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ACADEMIC ATTAINMENT

Trajectories in Cognitive Engagement, Fatigue, and School Achievement: The Role of Young Adolescents' Psychological Need Satisfaction

Stephen R. Earl^{*a}, Ian M. Taylor^b, Carla Meijen^c, and Louis Passfield^d

^aUniversity of Lincoln, United Kingdom

^bLoughborough University, United Kingdom

^cSt Mary's University, United Kingdom

^dUniversity of Calgary, Canada

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* Address for correspondence to Stephen R. Earl, School of Psychology, University of Lincoln, Brayford Pool, Lincoln, England, LN6 7TS, UK.

E-mail: SEarl@lincoln.ac.uk

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Highlights

Explores if psychological needs explain change in cognitive engagement, fatigue, and achievement.

Pupils high in need satisfaction reported stable and high cognitive engagement but low fatigue.

Those low in need satisfaction declined in cognitive engagement and had consistent high fatigue.

All pupils increased in school attainment, but higher need satisfaction was related to greater gains.

Abstract

The study investigates whether between-person differences in psychological need satisfaction may explain trajectories in cognitive engagement, fatigue, and academic attainment over a school year. A sample of 361 young adolescents in the United Kingdom (mean age = 11.89 years; 55% male, 45% female) completed self-report measures of psychological need satisfaction, cognitive engagement, and cognitive fatigue on four occasions. Official school grades for English and Maths were collected. Hierarchical growth modelling revealed that pupils higher in psychological need satisfaction reported stable levels of cognitive engagement and lower fatigue. Pupils lower in psychological need satisfaction displayed declining levels of cognitive engagement and consistently higher fatigue. All pupils showed increases in school grades, yet higher psychological need satisfaction was related to greater gains. These trends existed when controlling for age, sex, ethnicity, and learning needs. The findings offer temporal insights into the role of school-based psychological needs in fostering cognitive engagement at school.

Keywords: *psychological need satisfaction; cognitive engagement; cognitive fatigue; academic attainment; self-determination theory*

1. Introduction

A key objective for schools is to ensure that young adolescents achieve high academic grades within core subjects such as English and Mathematics (Department of Education, 2015). Against this backdrop, however, there are growing concerns regarding the downside associated with an exclusive focus on academic attainment. Namely, it may lead to an over-reliance on prescribed academic targets at the expense of engagement with learning (Mostafa, 2017). Pupils who become overly focused on school grades often display more deleterious experiences, such as psychological burnout, fatigue, and emotional ill-being (Tuominen-Soini et al., 2012; Palos et al., 2019). Consequently, endeavours within teaching have shifted towards promoting characteristics of engagement, such as pupils' cognitive effort, willingness to explore topics, and intentions to transfer knowledge between different subjects (Frey et al., 2017; Schnitzler et al., 2021). Such efforts have coincided with greater attempts to nurture pupils' intrinsic motivation to help foster better learning mastery and engagement (Froiland & Worrell, 2016). Aligned with this aim, the present longitudinal study investigates whether the satisfaction of pupils' basic psychological needs may explain trajectories in their cognitive engagement, cognitive fatigue, and academic attainment over a school year.

Engagement is defined broadly as a cognitive-affective state which is underpinned by a positive, fulfilling, and study-related state of mind (Upadyaya & Salmela-Aro, 2013). High engagement at school has often been related with a multitude of personal and academic benefits (Li & Lerner, 2011; Widlund et al., 2021). More nuanced interpretations, however, signify engagement as a multidimensional construct, comprising of cognitive, affective, and behavioural components (Fredricks et al., 2004). Whilst the latter two relate to learners' enjoyment and persistence at school, respectively, it is cognitive engagement that is particularly synonymous with pupils' psychological approach to learning (Appleton et al., 2006). Specifically, cognitive engagement denotes a self-regulated learning approach whereby an

individual will have an active intention to study and adopt different strategies to elaborate, organise, and memorise material (Appleton et al., 2008; Zimmerman & Schunk, 2011). That is, it reflects the extent to which one is thinking and attending to learning (Ben-Eliyahu et al., 2018). Pupils who are cognitively engaged will have a dedicated attitude towards learning, display committed investment to studying, be intrinsically motivated, and develop flexibility in their use of knowledge (Blumenfeld et al., 2006; Fredricks & McColskey, 2012; Li & Lajoie, 2022). As such, cognitive engagement signifies pupils who are actively absorbed in the learning process.

Cognitive engagement has received particular interest within college-level education, being associated with positive correlates such as better academic adjustment (van Rooij et al., 2017), self-efficacy (Papinczak et al., 2008), help seeking behaviours (Leenknecht et al., 2019), and higher academic performance (Salamonson et al., 2013). Such relations are likely linked with self-regulated motivation and deeper processing of information (Platow et al., 2013). Similarly, cognitive engagement has been associated with higher academic attainment within adolescent schooling (Pietarinen et al., 2014), although longitudinal investigations of adolescents' cognitive engagement are somewhat scarce. Nonetheless, hallmarks of cognitive engagement such as self-regulated learning (Wang & Eccles, 2012) and intrinsic motivation (Gillet et al., 2012) have been found to decline during the early years of secondary school. Thus, gaining insights into potential antecedents and trajectories of adolescents' cognitive engagement may be of substantive value to educators by identifying ways to foster higher quality learning engagement.

A framework that provides particular insights into the development of personal agency and self-regulation is self-determination theory (SDT; Ryan & Deci, 2017). A core tenet of SDT is that the fulfilment of the innate psychological needs for autonomy, competence, and relatedness is fundamental for one's psychological integration and personal wellness

(Vansteenkiste et al., 2018). More than just beneficial experiences, these three needs represent essential ingredients which underly optimal psychological development and functioning across all life domains (Chen et al., 2015). The need for autonomy reflects the feeling of volition and psychological freedom, whereby behaviour emanates from a sense of personal ownership and relevance (deCharms, 1968). Competence signifies the experience of feeling effective and capable of achieving desired goals (White, 1959), and relatedness denotes the need to feel connected and supported by others through close interpersonal relationships (Baumeister & Leary, 1995). It is through the satisfaction of these basic needs that individuals will be able to act authentically, explore intrinsic tendencies, master challenges, and fully absorb themselves in their environment (Ryan & Deci, 2016).

Within adolescent education, the notion of basic psychological needs has received considerable attention in relation to characteristics pertinent to personal and academic growth (Guay, 2022; Howard et al., 2021). Pupils' psychological need satisfaction has been positively associated with various developmental outcomes such as subjective well-being (e.g., Tian et al., 2014), enjoyment (Huhtiniemi et al., 2019), optimism (Carmona-Halty et al., 2019), and prosocial behaviour (Alivernini et al., 2021). From an academic perspective, psychological need fulfilment has also been linked with heightened autonomous school motivation (Bureau et al., 2021), greater help-seeking (Marchand & Skinner, 2007), and academic engagement (Buzzai et al., 2021). Such associations have been found consistent when accounting for different cultures and school subjects (Erturan-İlker et al., 2018), and typically result in higher academic attainment. This has been demonstrated in cross-sectional (Ahn et al., 2021), semester long (Jang et al., 2012), and multi-year studies (Wang et al., 2019b). In short, pupils high in psychological need satisfaction will be better able to self-regulate their own engagement and adjust to the social and academic demands of school (Ratelle & Duchesne, 2014; Vandenkerckhove et al., 2019; Charlot Colomès et al., 2021).

