASC improvement being driven by more positive affect. Also, whilst irrational beliefs and threat seemed to be important for anxiety, it is really through affect that ASC appears to be affected.

Even though these findings align with hypotheses and some extant research (e.g., Pekrun et al., 2004), it must be considered that negative affect could of course facilitate cognitive performance in some situations (Valiente et al., 2012), and may not always exert negative effects on academic achievement (Pekrun, 2006). Contemporary theory, such as REBT and challenge and threat theory, recognize that negative affect can be adaptive (Ellis & DiGiuseppe, 1993; Meijen et al., 2020). Indeed, Pekrun (2006) notes that, "from the perspective of outcome attainment and future well-being, the pattern is more complex than simplistic hedonism would suggest" (p. 327). The present study offers some support that more positive affect, underpinned by an adaptive appraisal profile, might indicate greater ASC, but does not capture the potentially adaptive functions of negative affect and does not consider the interpretation of affect as a predictive factor (e.g., Strack & Esteves, 2015). For example, evidence indicates that a positive perception of anxiety and stress might confer benefits on the perceiver (Crum et al., 2013; Kilby & Sherman, 2016). The explained variance for ASC was 3-7% across the change models, and the 20% explained variance for wave 2 ASC in the cross-lagged analysis can be mostly attributed to the auto regressive effect of wave 1 ASC, with challenge contributing in a small way. Also, few paths in the cross-lagged analysis were significant, and if irrational beliefs, cognitive appraisals, and challenge and threat were predictive of affect and ASC in a causal manner we would expect more significant paths. Indeed, given the proposed limitations of cross-lagged panel modeling (Littlefield et al., 2022), the findings of our analyses should be interpreted with caution. Cross-lagged panel models confound between – and within-person variance and render biased estimates of causal effects, especially with two waves of data (e.g., Lucas, 2023). In study 2, we approach longitudinal analyses in three different ways to offer more than one interpretation of the longitudinal effects.

Irrational beliefs, appraisals, challenge and threat, played a greater role in their relationships to anxiety and affect than they did in their relationship to ASC. Change in challenge and threat appeared to be particularly important for changes in affectivity, perhaps helping to justify their inclusion in studies examining cognitive appraisal and affect. The link between challenge/threat and affect has been the subject of previous research, including Meijen et al. (2013) who found that greater threat was related to higher anxiety, anger, and dejection. Meijen et al. (2014) did not find the same results but there was some methodological divergence from Meijen et al. (2013) that might explain why (i.e., laboratory experimental methods). In addition, Chadha et al. (2019; 2023) found that higher threat was related to a greater negative affect, and that greater challenge was related to greater positive affect across three independent samples of elite level golfers.

Importantly, and in line with findings from study 2 in the present paper, Chadha et al. (2023) also found that increases in irrational beliefs were associated with increases in threat and anxiety, however, the temporal effects occurred across a single week (leading up to a golf competition), rather than across an academic year as occurred in the present study, and the populations of athletes vs. students are clearly very different.

Whilst temporal effects are evidenced, they are taking place over a protracted period of time, reflecting how what participants thought and felt about examinations early in the academic year relates to what participants thought and felt about examinations later in the academic year. Temporal effects also reveal associations that are temporally parallel such that change in one variable between wave 1 and 2 is associated with change in other variables across the same time period. This might indicate a tighter association between these constructs than could be evidenced using atemporal data (such as in Study 1), but does not infer causation. Temporal results, however, do indicate that increases in irrational beliefs, a worsening of cognitive appraisal, increased threat, and decreased challenge, are related to poorer affective states. So, from wave 1 to wave 2, if there is an increase in my irrational beliefs, my appraisal becomes more negative (increased RGC, decreased coping), my threat evaluations increase and my challenge evaluations decrease, then I am more likely to report increased anxiety and a decline in positive affect. These findings are in line with some previous work that indicates irrational beliefs to be associated with increases in deleterious outcomes. For example, Allen et al. (2017) found that higher irrational beliefs in undergraduate students were associated with increased negative affect from mid-semester to end of semester. Allen et al. did not find significant effects on academic performance, however, unlike the present paper, Allen et al. used actual student profile grades for the semester, rather than ASC, which may explain the divergent findings. Also, Turner and Moore (2016) found that higher irrational beliefs were related to increased burnout across an 8-week period in elite county Gaelic football athletes. But most relevant is the aforementioned Chadha et al. (2023) study, whereby increases in the irrational beliefs of elite level golfers was associated with worsening appraisal, increased threat, and increased anxiety, in the lead up to an important golf competition. However, the data in Chadha et al. were collected across a single week, and perhaps the results of the current study may have differed if data were collected in a more acute and momentary way in the lead up to an actual specific and imminent examination.

