On the interplay of motivational characteristics and academic achievement: The role of Need for Cognition

Anja Strobel[1][§], Alexander Strobel[2][§], Franzis Preckel[3], & Ricarda Steinmayer[4]

[1] Department of Psychology, Chemnitz University of Technology, Chemnitz, Germany

[2] Faculty of Psychology, Technische Universität Dresden, Dresden, Germany

[3] Department of Psychology, University of Trier, Trier, Germany

[4] Department of Psychology, Technical University Dortmund, Dortmund, Germany

Author Note

Anja Strobel: https://orcid.org/0000-0002-0313-0615

Alexander Strobel: https://orcid.org/0000-0002-9426-5397

Franzis Preckel: https://orcid.org/0000-0002-5768-8702

Ricarda Steinmayr: https://orcid.org/0000-0002-0294-1045

§ These authors contributed equally to this work..

Correspondence concerning this article should be addressed to Anja Strobel,
Department of Psychology, Chemnitz University of Technology, 09120 Chemnitz, Germany.
E-mail: anja.strobel@psychologie.tu-chemnitz.de

Abstract

18 . . .

Keywords: Need for Cognition, Academic Achievement, Academic Self-Concept, Latent Change Score Modeling, Longitudinal

Word count: 5254

On the interplay of motivational characteristics and academic achievement: The role of Need for Cognition

In recent decades, a great deal of research has been conducted on the prediction of academic achievement. While meta-analyses indicate that intelligence is the strongest predictor for academic achievement (e.g., Deary, Strand, Smith, & Fernandes, 2007; Roth et al., 2015; Zaboski, Kranzler, & Gage, 2018), motivational variables have consistently been found to have incremental value for academic achievement (e.g., Kriegbaum, Becker, & Spinath, 2018; Steinmayr, Weidinger, Schwinger, & Spinath, 2019). Concepts like ability self-concept, hope for success and fear of failure, interest and values are well known and equally established indicators (Allan Wigfield & Cambria, 2010; e.g., A. Wigfield & Eccles, 2000) that are subsumed under the umbrella term of achievement motivation (Steinmayr et al., 2019).

Over the last years, an additional predictor of academic performance came into the focus of research in this field: the personality trait Need for Cognition (NFC), defined as the stable intrinsic motivation of an individual to engage in and enjoy challenging intellectual activity (Cacioppo, Petty, Feinstein, & Jarvis, 1996). Investment traits (von Stumm & Ackerman, 2013) such as NFC determine how individuals invest their cognitive resources and how they deal with cognitively challenging material. It has been shown that NFC is related to academic achievement in different stages of academic life (e.g., Ginet & Py, 2000; Grass, Strobel, & Strobel, 2017; Luong et al., 2017; Preckel, 2014; for a meta-analytical review see von Stumm & Ackerman, 2013) and to behaviors associated with success in learning. As examples, NFC was found to be related to ability self-concept (e.g., Dickhäuser & Reinhard, 2010; Luong et al., 2017), interest in school (e.g., Preckel, 2014) or deeper processing while learning (Evans, Kirby, & Fabrigar, 2003; Luong et al., 2017).

The enjoyment of accomplishing something, the interest in task engagement, and the intrinsic value of working on a task have been suggested to be relevant to learning and

48 academic achievement and have been integrated into models of achievement motivation

49 (e.g., A. Wigfield & Eccles, 2000; see also Allan Wigfield & Cambria, 2010 for a review).

50 Surprisingly, the concept of a more general joy of thinking, that is NFC, has not yet been

51 investigated systematically together with established motivational indicators or was

52 integrated into models for the prediction of academic achievement, especially in school

53 contexts. In particular, longitudinal studies are missing that have a comprehensive look at

54 the interplay of all relevant variables.