Expanding upon the evidence above, it seems plausible that psychological need satisfaction may facilitate greater cognitive engagement. At a university level, positive relationships have been observed between student's psychological need satisfaction and deep learning (Orisini et al., 2018), knowledge transfer (Wang et al., 2019a), complex thinking (Doménech & Gómez, 2014), and metacognitive strategies (Makarova, 2021). Comparable findings have also been evident when students experience autonomous learning motivation (e.g., Núñez & León, 2016; Vansteenkiste et al., 2005). For example, university students experiencing autonomous motivation were found to report higher cognitive strategies such as rehearsal, organisation, monitoring, elaboration, and critical thinking, although critical thinking was the only strategy related with enhanced academic performance (Manganelli et al., 2019).

In relation to young adolescents, school-based psychological need satisfaction has been found to foster greater learning engagement, specifically in relation to cognitions (i.e., information processing, critical thinking) and agency (i.e., active participation in one's own learning; Cohen et al., 2020; Jang et al., 2016; Zhen et al., 2017). Psychological need satisfaction has been found to coincide with higher mastery orientations and often leads to greater efforts to conceptually understand information (Duchesne et al., 2017; also see Liem et al., 2008). Moreover, pupils reporting higher psychological need satisfaction have been shown to display more effective cognitive learning strategies, such as concertation, time management, and information processing, due to greater feelings of autonomous motivation and perceived competence (Ulstad et al., 2016). Building on this evidence, exploring the temporal relationship between young adolescents' psychological need satisfaction and cognitive engagement may help identify pupils who are at risk of cognitively detaching at school.

An additional barrier to cognitive engagement, and overall learning, is cognitive fatigue. Cognitive fatigue reflects a non-specific state of reduced vitality which is particularly prevalent in young adolescents at the start of secondary school as they deal with new

educational and social demands (Ter Wolbeek et al., 2006). The experience of cognitive fatigue is detrimental to functions such as working memory, attentional focus, and the ability to regulate off-task thoughts (e.g., Mizuno et al., 2011; Nijhof et al., 2016). Furthermore, higher levels of cognitive fatigue are often associated with poorer learning and academic performance (Knight et al., 2018; Sievertsen et al., 2016). Whilst cognitive fatigue can arise from physical factors (e.g., sleep deprivation), it is also commonly associated with psychological struggle and poor motivational regulation (Hockey, 2011). Symptoms of mental fatigue stemming from maladaptive psychological experiences may be difficult to explicitly observe, and thus uncovering psychological determinants of these experiences may be helpful to educators.

The fulfilment of adolescents' psychological needs may help lessen their development of cognitive fatigue given it is concomitant with several energising outcomes, such as positive affect and vitality (Chen et al., 2015; Liu et al., 2017). Experimental findings have indicated that nurturing autonomous experiences in adolescents can help reduce cognitive load and enhance their retention of information (Schneider et al., 2018). Learners with low psychological need satisfaction, on the other hand, have been found to experience more deleterious cognitive consequences, such as burnout (Bartholomew et al., 2011), psychological distress (Gilbert et al., 2021), and feelings of pressure within the classroom (Wang et al., 2019c). These deenergising effects may manifest due to continual overregulation of negative thoughts, worries over failure, or desires to bolster self-worth (see Bartholomew et al., 2018). Furthermore, feelings of fatigue and diminished vitality may lead to passive classroom disengagement, reduced study efforts, and apathy towards learning (e.g., Earl et al., 2017; Mouratidis et al., 2011). Exploring differences in psychological need satisfaction at school may, therefore, help yield new understanding as to why certain pupils develop higher levels of cognitive fatigue compared to others.

1.1. The Present Research

The aim of the present study was to examine whether differences in pupils' general psychological need satisfaction at school were associated with different rates of change in their cognitive engagement, cognitive fatigue, and school grades (i.e., English and Mathematics). Pupils in the initial years of secondary school were the particular focus (e.g., children aged 11-14 years in the United Kingdom) as this represents a key period in which learning and academic engagement can be at risk of decline (Poorthuis et al., 2015; Riglin et al., 2013). Furthermore, young adolescents' learning, and academic development, are dynamic. Thus, exploring developmental patterns in these variables over time may offer richer insights into pupils' cognitive and academic adjustment. Equally, investigating positive changes in engagement and academic attainment is important for teachers to help them facilitate these processes in their pupils (Moilanen et al., 2010; Wang et al., 2015).

In the first instance, we sought to clarify the rates of change in cognitive engagement, cognitive fatigue, and academic attainment over an academic year. We then constructed multilevel models to explore whether interpersonal differences in pupils' psychological need satisfaction explained intrapersonal changes in their cognitive engagement, cognitive fatigue, and academic attainment (for comparable multilevel approaches see Birkeland et al., 2012; Taylor et al., 2010). In accord with previous studies (e.g., Tian et al., 2016), school-based psychological need satisfaction was measured at a general-school level, rather than classroom level, to assess how pupils' wider school experiences may relate to general change in their engagement and attainment. Inferring from the evidence described earlier, it was hypothesised that higher reports of psychological need satisfaction would explain linear increases in cognitive engagement and school grades, along with linear decreases in cognitive fatigue, over the school year.

2. Materials and Methods

2.1. Participants

The study included 361 adolescents (199 male; 162 female) from a state-funded school in the United Kingdom (mean age = 11.89 years, $SD = 0.94$ years, range = 11 – 14 years). All pupils were in secondary school (6th Grade, $n = 164$; 7th Grade, $n = 122$; 8th Grade, $n = 75$), and recruited from 11 different classes which were differentiated on academic ability (mean size = 33 pupils). Approximately a third of the pupils were disclosed as having a form of special educational need ($n = 116$). Many of these educational needs were specific behavioural or learning requirements identified by the school ($n = 75$), whilst others were specialised diagnoses, such as dyslexia or dyspraxia ($n = 19$), Autistic Spectrum Disorder ($n = 9$), and physical impairments (i.e., visual or hearing; $n = 13$). Pupils were White ($n = 329$), Asian ($n = 14$), Black Caribbean/ Black African ($n = 16$) or Arabic ($n = 2$), with 5% of pupils registered as not having English as their native language.