To elaborate, the cognitive appraisal of a given stimulus is not static, but is iterative and ongoing, and can thus change momentarily on the basis of new information (Lazarus, 1999), such that as stimuli draw closer, cognitive appraisal becomes more intense (cf. Lazarus & Folkman, 1984). For example, in one study of elite rowers, challenge and threat intensified over time in line with competitive events of increasing prestige and magnitude (Cumming et al., 2017), a finding also revealed in university student samples (Skinner & Brewer, 2002). Therefore, the temporal data in study 2 reflects a snapshot at either end of an academic year through which we can draw some conclusions about how cognitive appraisals, challenge and threat, irrational beliefs, affect, and ASC, connect to one another and change together. Also, it could be argued that our measurement of irrational beliefs and challenge and threat are dispositional. That is, we do not orient these questionnaires toward exams, but rather we capture general beliefs about important situations rather than participants' next exam. Therefore, there is construct asymmetry between these measures and the assessment of cognitive appraisal, exam anxiety, and affect, which could reduce empirical relations. Had we have obtained beliefs about their upcoming exams specifically, perhaps we might be explained more variance in ASC.

The mixture of temporal and reciprocal effects evidenced in study 2 highlights the importance of viewing the cognitive–affective components of examinations as influencing one another longitudinally, perhaps reciprocally. It is not the case in these data that the causal direction exclusively flows from that which is explicitly "cognitive" (i.e., cognitive appraisals, irrational beliefs) to that which is "affective" (i.e., anxiety, mood) and "behavioral" (ASC). Indeed, anxiety at wave 1 was related to lower RGC and higher threat and at wave 2, and ASC at wave 1 was related to higher

EFC, higher PFC, higher challenge, and higher affect at wave 2. This may evidence that, longitudinally, affect can predict cognitive appraisal. It could be that, as a participating student, my experience of anxiety at wave 1 helped to shape an appraisal of lower RGC and higher threat at wave 2: since I am so anxious around examinations, then perhaps I will not achieve what I want, and perhaps examinations are a negative stimulus for me. Perhaps if I have a more positive ASC at wave 1, I am more likely to appraise greater coping potential and challenge, helping me to feel more positive about exams at wave 2. Success at learning influences students' appraisals and emotions (Pekrun, 2006), and research has demonstrated that past experiences in evaluative tasks can predict task performance (Turner et al., 2021), and in the present study, attainment at wave 1 was highly predictive of attainment at wave 2. Also, past research shows that more confidence in one's ability is related to superior performance in pressurized tasks (Turner et al., 2013). Thus, ASC at wave 1 may have enhanced coping self-efficacy, which has been linked to performance outcomes in past research (e.g., Nicholls et al., 2010).