55   Only last year, a large longitudinal study examined intelligence, the Big Five, a range

56 of different motivational measures together with NFC in order to determine their value in

57 predicting academic achievement in school (Lavrijsen, Vansteenkiste, Boncquet, &

58 Verschueren, 2021). Their results showed intelligence and NFC to be the strongest

59 predictors of academic performance. The ability self-concept was the best predictor within

60 the group of motivational variables. This underscores the importance to consider NFC

61 along with established predictors in gaining a comprehensive picture of the prediction of

62 academic achievement.

63   To follow-up on these findings and to provide new insights in the interplay of

64 academic achievement, NFC and motivational variables, we examined the incremental

65 value of NFC, considering well-established motivational constructs as well as prior

66 achievement in the prediction of academic achievement across different subjects in a

67 longitudinal approach in a sample of secondary school students.

Achievement Motivation and its relation to academic achievement

69   Achievement motivation is operationalized through various variables and can be seen

70 as an essential predictor of academic achievement (e.g., Hattie, 2009; Steinmayr & Spinath,

71 2009; Allan Wigfield & Cambria, 2010). Well-established concepts such as ability

72 self-concept, hope for success and fear of failure, or variables such as interests and values

can be found under this term (Hulleman, Barron, Kosovich, & Lazowski, 2016; Steinmayr

et al., 2019). These constructs are part of prominent motivational theories (cf., Eccles &

Wigfield, 2020; A. Wigfield & Eccles, 2000; **Elliot1997?**), and they positively predict

academic achievement (e.g., Steinmayr & Spinath, 2009; Steinmayr, Weidinger, & Wigfield,

2018), which is why they were included in this study as important motivational indicators.

They are briefly introduced below.

Ability Self-concept. Ability self-concept can be described as generalized or

subject-specific ability perceptions that students acquire based on competence experiences

in the course of their academic life (Möller & Köller, 2004). They thus reflect cognitive

representations of one's level of ability (Marsh, 1990), which affects students' academic

performance (e.g., A. Wigfield & Eccles, 2000). A meta-analysis found moderate

correlations with academic achievement ($r = .34$, Huang, 2011), whereas the association

was lower (r .20) when controlled for prior achievement (e.g., Marsh & Martin, 2011).

Steinmayr et al. (2019) demonstrated that among several motivational indicators,

domain-specific ability self-concept was the strongest predictor of academic achievement.

Moreover, ability self-concept and academic achievement influence each other and can thus

mutually reinforce or weaken each other (e.g., Guay, Marsh, & Boivin, 2003).

Hope for Success/Fear of Failure. Murray (1938) considered the Need for

Achievement as one of the basic human needs and as a relatively stable personality trait.

His concept was extended by McClelland, Atkinson, Clark, and Lowell (1953), who

differentiated the achievement motives hope for success (the belief of being able to succeed

accompanied by the experience of positive emotions) and fear of failure (worry about

failing in achievement situations and the experience of negative emotions). Such affective

tendencies in the context of achievement motivation are reflected, for instance, in the

choice of task difficulty, affinity for risk, and quality of task completion (Diseth &

Martinsen, 2003). Hope for success may facilitate knowledge acquisition, whereas fear of

failure may impede it (Diseth & Martinsen, 2003). A meta-analysis found achievement

motivation in the sense of hope for success weakly to moderately positively related to

academic achievement ($r = .26$, Robbins et al., 2004). For the association of fear of failure

and academic achievement, findings from individual studies suggest a relationship of

similar magnitude but in a different direction (e.g., $r = -.26$, Dickhäuser, Dinger, Janke,

Spinath, & Steinmayr, 2016).

Task values - Interest. Another important motivational indicator that was also

included in the influential model of A. Wigfield and Eccles (2000); see also Eccles and

Wigfield (2020), describes task values. Such task values focus on importance, perceived

utility, and interest in a task and costs associated with it, whereas the latter is often

omitted (cf. Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). Findings on relations

between task values and academic achievement point to reciprocal relationships between

them (Li, Huebner, & Tian, 2021). Furthermore, there is some evidence that the

interaction of task values and self-concept may be of special relevance for predicting

academic achievement, although the state of evidence on this is still mixed (Meyer,

Fleckenstein, & Köller, 2019). Specifically on the domain of interest, a number of papers

are available on the relationship with academic achievement in school, with correlations

being in a low to moderate range (for an overview, see Steinmayr et al., 2019). A

meta-analysis on the relationship between interest and achievement found moderate

positive correlations between these two variables (Schiefele, Krapp, & Winteler, 1992).