2.2. Procedure

Ethical approval was obtained from the ethics committee at the principal researcher's university. Consent for pupils to take part in the study was provided by the school at an institutional level with parental opt-out forms provided to enable parents to indicate if they did not wish for their child to participate. From the initial recruitment, four parents opted for their child not to participate which resulted in the final sample of 361 pupils. Pupils were provided with verbal and written details of the study and provided written assent to confirm their willingness to participate. Pupils were instructed that they did not have to complete the questionnaire, or any specific questions, if they did not wish to. The questionnaire was administered by the principal researcher at the beginning of a general tutor session, rather than specific subject lesson, and collected on completion. This was to encourage pupils to respond in relation to their general school experiences, rather than a distinct class or specific teacher. The questionnaire took approximately ten minutes to complete. Data collection was conducted at four separate timepoints across the school year. The first data collection was conducted in

the third week of the academic year and the subsequent data collections were conducted at the end of each academic term (i.e., Fall, Spring, and Summer).

2.3. Measures

2.3.1. *Basic Psychological Need Satisfaction*

Fifteen items were used to tap into pupils' general experience of autonomy, competence, and relatedness satisfaction at school. These items were preceded by the stem "When at school . . ." and were responded to on a 7-point scale, ranging from 1 (*not at all true*) to 7 (*very true*). Autonomy was measured using five items (e.g., "I feel that I do school lessons because I want to", "I feel a certain freedom in choosing what I do"). These items were taken from previous research within adolescent education, whereby they demonstrated acceptable factorial structure and internal consistency ($\alpha = .81$; Standage et al., 2003). Confirmatory factor analysis in the present study revealed these items loaded appropriately together at each timepoint¹ (all loadings $\geq .62$). Competence was assessed using the five item Perceived Competence subscale of the Intrinsic Motivation Inventory (McCauley et al., 1989), which was adapted to a broad school context (e.g., "I think I am pretty good at school activities"). These items previously demonstrated good internal consistency ($\alpha = .84$; McCauley et al., 1989), and demonstrated acceptable factor loadings across every time point in the present study (all loadings $\geq .48$). Relatedness was measured using the five item Acceptance subscale of the Need for Relatedness Scale (Richer & Vallerand, 1998; e.g. "I feel listened to", "I feel supported"). These items demonstrated good internal consistency in the original work ($\alpha = .85-.94$) and demonstrated acceptable factor loadings throughout the present study (all loadings $\geq .68$). Collectively, the 15 items were collated to create an overall indicator of psychological need satisfaction which demonstrated high composite reliability throughout the study ($\rho_c \geq .88$, see Table 1).

2.3.2. *Cognitive Engagement*

¹ Factor loadings of .40 or greater were considered acceptable based on criteria proposed by Stevens (2012).

Pupils' cognitive engagement to learning was measured using six items from the deep approach scale of the Learning Process Questionnaire (LPQ –R -2F; Kember et al., 2004), and have been specifically used in secondary schools (Phan & Deo, 2007). These items tapped into pupils' interest taking (e.g., "I work hard at my studies because I find the material interesting") and cognitive commitment (e.g., "I like to do enough work on a topic so that I can form my own conclusions before I am satisfied"), as well as cognitive strategies to relate ideas (e.g., "I try to link what I have learned in one subject to what I learn in other subjects") and conceptually understand material ("I try to link new material, as I am reading it, to what I already know on that topic"). Pupils rated each item on a 5-point scale which ranged from 1 (*almost never*) to 5 (*almost always*). Confirmatory factor analysis revealed that these items loaded appropriately to a cognitive engagement construct at every timepoint (all loadings ranged between .53 and .78) and demonstrated high composite reliability across the study ($\rho_c \geq .78$, see Table 1).

2.3.3. Cognitive Fatigue

Cognitive fatigue at school was measured using the Cognitive Fatigue subscale of the PedsQLTM Multidimensional Fatigue Scale (Varni & Limbers, 2008). Pupils read the stem "How tired are you generally at school" and then responded to six items (e.g., "It is hard for me to keep my attention on things", "I have trouble remembering what I was just thinking"). These items were rated on a 5-point scale which ranged from 1 (*never*) to 5 (*almost always*). Confirmatory factor analysis demonstrated appropriate factor loadings for each item throughout the study (ranging between .66 and .87), as well as high composite reliability at every timepoint ($\rho_c \geq .87$, see Table 1).

2.3.4. Academic Attainment

Pupils' academic grades in the core subjects of English and Mathematics were obtained from official school records at every timepoint. Pupils completed initial assessments at the onset of the school year and at the end of each term based on their work throughout that term.

These grades are reflective of pupils' academic performance across each distinct term, and not an incremental grade average for the entire school year at that point. Pupil attainment was based upon a numeric achievement level, ranging from a lower *Level 1* up to a higher *Level 8*. Inspection of attainment scores for English and Mathematics revealed they were moderately and positively correlated at every timepoint across the study (r values ranged between .48 and .59; $p < .001$). Thus, an overall attainment score was calculated at each timepoint by averaging these scores. The use of a composite score offered a better objective overview of pupils' general academic attainment as opposed to examining differences in subject-specific grades.

2.4. Data Analysis

Multilevel modelling techniques were employed, using to MLwiN software (Version 3.05: Rasbash et al, 2020), to explore whether differences in psychological need satisfaction may explain changes in cognitive engagement, cognitive fatigue, and academic attainment. A three-tiered structure was accounted for in the models as the repeated measures at Level 1 (i.e., time varying) were nested within each pupil at Level 2 (i.e., time invariant) who were nested within separate classes at Level 3 (Curran & Bauer, 2011). To identify the proportional amount of variance accountable at each level of analysis, intraclass correlation coefficients (ICCs) were calculated from intercept-only models for all study variables (i.e., no predictor variables; Hox, 2010).

Unconditional growth models were first constructed to describe linear change over the school year in psychological need satisfaction, cognitive engagement, cognitive fatigue, and academic attainment. This was achieved by using a 'time' variable which was centred on the first time point (i.e., Time 1 equated to zero). Thus, the intercept of these growth models was interpreted as pupils' scores at the beginning of the study, with the slope coefficient signifying any linear change over the study. The slope coefficients were entered as fixed (i.e., the rate of

change is consistent across pupils) and random effects (i.e., the rate of change may differ between pupils) and compared to obtain the better model fit.

Three conditional growth models were then constructed to test the extent that between-person differences in psychological need satisfaction explained trajectories in cognitive engagement, cognitive fatigue, and academic attainment. Building on the unconditional growth models, pupils' psychological need satisfaction scores at each time point were converted to standardised z -scores and averaged across time before being added to the models. This variable was grand mean centred so they were comparable against the overall sample mean (Enders & Tofghi, 2007). Thus, each model indicated whether pupil-differences in psychological need satisfaction at Level 2 were associated with intrapersonal change in each outcome at the lower Level 1 (Raudenbush & Bryk, 2002). As the first timepoint was centred at zero, the main effects could be interpreted as the extent that pupil differences in psychological need satisfaction explained each outcome at the start of the study. In addition, a psychological need satisfaction \times time interaction term was included in each model to determine whether psychological need satisfaction predicted the development of each outcome. The emergence of significant interactions was followed up by simple slope analyses based on values of ± 1 standard deviation in psychological need satisfaction (Preacher et al., 2006).