The reciprocity found between appraisals/beliefs and affect/behavior amongst students in the present study is in line with suggestions that trait-anxious individuals, when under stress, are more likely to adopt a threatening interpretation of ambiguous information (Mathews & MacLeod, 2002). As such, it is likely that anxiety and cognitive distortions have a reciprocal relationship (Mathews & MacLeod, 2002), and that appraisals might be both antecedent and descendant to emotions, linked by reciprocal causation over time (Pekrun, 2006). Thus, it is possible that positive and negative feedback loops could exist between appraisal and affect whereby positive affect leads to positive appraisal, which then leads to subsequent positive affect, and negative affect leads to negative appraisal, which then leads to subsequent negative affect (Pekrun, 2006). Those reporting high examination anxiety could be more likely to detect minor threats (MacLeod & Mathews, 2012), which is borne out by the data of study 2 whereby higher anxiety at wave 1 predicted lower RGC and greater threat at wave 2. This hypervigilance is no doubt exacerbated by the aggrandizement and inflated consequences of failure reflected in irrational beliefs in the current study. A reciprocal relationship exists between emotional difficulties and seeing events in ways that are exaggerated beyond available evidence (Wills & Sanders, 2013). Indeed, listening to anxious automatic thoughts can cause attentional biases toward threat-relevant stimuli (Wenzel, 2006), suggesting that individuals may consciously allocate their attention to threat information (Mobini & Grant, 2007). Thus, being prone to examination anxiety might sensitize one to greater threat appraisal and greater irrational beliefs, because anxious individuals may selectively attend to the threat-related information (Mobini & Grant, 2007).

Internal personal factors such as cognitive, affective, and biological events, behavioral patterns, and environmental influences all interact bidirectionally and not necessarily in a simultaneous manner (Bandura, 2006). Further, the notion that emotions can influence cognition is recognized by appraisal theorists (e.g., Frijda et al., 2000), and evidenced within experimental contexts (e.g., Eich et al., 2000; Forgas et al., 2009; Niedenthal, 2007). On the basis of study 2, perhaps the cognitive–affective components of examinations should be seem as interacting with and helping to shape one another. Thus, a unidirectional appraisal-affect directional hypothesis might be too simplistic, and instead, a bidirectional appraisal-affect hypothesis might be more appropriate for future research. As a result of study 2, the placement of variables in the path model perhaps should not be taken to reflect unidirectional causal paths. Rather, the path model indicates a network of constructs that may interact to provide a complex portrayal of how cognitive appraisals, irrational beliefs, affect, and attainment (or ASC), interact bidirectionally, statically, and dynamically across time.

General discussion

In the present paper, our main aim was to examine the underpinning cognitive appraisals of undergraduate examination anxiety and affect in line with Elliasian irrational beliefs (REBT; Ellis, 1994) and Lazarusian cognitive appraisals (Lazarus, 1999). We attempted to build on previous work indicating

that affect can be determined by irrational beliefs and cognitive appraisals (David et al., 2002, 2005). We also tested aspects of contemporary theory (Meijen et al., 2020) and research (Chadha et al., 2019) which have incorporated irrational beliefs, cognitive appraisals, and challenge and threat (study 2 only), for the first time in students. Study 2 built on study 1 by adopting a longitudinal approach to data collection and analyses, but replicated some of the findings of study 1.