Need for Cognition and academic achievement

NFC describes the stable intrinsic motivation of an individual to engage in and enjoy

challenging intellectual activity (Cacioppo et al., 1996). While individuals with lower NFC

scores tend to rely more on other people, cognitive heuristics or social comparisons in

decision making, individuals with higher NFC scores show a tendency to seek, acquire and

reflect on information (Cacioppo et al., 1996). NFC, mirroring the typical cognitive

performance of a person, has been shown to be rather modestly related to intelligence and

126   its fluid (Fleischhauer et al., 2010) and crystallized (von Stumm & Ackerman, 2013)

127   components.

128   NFC correlates with academic achievement across different stages of school and

129   university: For example, Preckel (2014) reported a weak positive correlation primarily for

130   Math in secondary school. Ginet and Py (2000) found a mean correlation of $r = .33$

131   between NFC and academic achievement in school across all school years studied, with

132   lower correlations in earlier and higher correlations in later school years, a pattern that can

133   also be found in Luong et al. (2017). Colling, Wollschläger, Keller, Preckel, and Fischbach

134   (2022) also report differences in the strength of the correlations with academic achievement

135   in school, here depending on the type of school, with the associations between NFC and

136   academic achievement being strongest in the highest and weakest in the lowest school

137   track. As regards university, low to medium correlations were found for NFC and average

138   grades (see Richardson, Abraham, & Bond, 2012; von Stumm & Ackerman, 2013). A

139   similar picture emerges for the correlation of NFC and university entrance tests results

140   (Cacioppo & Petty, 1982; Olson, Camp, & Fuller, 1984; Tolentino, Curry, & Leak, 1990).

141   Concerning the interplay of intelligence and NFC in the context of academic

142   achievement, Strobel, Behnke, Grass, and Strobel (2019) found that reasoning ability and

143   NFC both significantly predicted higher grade point average (GPA). Interestingly, NFC

144   also moderated the relation between intelligence and GPA: at higher levels of NFC, the

145   relation of reasoning ability and GPA was diminished. Although this finding requires

146   independent replication, it could point to a potentially compensating effect of NFC.

NFC and motivational aspects of learning

148   The increased willingness to invest mental effort and attention in task and

149   information processing that is typical for individuals with higher NFC is also associated

150   with positive correlations to various traits, behaviours and indicators relevant to learning.

Evans et al. (2003) found associations of NFC with deeper processing while learning. Dickhäuser and Reinhard (2010) reported strong associations of NFC with the general ability self-concept and smaller correlations with subject-specific ability self-concepts. Luong et al. (2017) not only reported moderate to high correlations of NFC with aspects of the ability self-concept, but also with learning orientation, processing depth and the desire to learn from mistakes. Preckel (2014) found medium correlations of NFC with learning goals and interest in various school subjects (for the latter association, see also Keller et al., 2019). Furthermore, Elias and Loomis (2002) found NFC and efficacy beliefs to be moderately correlated. Their results suggested that the relationship between NFC and GPA was mediated by efficacy beliefs, in a way that individuals with higher NFC had higher efficacy beliefs which in turn had a positive effect on academic achievement. Diseth and Martinsen (2003) examined another indicator of performance motivation: In a student sample, they found a high positive correlation between NFC and hope for success and a medium negative relationship between NFC and fear of failure. Bless, Wänke, Bohner, Fellhauer, and Schwarz (1994) report comparable findings. In a large sample of 7th grade students, Lavrijsen et al. (2021) found a strong positive correlation with achievement motivation and no relation of NFC to fear of failure.