Parametric bootstrapping was performed for all conditional growth models based on resampling the residuals with 5 sets of 300 replicates (Rashbash et al., 2020). Bootstrapped estimates, standard errors, and 95% confidence intervals were thus provided for all model coefficients. The proportional amount of variance explained at each level was also indicated using R_1^2 (within-person), R_2^2 (between-person), and R_3^2 (classroom) statistics (Hox, 2010). Previous literature has suggested that developmental changes in adolescents' school experiences (Fan, 2011; Rogers & Tannock, 2018), cognitive fatigue (Ter Wolbeek et al., 2006), and academic attainment (Erickson et al., 2015) may vary as a function of such

demographic factors. Therefore, all models were subsequently re-examined controlling for the effects of sex, age, learning difficulties, and ethnicity (see Table 3).

3. Results

3.1. Completion Rate at Each Time Point

From the overall 361 pupils, the percentage providing data at each timepoint were 68% at Time 1, 91% at Time 2, 92% at Time 3, and 83% at Time 4. In total, 87% of the sample provided data for at least three data points. Multilevel modelling techniques can account for unequal datasets, thus, pupils with missing time points were not omitted from the analysis (Raudenbush & Bryk, 2002). In general, pupils' non-participation at a given timepoint was due to absence from school during data collection, rather than a refusal to participate in the study.

3.2. Descriptive Statistics

Means and standard deviations for all measurement scales at each time point are presented in Table 1. Intercept-only models revealed that between 33% and 40% of the variance in psychological need satisfaction, cognitive engagement, and cognitive fatigue was attributable to within-person change, whereas only 21% of the variance in academic attainment was at this level. Alternatively, between 48% and 59% of the variance in each study variable was attributable to between-person differences (see Table 1 for ICCs). Minimal variance (3%) at the classroom level was found in both psychological need satisfaction and cognitive engagement, yet 12% of the variance in cognitive fatigue and 31% of the variance in academic attainment was attributable to classroom differences. Bivariate correlations between the study variables at each timepoint are displayed in Table 2 for informational purposes. Preliminary inspection at the onset of the study revealed no sex-related differences in psychological need satisfaction ($M_{\text{Females}} = 4.56$, $M_{\text{Males}} = 4.42$; $t[239] = 1.16$, $p = .25$), which was consistent at every subsequent timepoint. Moreover, age was found not to correlate with psychological need satisfaction at any point in the study.

INSERT TABLE 1 HERE**3.3. Trajectories of Change in Study Variables**

Results of the unconditional growth models revealed that pupils' psychological need satisfaction showed a generic decrease over the school year ($b = -.15$; $p < .001$), albeit this pattern was heterogenous across the sample (i.e., significant random effects; $\sigma^2 = .03$; $p = .01$). Cognitive engagement also demonstrated a linear decline over the course of the study ($b = -.05$; $p < .001$), however this was found to be uniform across the sample ($\sigma^2 = .01$, $p = .23$). In contrast, cognitive fatigue showed no linear change over the study ($b = -.01$; $p = .69$) which was consistent across the sample ($\sigma^2 = .01$, $p = .09$). Finally, academic attainment displayed a linear increase over the school year ($b = .22$; $p < .001$), although this trend varied between pupils ($\sigma^2 = .01$; $p = .05$).

INSERT TABLE 2 HERE**3.4. Psychological Need Satisfaction Explaining Trajectories in Cognitive Engagement, Cognitive Fatigue, and Attainment**

Standardised regression coefficients and standard errors from all conditional growth models are presented in Table 3. These models tested whether between-person variability in school-based psychological need satisfaction explained cognitive engagement, cognitive fatigue, and academic attainment over the school year. In regard to cognitive engagement, pupils with high psychological need satisfaction were found to report greater levels of cognitive engagement at the start of the study compared to those low in need satisfaction. These differences were moderate in effect size based on criteria proposed by Cohen (1988). Moreover, a statistically significant psychological needs \times time interaction was found. Simple slopes analysis revealed that pupils lower in psychological need satisfaction displayed a small decline in the development of their cognitive engagement over the school year ($b = -.012$, $p < .001$; see Figure 1), whereas those higher in psychological need satisfaction displayed no

deterioration in cognitive engagement ($b = 0.01$, $p = .71$). The inclusion of the predictor variables in this model accounted for 44% of the proportional between-person variance in cognitive engagement, yet only 2% of the within-person variance and 0% of the classroom variance (see R^2 statistics in Table 3). The inclusion of covariates resulted in minor changes to the statistical parameters but no overall changes in temporal trends and proportional variance (see Table 3 for a comparison of both sets of models).

INSERT TABLE 3 HERE

Pupils higher in psychological need satisfaction were found to report lower levels of cognitive fatigue at the start of the study compared to those lower in psychological need satisfaction. These differences were moderate to large in effect size. A statistically significant psychological needs \times time interaction was also evident, however, simple slopes analysis indicated that reports of cognitive fatigue did not meaningfully vary over the study regardless of whether pupils were high ($b = -0.05$, $p = .16$) or low ($b = 0.04$, $p = .27$) in psychological need satisfaction (see Figure 1). The inclusion of the predictor variables in this model accounted for 27% of the proportional between-person level variance and 33% of the classroom level variance in cognitive fatigue, but only 1% of the within-person variance. The addition of the covariates accounted for a greater proportion of the classroom level variance in cognitive fatigue, however there were no changes to the results examining our study hypotheses, including the interaction terms.

In relation to academic attainment, pupil differences in psychological need satisfaction had no association with academic attainment at the start of the study. Nonetheless, a statistically significant psychological needs \times time interaction was found, albeit this was small in magnitude (Cohen, 1988). Inspection of the simple slopes indicated that, whilst all pupils increased in school grades over the school year, pupils higher in psychological need satisfaction demonstrated greater attainment increases ($b = 0.25$, $p < .001$) compared to pupils lower in

psychological need satisfaction ($b = 0.20, p < .001$; see Figure 2 for graphical depiction). The inclusion of the predictor variables in this model were found to explain 35% of the within-person variance in academic attainment, 9% of the classroom level variance, and 5% of the between-person variance. The attainment trajectories associated with psychological need satisfaction remained consistent when accounting for the covariates, although they accounted for a greater proportion of classroom variance and less of the between-person variance.