This paper builds upon past research in several important ways. First, it includes REBT as part of the discussion concerning exam anxiety, a sparsely used theory in this domain. Indeed, to the authors' knowledge, much of the work in the examination anxiety/affect domain has not included REBT theory, even though researchers have indicated that "Irrational beliefs can make students highly vulnerable to anxiety and related negative achievement emotions" (Pekrun & Stephens, 2010, p. 277). One exception is Wong (2008) who found that irrational beliefs were related to debilitating test anxiety in a sample of undergraduate students. Across the studies of the current paper, irrational beliefs (a core aspect of REBT) are found to be a valid construct for study in relation to exam anxiety, that also contributes significantly to understanding exam anxiety and affect. Second, challenge and threat are included in study 2, which appear to be an important facet of exam anxiety and affect, adding to the sparse research that has studied challenge and threat in the exam anxiety domain. Indeed, in a 2020 review concerning anxiety for educational assessments for the Office of Qualifications and Examinations Regulation (OFQUAL), Emma Howard indicates that challenge and threat may play an important role in exam emotion and performance, citing the work of Putwain and colleagues (e.g., 2014, 2016), which indicates that challenge and threat may be important for exam-relevant behaviors and performance. In addition, Skinner and Brewer (2002) found that challenge was associated with a more adaptive orientation to exams, including more positive affect, which subsequently benefited exam performance. Therefore, for both irrational beliefs and challenge/threat, findings potentially open doors to intervention for deleterious exam affectivity, because for both constructs there exists evidence-based strategies for weakening irrational beliefs (e.g., REBT; Ellis, 1994; Turner, 2022), and enhancing challenge (whilst reducing threat; Jamieson, 2017; Turner et al., 2014). This paper also offers support for a reciprocal understanding of how cognition and affect might associate bidirectionally, rather than unidirectionally.

Across the results of both studies, there are some key findings that emerge in each study that advance the understanding of examination anxiety and affect in undergraduate students. First, in line with theory (e.g., Ellis, 1994; Lazarus, 1999; Meijen et al., 2020) and research (e.g., David et al., 2002; 2005), cognitive appraisals of goal relevance, goal congruence/incongruence, coping, and irrational beliefs, appear to be important for examination anxiety and affect. Specifically, more positive appraisals (i.e., greater RGC and coping) and lower irrational beliefs are related to less anxiety and more positive (and less negative) affect (studies 1 and 2). Further, in study 2, in line with theory (e.g., Meijen et al., 2020) and some research (Chadha et al., 2019; 2023) greater challenge appears to be associated with more positive (and less negative) affect, and greater threat is related to greater examination anxiety and more negative (and less positive) affect. In addition, on balance across the studies, it appears that more positive (and less negative) affect is associated with better ASC. Longitudinally (study 2), temporal-reciprocal effects indicate that cognitive appraisal is predictive of affect, but also affect is predictive of cognitive appraisal.

Consistent atemporal and temporal associations between greater irrational beliefs and more negative cognitive appraisal also emerged, specifically, a student who views an upcoming examination as inconsistent with their goals, views themselves as having limited coping potential, and sees the situation as a threat, will be more likely to hold rigid and extreme irrational beliefs. One previous study found evidence for the association between irrational beliefs and poorer affect in university students (Allen et al., 2017), but found no effects for academic attainment. However, actual grades were used by Allen et al., which provided a more objective criterion with which to measure attainment compared to the present study. But, the focus of the present study was not on objective academic attainment, but more specifically general (past, present, and predicted

future) examination attainment or ASC. Therefore, the way in which attainment is measured may dictate the extent to which irrational beliefs can predict attainment.

The present paper supports the findings of David et al. (2002) by demonstrating the combined role of primary (GR, GC) and secondary (EFC, PFC) cognitive appraisals and irrational beliefs on affect, but extends this work by illustrating the additional effects of challenge and threat on anxiety and affect. Specifically, challenge and threat were related to GR, RGC, irrational beliefs, examination anxiety, and affect. Longitudinally, threat predicted higher irrational beliefs, and GR predicted a lower threat. Therefore overall, it would appear that in determining examination anxiety and affect, the confluence of cognitive appraisal (including challenge and threat) and irrational beliefs might be important. In a practical sense, a student approaching the examination period of an academic year who believes "I must perform well, it would be terrible to fail" (irrational beliefs) and who has a negative appraisal of examinations is more likely to experience greater anxiety and worse affect, and potentially, may underperform in the examinations.