Several studies examined NFC along with other motivational variables and found NFC to explain variance in academic achievement beyond established motivational variables such as learning orientation or ability self-concept (Keller et al., 2019; Luong et al., 2017). Meier, Vogl, and Preckel (2014) examined potential predictors of the attendance of a gifted class. They found that NFC, compared to other motivational constructs like academic interests and goal orientations, significantly predicted the attendance of a gifted class even when controlling for cognitive ability and other factors like parental education level or ability self-concept. Lavrijsen et al. (2021) examined the predictive value of intelligence, personality (Big Five and NFC) and different motivational constructs for academic achievement and found intelligence, NFC, and the ability self-concept to be the

strongest predictors of Math grades and performance in standardized Math tests.

The present study

Overall, NFC has been proven to be a very promising predictor of academic achievement over and above other motivational constructs. Yet, so far the evidence on its incremental predictive value is limited by the mainly cross-sectional nature of available studies and by the fact that only a few school subjects were considered. Furthermore, up to now, prior achievement was not integrated as performance predictor in studies examining NFC. This is a limitation insofar as besides students' cognitive abilities their prior achievement is a relevant predictor of future academic achievement (e.g., Hailikari, Nevgi, & Komulainen, 2007; Steinmayr et al., 2019).

With the present study, we aim at adding to the existing body of research by examining NFC, motivational indicators (ability self-concept, hope for success and fear of failure, interests, each of them general and subject-specific) and academic achievement (assessed via GPA, and grades in German, Math, Physics, and Chemistry) at two points of time. By considering GPA plus four subject grades we extend the existing literature on predicting academic achievement in school not only in general and in the domains of math and German (see Steinmayr & Spinath, 2009), but also on focusing on the further domains Physics and Chemistry. By applying latent change score modelling, we will be able to determine the influence of our different predictors on the change of academic achievement in general and in different domains in school over time. At the same time, mutual influences of changes in academic achievement, NFC and motivational constructs can be detected (i.e., correlated change). We examine the following hypotheses and research questions:

1. Is Need for Cognition able to predict changes in academic achievement over time? Because of evidence of relations of NFC with academic achievement in cross-sectional studies, we expect NFC to also be able to predict changes in academic achievement

over time.

2. What is the incremental value of Need for Cognition in the prediction of academic achievement over and above different motivational constructs and prior achievement in school? At the background of previous findings we assume that NFC will be able to predict academic achievement even when the influence of established motivational variables and prior achievement is controlled for.

3. Are changes in motivational variables, Need for Cognition and academic achievement in school related over time?

Methods

Openness and transparency

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study (cf. Simmons, Nelson, & Simonsohn, 2012) and follow JARS (APA Publications and Communications Board Working Group on Journal Article Reporting Standards, 2008). Data were analyzed using R (version 4.1.1, R Core Team, 2018). All data and code for reproducing our analyses are permanently and openly accessible at https://github.com/alex-strobel/NFC-Grades. This study was not preregistered.

Participants

Sample size was determined by pragmatic considerations, i.e., to collect as many participants given existing time constraints and the longitudinal nature of the project. We eventually managed to recruit a sample of $N = 277$ participants (60% women) at the first measurement occasion (T1) of which $N = 251$ participants (61% women) also took part at the second measurement occasion (T2) that took place 53-59 weeks later. Students attended eleventh grade at two academic-track schools in Baden-Wuerttemberg at T1. Age

227 range was 14-19 years (median = 17 years) at T1 and 15-20 years (median = 18 years) at

228 T2. With the sample size accomplished at T2, we were able to detect correlations of $r \geq$

229 .18 at $\alpha = .05$ (two-sided) and $1-\beta = .80$. Yet, we tried to impute missing values to raise

230 power (see below, *Statistical analyses*).

Material

232   We used the following self-report measures to assess the measures of interest for the

233 present study.