INSERT FIGURE 1 HERE

Finally, previous studies have demonstrated positive temporal relationships between self-efficacy beliefs and both cognitive engagement and attainment (e.g., Caprara et al., 2008). Given the conceptual overlap between the psychological need of competence and self-efficacy, we ran three supplementary models to check whether a composite of autonomy and relatedness satisfaction continued to explain each dependent variable when competence satisfaction was excluded. Indeed, the direction and strength of the need \times time interaction remained consistent for cognitive engagement ($b = .06, p < .001$) and cognitive fatigue ($b = -.04, p = .02$), although this interaction no longer reached statistical significance in relation to attainment ($b = .02, p = .09$).

INSERT FIGURE 2 HERE

4. Discussion

The present study provides a longitudinal examination of how individual differences in psychological need satisfaction explain trajectories in young adolescents' cognitive engagement, cognitive fatigue, and academic attainment. Pupils' experiencing greater psychological need satisfaction at school demonstrated higher and consistent levels of cognitive engagement over the school year, whereas pupils lower in psychological need satisfaction showed declines in their cognitive engagement over the same period. Pupils with heightened psychological need satisfaction also reported lower levels of cognitive fatigue

compared to those lacking psychological need satisfaction, and these differences remained constant over the school year. Furthermore, although increases in school grades were evident for all pupils, the experience of higher psychological need satisfaction was associated with greater increases in attainment across the year. Building on theoretical propositions within SDT (Deci & Ryan, 2016), these findings offer temporal insights into the adaptive role that psychological need satisfaction may play in maintaining young adolescents' learning engagement at school.

Extending existing knowledge (Cohen et al., 2020; Jang et al., 2016), young adolescents higher in psychological need satisfaction not only reported greater cognitive engagement at school but were found to maintain it throughout the year. As with previous studies (e.g., Wang & Eccles, 2012), a generic decline in cognitive engagement was found across the current sample, yet this was not evident for pupils reporting high psychological need satisfaction. Pupils who experience fulfilment of their psychological needs will feel they can be successful at school, are able to express themselves freely, and that they are supported by others in a non-judgmental way. Previous studies have indicated that such feelings may prompt enhanced levels of autonomous engagement with learning (Bureau et al., 2021; Zhen et al., 2017), agency towards learning (Cohen et al., 2020), and mastery strivings towards tasks (Duchesne et al., 2017). The present findings suggest that pupils whose psychological needs are satisfied appear to be more dedicated towards their learning and have a prolonged deep engagement with the information they learn at school.

On the other hand, pupils lacking in psychological need satisfaction at school displayed lower levels of cognitive engagement which declined over the school year. This pattern is somewhat worrying as it suggests these pupils may gradually disengage from the learning process over time. Deficits in psychological need satisfaction often manifest in self-handicapping learning strategies, such as cognitive detachment from tasks (e.g., Jang et al.,

2016), passive withdrawal to hide feelings of incompetency (e.g., Earl et al., 2017), and general disconnection from learning (e.g., Collie et al., 2019). These processes may inhibit a deep engagement with learning as pupils may simply try to avoid failure or become preoccupied by negative thoughts which hamper their ability to think critically and elaborate on information. Pupils who lack psychological need satisfaction at school may therefore become increasingly withdrawn from learning and require more targeted learning support from teachers (e.g., Filippello et al., 2019; Mahmoudi et al., 2018).

It is notable that cognitive engagement, unexpectedly, did not correlate with academic attainment at any timepoint across the present study. Likewise, cognitive engagement demonstrated a generic decline over the school year whilst academic grades showed a linear increase. This would imply that cognitive engagement at school may not translate into high achievement. Previous evidence with university students found that whilst autonomous motivation was positively related with various cognitive learning strategies (e.g., rehearsal, organisation, monitoring, elaboration), it was only critical thinking that had any association with academic attainment (Manganelli et al., 2019). Further research may be needed to explore how distinct cognitive strategies may relate to school performance. Alternatively, it may be that traditional assessment methods tend to evaluate abilities more attributable to the memorisation of information, as opposed to pupils' ability to elaborate or transfer knowledge across subjects (e.g., Nieminen et al., 2021). The present measure of attainment encompassed the subjects of English and Mathematics which often rely on the memorisation of spelling, grammar, or arithmetic calculations. Future studies could assess whether the present trends vary when using assessments that rely on the memorisation of information compared to tests regarding the application of concepts to real-world problems.

Additionally, pupils higher in psychological need satisfaction displayed lower levels of cognitive fatigue throughout the school year compared to their counterparts. The experience of

cognitive fatigue during secondary school is often detrimental to learning, engagement, and performance (Mizuno et al., 2011; Sievertsen et al., 2016). This seemed to be the case in our study as cognitive fatigue was negatively correlated with both cognitive engagement and academic attainment at every timepoint. Pupils with higher fulfilment of their psychological needs will have a heightened sense of autonomy, psychological freedom, and capability at school. Consequently, these pupils may be less likely to overthink how they act or perform (Schneider et al., 2018), and thus able to maintain higher levels of psychological energy throughout the school year (see Chen et al., 2015; Liu et al., 2017). On the contrary, lower psychological need satisfaction is concordant with symptoms of cognitive fatigue and psychological burnout (e.g., Bartholomew et al., 2011). This fatigue may derive from a continual monitoring of maladaptive thoughts linked to feelings of distress (Gilbert et al., 2021), perceived pressure (Wang et al., 2019c), or a need to prove oneself to others (Bartholomew et al., 2018). As a result, these experiences may make it more challenging for pupils to cognitively engage with school-based activities (e.g., Jang et al., 2016; Mouratidis et al., 2011).

In regard to academic attainment, although differences in psychological need satisfaction had no relation to school grades at the onset of the study, pupils higher in need satisfaction demonstrated greater attainment increases over the year. Inferring from extant evidence, these increases could potentially stem from academically advantageous consequences of greater behavioural engagement (Buzzai et al., 2021; Wang et al., 2019b), help seeking (Marchand & Skinner, 2007), and autonomous motivation (Ahn et al., 2021). Nevertheless, it is noticeable that a greater proportion of the variance in attainment was accounted for at the within-person and classroom level, as opposed to the between-person level. Indeed, uniform gains in school grades were observed for all pupils regardless of their experience of psychological need satisfaction (see Barkoukis et al., 2014 for comparable

trajectories). These generic attainment gains may simply be attributable to the inevitable time-based learning effects of school tuition. Moreover, it is plausible that changes in academic attainment may be partially explained by differences between classrooms. For instance, increases in school grades may be the result of differences in teacher grading practices, such as using more stringent marking criteria at the start of the school year (Hochweber et al., 2014). Alternatively, pupils who achieve higher grades may potentially receive greater levels of academic support and more challenging learning tasks within the classroom (McKown et al., 2010). These pupils may therefore be predisposed to experience higher fulfilment of their psychological need satisfaction, as well as higher school grades (Morgan & Fuchs, 2007). On the contrary, pupils attaining lower school grades may be underestimated and not provided with the same supportive opportunities, which may thwart their psychological needs (Urhahne et al., 2011).