This mixture of appraisals and beliefs appears to underpin greater examination anxiety and a more negative (and less positive) affect. That is, in the findings reported in the current paper, the indirect effects of cognitive appraisal and irrational beliefs on ASC occurred through examination anxiety and affect. Therefore, whilst cognitive appraisal and irrational beliefs appear to be important for affect, it is through affect that ASC is implicated. In addition, whilst affect is important for ASC (in both a beneficial and harmful way), it is really the combined effects of cognitive appraisal, irrational beliefs, anxiety, and affect, that explains the variance in ASC.

By understanding the atemporal and temporal cognitive associates of examination anxiety and affect in undergraduate students it is possible to devise strategies and interventions that can help students to reduce their anxiety and enhance their affect, in the interest of greater examination attainment. Not only can we target cognitive appraisal and irrational beliefs, for example through cognitive–behavioral strategies such as cognitive change (e.g., via REBT; Turner, 2022), reappraisal of emotion symptoms (e.g., Jamieson et al., 2010), and imagery (Williams et al., 2010), but we can also target anxiety and affect more directly, through affect (response) modulation (e.g., behavioral, physiological, and experiential techniques; Gross, 2014) which could influence subsequent cognitive appraisal and irrational beliefs. Therefore, educators and administrators have a range of potential options to help students to cope with assessment orientated affect in the interest of examination attainment. The use of cognitive–behavioral interventions is in keeping with extant research and examination anxiety recommendations (e.g., Von der Embse et al., 2013).

Limitations

There are some limitations that should be considered for future research. First, we did not collect data on actual examination grades, instead opting to have participants self-report their ASC across three contexts: last exam grade, their typical exam grade, and their predicted future exam grade. Whilst this is less objective than actual grades, we believe that this marker could be a useful and important measure of attainment because it not only captures the most recent previous grade, but it also provides a general indication of how the student typically performs in exams. In addition, it provides an indication of what the student expects to achieve in their next exam, which to some extent encapsulates their self-confidence. Taken together, these three indicators of examination attainment provide a well-rounded picture of the student's examination abilities. Of course, it is possible that the student could fabricate their responses to the three attainment items, given that self-reports are open to bias. So, the collection of objective grades alongside these markers would be an important addition for future research.

Second, future researchers could consider using a more specific measure of academic emotions (e.g., academic emotions questionnaire, AEQ; Pekrun et al., 2011). We used the PANAS which is not specific to the academic milieu, but has been used widely in affect research, and in similar research with undergraduate populations (e.g., Allen et al., 2017). Third, cognitive appraisal can occur

explicitly (in conscious awareness), and or implicitly (outside of conscious awareness), and therefore the effects of unconscious appraisal cannot be evidenced or accounted for in the current study due to the use of explicit appraisal measurements. Future research could explore ways in which we can capture implicit appraisal in students approaching examinations. The measurement for irrational beliefs we tested and used in the present paper was originally developed for use in work and performance contexts, and for the purposes of the present research, was adjusted to fit the context. However, perhaps we need to develop a measure of irrational beliefs that fits the context more squarely, and perhaps is contextually specific to exams. For example, an irrational exam beliefs scale might be a valuable tool for future researcher wishing to study the role of irrational beliefs in exam anxiety. These measurement limitations might explain why some of effects reported for both studies are small, particularly for indirect effects. It might be that more specific measures of the core variables would yield greater variance explained. As such, the results here should be viewed with caution in lieu of further research.

Conclusions

A complex picture emerges concerning the cognitive appraisals and irrational beliefs that underpin examination anxiety and affect in undergraduate students. Whilst findings were largely consistent with prominent theory, the extent to which cognition was predictive of affect was challenged through the application of longitudinal analyses. When considering theory that incorporates cognitive appraisal and irrational beliefs, reciprocity must be considered, rather than assuming a linear unidirectional cognition-affect process. It also remains unclear the extent to which examination attainment is determined by cognitive appraisal, irrational beliefs, and affect, although atemporal results indicate that better attainers tend to report more adaptive cognitive appraisals, and lower irrational beliefs. It is hoped that the present paper stimulates the development of programs designed to help students manage their examination related affect.

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