234   *Academic achievement* We assessed school grades in general, i.e., Grade Point

235 Average (GPA), and grades in German, Math, Physics, and Chemistry via self-report. In

236 Germany, school grades range from 1 (excellent) to 6 (insufficient). For better

237 interpretability, we reversed this coding via $6 - grade$, so the values we used for statistical

238 analyses ranged from 0 (insufficient) to 5 (excellent).

239   *Need for Cognition* (NFC) was assessed with the 16-item short version of the German

240 NFC scale (Bless et al., 1994). Responses to each item (e.g., "Thinking is not my idea of

241 fun", recoded) were recorded on a four-point scale ranging from -3 (completely disagree) to

242 +3 (completely agree) and were summed to the total NFC score. The scale has a

243 comparably high internal consistency, Cronbach's $\alpha > .80$ (Bless et al., 1994; Fleischhauer

244 et al., 2010), and retest reliability, $r_{tt} = .83$ across 8 to 18 weeks (Fleischhauer, Strobel, &

245 Strobel, 2015).

246   *Hope for Successs* and *Fear of Failure* were assessed using the Achievement Motive

247 Scales (German version: Göttert & Kuhl, 1980). For the present study, we used a short

248 form measuring each construct with seven items. All items were answered on a four-point

249 scale ranging from 1 (does not apply at all) to 4 (fully applies). Example items for the two

250 scales are "Difficult problems appeal to me" and "Matters that are slightly difficult

251 disconcert me". Both scales exhibit high internal consistencies, Cronbach's $\alpha \geq .85$

252 (Steinmayr & Spinath, 2009).

253   The *Ability Self-Concept* in school in general and in the four subjects German, Math,
254 Physics, and Chemistry were assessed with four items per domain using the Scales for the
255 Assessment of Academic Self-Concept (Schöne, Dickhäuser, Spinath, & Stiensmeier-Pelster,
256 2002) (example item: "I can do well in . . . (school, Math, German, Physics, Chemistry).").
257 Items were answered on a 5-point scale ranging from 1 (. . .) to 5 (. . .). The scales' internal
258 consistency, Cronbach's $\alpha \geq .80$, and retest reliability, $r_{tt} \geq .59$ across six months, can be
259 considered as high.

260   *Interest* in school in general and in the above four subjects were measured using
261 Interest subscales of the Scales for the Assessment of Subjective Values in School
262 (Steinmayr & Spinath, 2010). Answers to three items per domain (example item: "How
263 much do you like . . . (school, Math, German, Physics, Chemistry).") were recorded on a
264 5-point scale ranging from 1 (. . .) to 5 (. . .). The scales have high internal consistency,
265 Cronbach's $\alpha \geq .89$, and retest reliability, $r_{tt} = .72$ across six months (Steinmayr &
266 Spinath, 2010).

267 **Procedure**

268   Testing took place during a regular school day between March 2008 and 2009. Tests
269 were administered at school during a regular class, which was scheduled for our study.
270 Parents of underaged students (age < 18) provided informed consent. As the school
271 actively supported the study participation rate was very high (96%). However, some
272 students could not participate at measurement point 1 or 2 due to illness or other reasons
273 (T1: n = 18; T2: n = 26). Students were separated into groups of about 20 and tested by
274 trained research assistants. The test sessions lasted approximately 45 minutes.

Statistical analysis

276   We used *RStudio* (Version 2021.9.0.351, RStudio Team, 2016) with R (Version 4.1.1;

277   R Core Team, 2018) and the R-packages *lavaan* (Version 0.6.10; Rosseel, 2012), *naniar*

278   (Version 0.6.1; Tierney, Cook, McBain, & Fay, 2021), *psych* (Version 2.1.9; Revelle, 2018),

279   and *pwr* (Version 1.3.0; Champely, 2018). This manuscript was created using RMarkdown

280   with the packages *papaja* (Version 0.1.0.9997, Aust & Barth, 2018), *knitr* (Version 1.37, Xie,

281   2015), and *shape* (Version 1.4.6, Soetaert, 2018). Additionally, the packages *renv* (Version

282   0.14.0, Ushey, 2021) and *here* (Version 1.0.1, Müller, 2020) were employed to enhance the

283   reproducibility of the present project (see https://github.com/alex-strobel/NFC-Grades).