4.1. Conceptual and Practical Implications

The current findings offer insights into the benefits of school-based psychological need satisfaction on young adolescents' cognitive engagement, cognitive fatigue, and general achievement. The fulfilment of pupils' psychological needs is an intrapsychic experience that is dependent on the subjective meaning they place upon the school context (Deci et al., 1996). Some pupils may perceive school as an appealing environment in which they actively seek out learning opportunities and deeply engage with learning material across multiple subjects. For other pupils, however, aspects of the school environment may be perceived as coercive, isolating, and overly judgemental (e.g., Shukla et al., 2016; Warburton et al., 2020). Pupils in this latter case appear to be at risk of gradually disengaging with learning over time and experiencing persistent cognitive fatigue at school. The main motive for these pupils may be to simply avoid failure rather than maximise their learning. It may be worthwhile for educators to devise ways to enhance pupils' own awareness of their psychological experiences and

learning, so they avoid becoming solely concerned with academic performance (e.g., Earl et al., 2021). Encouraging pupils to draw comparisons between different topics they find interesting, so they develop a sense of agency towards their learning, may be valuable rather than solely emphasising assessment-based outcomes.

From a practical perspective, methods to nurture learning motivation and engagement have grown in focus within educational domains (e.g., Frey et al., 2017). Initiatives have often included developing new pedagogies or incorporating new computer technologies to broaden learning (e.g., Dolmans et al., 2016; Tao, 2021). In combination with these practices, creating school ambiances that foster young adolescents' psychological need satisfaction may be valuable in helping facilitate their learning engagement. Principally, psychological need satisfaction derives from school-based interactions that are autonomy supportive (Reeve & Cheon, 2021). Autonomy support involves offering patience rather than pressure towards learning, emphasising the relevance of taught material, and allowing pupils to make meaningful decisions over their learning (Aelterman et al., 2019; Cheon et al., 2018). Such provisions centre on taking a pupil-focused perspective which cultivates a sense of relatedness by acknowledging pupils' feelings, thoughts, and opinions (Opdenakker, 2021). Moreover, autonomy support should be accompanied with informational and structured direction so that pupils feel they know how to improve and can identify ways to succeed in their academic work (Hospel & Galand, 2016). This guidance will enable pupils to feel they can be effective in their academic pursuits and encourage them to direct their engagement towards their learning without fear of being criticised (Cheon et al., 2020; Guay et al., 2017).

4.2. Limitations and Directions for Future Research

The present research focuses on the early years of secondary school as they signify an important developmental phase of adolescence (Wigfield et al., 2006), as well as a pivotal time in children's schooling (e.g., Goldstein et al., 2015). Nevertheless, it is acknowledged that the

present sample only included one school institution and tracked pupils across a single year. Further research would be required to replicate the current study across multiple school years and academic institutions. Moreover, it would be worthwhile to assess whether the decline in cognitive engagement for pupils low in psychological need satisfaction is exacerbated over several years. A possible explanation for the present findings may be that the pupils higher in psychological need satisfaction were more self-aware and better understood the cognitive engagement items. Cognitive engagement typically encompasses abstract thinking, metacognition, and conceptual understanding which develop with age during adolescence (Schneider, 2008). Future multiyear examinations may facilitate a wider age-range in the sample population to explore whether changes in cognitive engagement become more apparent as pupils enter later stages of adolescence, and whether the associations between cognitive engagement and psychological need satisfaction are more apparent with older rather than younger adolescents.

The present findings were found to remain consistent when accounting for the potential confounding effects of sex, age, educational need, and ethnicity. Recent studies, however, have indicated that socio-economic status (SES) may be an antecedent for adolescents' psychological experiences at school (Alivernini et al., 2019; 2020). Data on pupils SES was not available in the present study, yet its inclusion in future work may offer greater insights into pupils at risk of lower psychological need satisfaction and higher cognitive fatigue at school.

A further consideration is that the psychological needs in the present study were assessed using separate scales. Advances in the measurement of psychological needs have resulted in holistic scales that offer stronger reliability across cultures and minimise high intercorrelations between the needs (e.g., Chen et al., 2015). Such scales may offer a more comprehensive evaluation of school-based psychological needs in future work. Additionally,

such measures make the theoretical distinction between the satisfaction of one's psychological needs and the more overt frustration of their needs (see Cheon et al., 2019). A growing number of studies have found psychological need frustration to be uniquely associated with more deleterious outcomes, such as school disengagement (Jang et al., 2016), pressurised school motivation (Warburton et al., 2020), and behavioural defiance (Haerens et al., 2015). It seems feasible that pupils reporting greater frustration of their psychological needs may demonstrate greater declines in cognitive engagement, as well as enhanced cognitive fatigue, compared to those reporting higher satisfaction of their needs. Clarifying any temporal discrepancies between experiences of psychological need satisfaction and frustration may shed further light on pupils' adaptive and maladaptive learning experiences at school.

Finally, a particular strength of the current work is that official school grades were used to evaluate academic attainment, as opposed to relying on pupil or teacher reported achievement (e.g., Kuncel et al., 2005). Nonetheless, the present measure of academic attainment related to the specific subjects of English and Mathematics, whereas psychological need satisfaction was assessed at a generic school level. It would be insightful to evaluate whether the relationships found between psychological need satisfaction and academic attainment remained consistent if both constructs were assessed in relation to specific school subjects (see Erturan-İlker et al., 2018). In addition, the antecedents of academic attainment are diverse and may extend to a multitude of external factors not covered in this study, including the difficulty level of academic content, parental support, and pupils' interest in specific subjects (e.g., Kerpelman et al., 2008; Zwick & Himelfarb, 2011; Zhen et al., 2018). Accounting for these additional variables in future work may offer more nuanced insights into trajectories in academic attainment.

5. Conclusions

Over the past decade, calls for educational policies to emphasise learning engagement and pupil well-being, rather than attainment outcomes, have gained precedence (Bonell et al., 2014). The present work helps advance knowledge by unearthing longitudinal insights into how differences in school-based psychological need satisfaction may predict trajectories in cognitive engagement, cognitive fatigue, and school grades. Pupils experiencing lesser psychological need satisfaction at school demonstrated lower and declining cognitive engagement, which coincided with high and consistent levels of cognitive fatigue. Conversely, pupils higher in psychological need satisfaction displayed heightened cognitive engagement and lower cognitive fatigue which did not vary throughout the school year. The experience of psychological need satisfaction was also found to predict greater increases in school grades, albeit all pupils showed attainment improvements. Collectively, these findings highlight the potential cognitive benefits that psychological need satisfaction may yield for young adolescents at school. This knowledge may be informative for educators in considering how school practices may best support pupils' psychological needs to help sustain their academic engagement and development.

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Tables

Table 1

Descriptive statistics, composite reliability, and between-pupil variance (Intraclass Correlations Coefficients; ICC's)

Variable	Range	<u>Time 1 (n=241)</u>			<u>Time 2 (n=327)</u>			<u>Time 3 (n=331)</u>			<u>Time 4 (n=298)</u>			ICC
		M	SD	ρ_c	M	SD	ρ_c	M	SD	ρ_c	M	SD	ρ_c	
Psychological Needs	1-7	4.49	0.93	.88	4.30	0.97	.90	4.02	1.06	.92	4.08	1.04	.93	.59
Cognitive Engagement	1-5	3.31	0.61	.78	3.16	0.69	.84	3.08	0.75	.86	3.12	0.73	.86	.57
Cognitive Fatigue	1-5	2.90	0.89	.87	2.89	0.90	.91	2.83	0.89	.90	2.87	0.87	.91	.55
Academic Attainment	1-8	4.27	0.77	-	4.47	1.01	-	4.75	0.90	-	5.01	1.05	-	.48

Note. Composite reliability could not be computed for academic attainment as this was calculated based on English and Mathematics grades from official school records.

Table 2

Bivariate correlations between all study variables at each time point

	<u>Time 1</u>			<u>Time 2</u>			<u>Time 3</u>			<u>Time 4</u>		
	1	2	3	1	2	3	1	2	3	1	2	3
1. Psychological Needs	-			-			-			-		
2. Cognitive Engagement	.42***	-		.51***	-		.55***	-		.60***	-	
3. Cognitive Fatigue	-.43***	-.28***	-	-.37***	-.18***	-	-.38***	-.31***	-	-.45***	-.25***	-
4. Academic Attainment	.30***	.06	-.42***	.12*	.06	-.30***	.12*	.09	-.29***	.04	.06	-.31***

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3

Between-Person Differences in Psychological Need Satisfaction Explaining Variability in Cognitive Engagement, Cognitive Fatigue, and Academic Attainment.

Predictors	Initial Models (No Covariates)			Models (With Covariates)		
	Cog. Engagement	Cog. Fatigue	Attainment	Cog. Engagement	Cog. Fatigue	Attainment
	<i>b</i> (<i>SE</i>) [95% CI]	<i>b</i> (<i>SE</i>) [95% CI]	<i>b</i> (<i>SE</i>) [95% CI]	<i>b</i> (<i>SE</i>)	<i>b</i> (<i>SE</i>)	<i>b</i> (<i>SE</i>)
Fixed Effects						
Intercept	3.24*** (.03) [3.19/ 3.29]	2.90*** (.06) [2.80/ 3.00]	4.49*** (.09) [4.34/ 4.64]	3.28*** (.28)	3.04*** (.50)	5.73*** (.41)
Time	-.05*** (.01) [-.08/ -.03]	-.01 (.01) [-.03/ .02]	.22*** (.01) [.20/ .24]	-.05*** (.02)	-.00 (.01)	.25*** (.01)
Sex	-	-	-	.03 (.05)	.13 (.08)	-.25** (.08)
Age	-	-	-	-.01 (.01)	-.02 (.11)	-.09** (.04)
Special Educational Need	-	-	-	.00 (.01)	.16* (.08)	-.16 (.08)
Ethnicity	-	-	-	-.02 (.09)	-.06 (.12)	-.05 (.18)
Between-Person Predictors						
Psychological Needs: Mean	.31*** (.04) [.24/ .37]	-.37*** (.05) [-.46/ -.30]	.06 (.06) [-.03/.15]	.31*** (.04)	-.37*** (.05)	.05 (.05)
Psychological Needs × Time	.06*** (.02) [.04/ .09]	-.04* (.02) [-.07/ -.01]	.03* (.01) [.01/.04]	.06*** (.02)	-.04* (.02)	.03* (.01)
Random Effects						
Level 3 Error (Classroom)	.00 (.00) [.00/ .00]	.07* (.04) [.01/ .13]	.29** (.09) [.14/ .42]	.00 (.00)	.06* (.03)	.25** (.08)
Level 2 Error (Between-Person)	.17*** (.02) [.14/ .20]	.33*** (.03) [.27/ .38]	.49*** (.05) [.42/ .57]	.17*** (.02)	.33*** (.03)	.47*** (.04)
Level 1 Error (Within-Person)	.20*** (.01) [.18/ .21]	.27*** (.01) [.24/ .29]	.14*** (.01) [.13/ .15]	.20*** (.01)	.27*** (.01)	.14*** (.01)
R ₃ ² (Level 3 Variance)	.00	.33	.09	.00	.48	.20
R ₂ ² (Level 2 Variance)	.44	.27	.05	.44	.27	.01
R ₁ ² (Level 1 Variance)	.02	.01	.35	.02	.01	.35
-2*log likelihood	1913.68	2361.20	1943.30	1902.14	2350.60	1928.64

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Cog. = Cognitive. 95% CI = Parametric bootstrapped confidence intervals after resampling the data five times using 300 replicates (for brevity, confidence intervals are not provided in the covariate models, although the coefficient estimates and standard errors for these models were obtained using the same bootstrapping procedures). Age was entered as a continuous variable, whereas binary dummy codes were used to differentiate Sex (0 = Female; 1 = Male), Special Educational Need (0 = None; 1 = Educational Need), and Ethnicity (0 = White; 1 = Black, Asian, and Minority Ethnicity).

The proportional amount of variance that the current models explain in each dependent variable, when compared to the intercept only models, are shown at the classroom (R_3^2), between-person (R_2^2), and within-person (R_1^2) levels.