284   First the variables were separated into four sets, each containing the T1 and T2

285   measurements of the variables Hope for Success (HfS), Fear of Failure (FoF), and Need for

286   Cognition (NFC) as well as either GPA, overall ability self-concept regarding school, and

287   general interest in school, or domain-specific grades, ability self-concept and interest in

288   German, Math, Physics, and Chemistry. All measures were initially analyzed with regard

289   to descriptive statistics, reliability (retest-reliability r_{tt} as well as Cronbach's α), and

290   possible deviation from univariate and multivariate normality. Almost all relevant variables

291   deviated from univariate normality as determined using Shapiro-Wilks tests with a

292   threshold of $\alpha = .20$, all $p \leq .089$ except for NFC at T2, $p = .461$. Also, there was

293   deviation from multivariate normality as determined using Mardia tests, all p_{skew} and

294    $p_{kurtosis} < .001$. Therefore, we used more robust variants for the statistical tests to be

295   performed, i.e., Spearman rank correlations (r_s) for correlation analyses and Robust

296   Maximum Likelihood (MLR) for regression analyses and latent change score modeling.

297   Possible differences between the measurement occasions T1 and T2 were descriptively

298   assessed via boxplots, with overlapping notches—that can roughly be interpreted as 95%

299   confidence intervals of a given median—pointing to noteworthy differences. Otherwise,

300   differences between time points were not considered further given the scope of the present

report. Correlation analyses were performed separately for the five sets of data (see Table 1

and Supplementary Tables S1 to S4). Where appropriate, evaluation of statistical

significance was based on 95% confidence intervals (CI) that did not include zero.

Evaluation of effect sizes of correlations was based on the empirically derived guidelines for

personality and social psychology research provided by Gignac and Szodorai (2016), i.e.,

correlations were regarded as small for $r < .20$, as medium for $.20 \leq r \leq .30$, and as large

for $r > .30$.

To examine which variables measured at T1 would be significant predictors of

academic achievement at T2, we ran five regression analyses with the GPA and the four

subject-specific grades as criterion. We than used the results of the first regression analysis

(with the domain-general Ability Self-Concept, Interest in School, Hope for Success and

Fear of failure, and NFC measured at T1 as predictors and GPA at T2 as criterion) to

select the variables for latent change score modeling. Significant predictors in this model

were used for all latent change score models even if, for certain subjects, the predictors

were not significant in the respective regression models. Regression models were fitted via

lavaan, using MLR as estimation technique and—because missing data were missing

completely at random (MCAR), all $p \geq .169$—the Full-Information Maximum Likelihood

(FIML) approach to impute missing values. Due to missing patterns, this resulted in an

effective sample size of $N = 271$-276. To assess whether a model that included NFC was

superior to a model that included established predictors of academic achievement, we (1)

evaluated the fit of the respective models based on the recommendations by Hu and

Bentler (1999), with values of CFI $\geq .95$, RMSEA $\leq .06$, and SRMR ≤ 0.08 indicating

good model fit, and (2) performed χ^2-difference tests between the former and the latter

model (and all other variables' loadings fixed to zero).

In the final step, latent change score modeling was applied. In this approach (see

Kievit et al., 2018), one can examine (1) whether true change in a variable has occurred via

a latent change score that is modeled from the respective measurements of this variable at

different measurement occasions, here T1 and T2, (2) to what extent the change in a

variable is a function of the measurement of the *same* variable at T1 (self-feedback), and

(3) to what extent the change in this variable is a function of the measurement of *other*

variables in the model at T1 (cross-domain coupling). Thereby, cross-domain effects, i.e.,

whether the change in one domain (e.g., academic achievement) is a function of the

baseline score of another (e.g., NFC) and vice versa can be examined. In addition,

correlated change in the variables of interest can be examined, i.e., to what extent does the

change in one variable correlate with the change in another variable. Fig. 1A provides an

example of a bivariate latent change score model. For latent change score modeling, again

MLR estimation and imputation of missing values via FIML was employed.