Figure 1

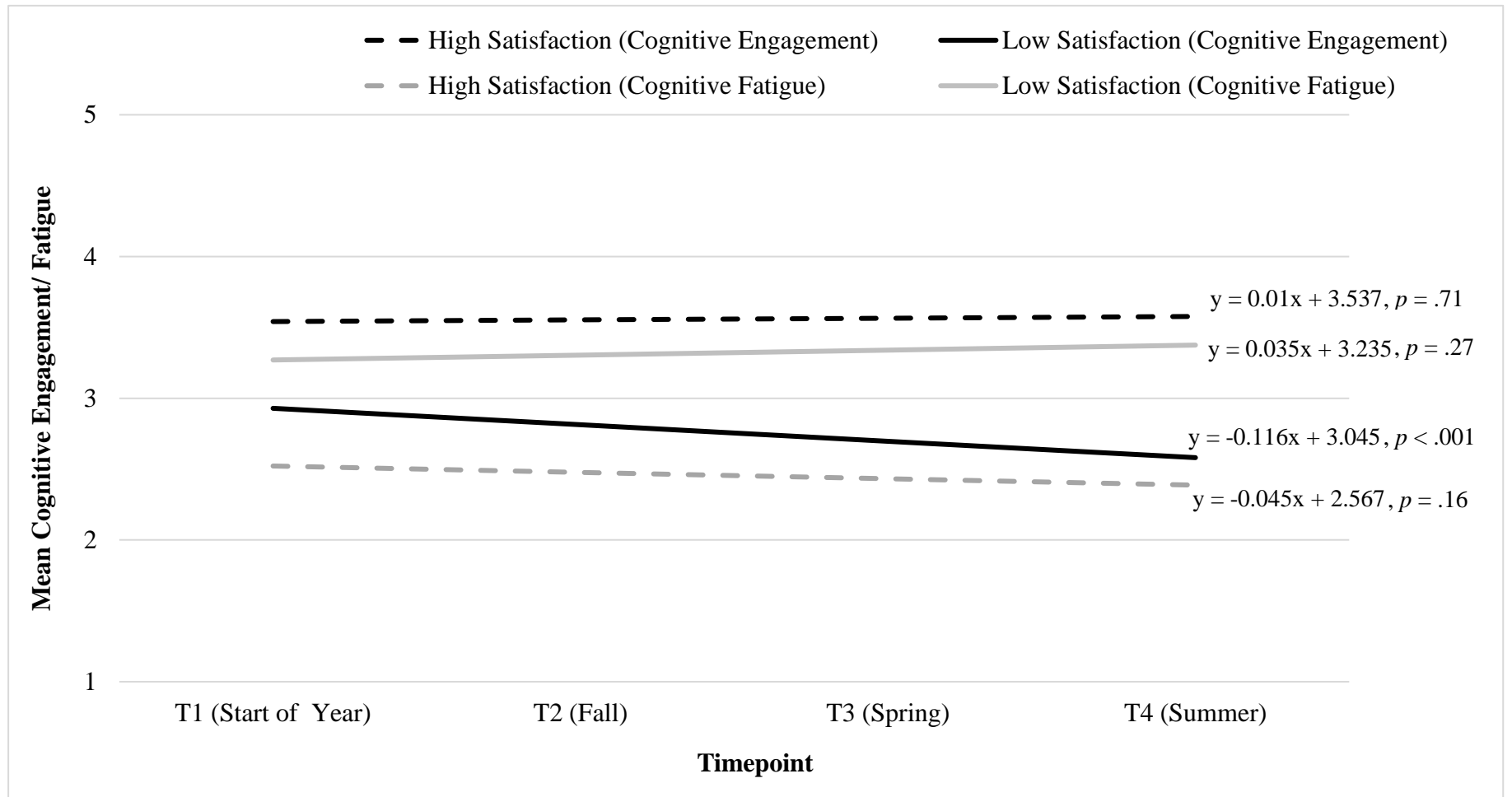


Figure 2

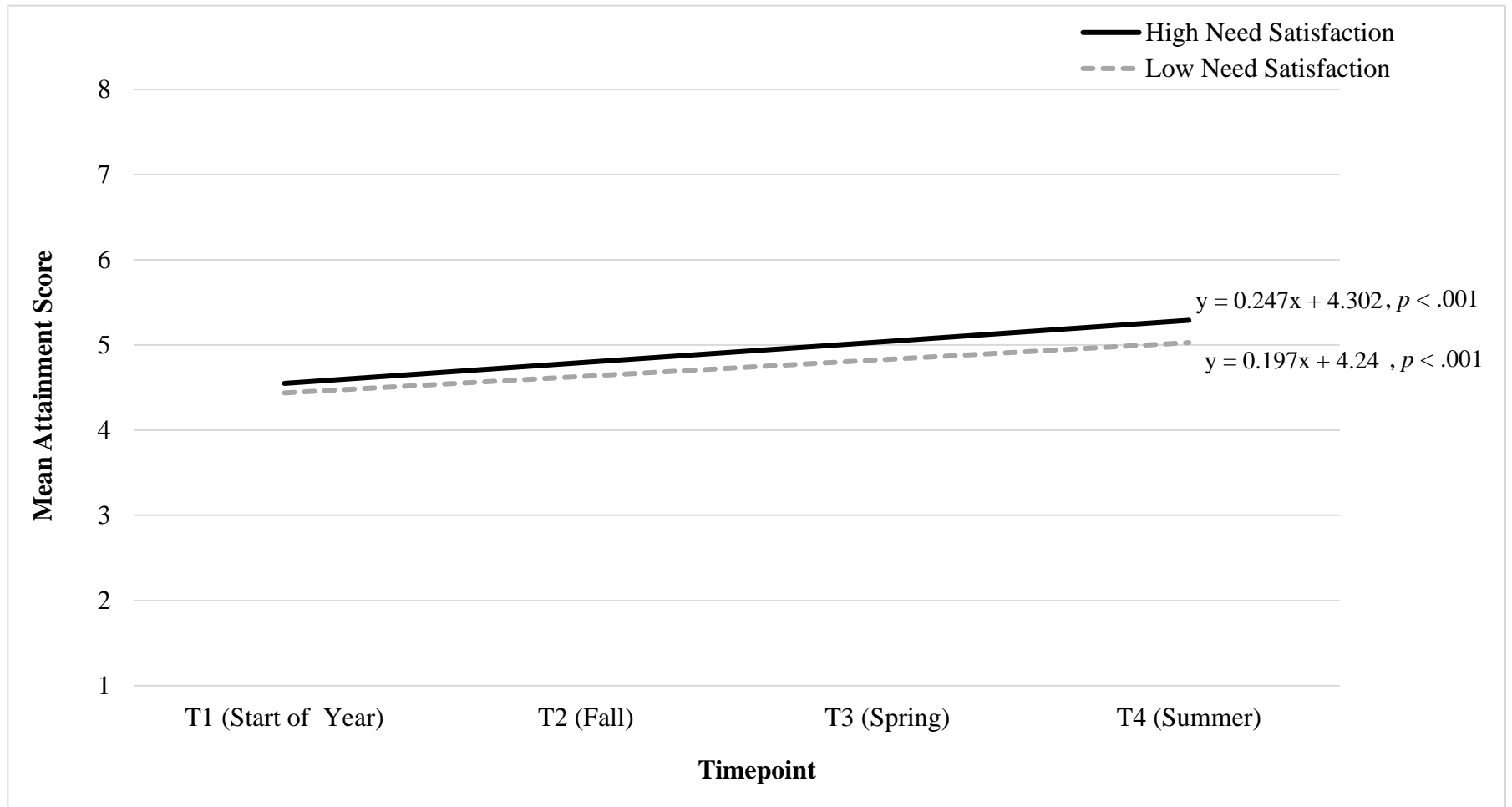


Figure Subscripts

Figure 1. Trajectories in cognitive engagement and cognitive fatigue associated with differences in pupils' psychological need satisfaction over the school year. Relevant equations for each slope are depicted within the figure along with the level of statistical significance.

Figure 2. Trajectories in academic attainment associated with differences in pupils' psychological need satisfaction. Relevant slopes equations are shown for pupils high and low in psychological need satisfaction (both slopes statistically differed from zero; $p < .001$).