Results

Domain-general grades

Table 1 gives the descriptive statistics and intercorrelations of the variables of interest

in this analysis step, i.e., the T1 and T2 measurements of GPA, domain-general ability

self-concept, and general interest in school as well as the variables Hope for Success, Fear of

Failure, and NFC. As can be seen in the diagonal and the upper right of the correlation

table, all variables exhibited good internal consistency, Cronbach's $\alpha \geq .83$, and retest

reliability, $r_{tt} \geq .56$. Among the predictors at T1, GPA at T1 showed the strongest relation

to GPA at T2, $r_s = .75$, followed by the domain-general ability self-concept, $r_s = .53$, and

NFC at T1, $r_s = .46$, all $p < .001$. The other variables at T1 showed significant correlations

with GPA at T2 as well, $|r_s| \geq .20$, $p \leq .004$.

A multiple regression analysis involving all measures at T1 (see Table 2) showed that

apart from GPA at T1, $B = 0.61$, 95% CI [0.49, 0.73], $p < .001$, the only significant

predictors were the domain-general ability self-concept, $B = 0.12$, 95% CI [0.01, 0.22],

$p = .031$, and NFC, $B = 0.09$, 95% CI [0.01, 0.17], $p = .024$. Model fit was better for a

353   model that included GPA, the ability self-concept, and NFC at T1 (while all other

354   predictors were set to zero), $\chi^2(3) = 3.68$, p .299, CFI $= 1.00$, RMSEA $= .03$ with 90% CI

355   [0.00, 0.11], SRMR $= .01$, than a model that included GPA and the ability self-concept

356   only, $\chi^2(4) = 10.91$, p .028, CFI $= 0.96$, RMSEA $= .08$ with 90% CI [0.02, 0.14], SRMR $=$

357   .02, and a χ^2-difference test supported the superiority of the former compared to the latter

358   model, $\chi^2(1) = 6.34$, $p = .012$.

359   We therefore further examined a trivariate latent change score model involving

360   academic achievement, the ability self-concept, and NFC. Fig. 1B gives the results of the

361   latent change score modeling with regard to the prediction of change and correlated change

362   in overall academic achievement, i.e., GPA. While the best predictor of change on GPA was

363   GPA at T1 (i.e., self-feedback via prior achievement), $B = -0.37$, 95% CI [-0.48, -0.25],

364   $p < .001$, $\beta = -.55$, there was also evidence for cross-domain coupling, as the overall ability

365   self-concept and NFC at T1 also significantly predicted change in GPA, $B = 0.13$, 95% CI

366   [0.02, 0.24], $p = .020$, $\beta = .19$, and $B = 0.08$, 95% CI [0.02, 0.15], $p = .009$, $\beta = .19$,

367   respectively. Correlated change was observed for GPA and the ability self-concept, $B =$

368   0.03, 95% CI [0.01, 0.05], $p = .001$, $\beta = .22$, and the ability self-concept and NFC, $B =$

369   0.05, 95% CI [0.02, 0.08], p.001, $\beta = .22$, while the correlated changes in GPA and NFC did

370   not reach significance, $B = 0.03$, 95% CI [0.00, 0.05], $p = .053$, $\beta = .14$.

Domain-specific grades

372   For the four subjects examined, i.e., German, Math, Physics, and Chemistry, similar

373   results were obtained with regard to correlation analyses (see Supplementary Tables S1 to

374   S4). As regards multiple regression analyses (see Table 3), for all subjects, grades at T1

375   were significant predictors of grades at T2, $p < .001$. The subject-specific ability self

376   concept at T1 was a significant predictor of grades at T2 in German only, $B = 0.29$, 95%

377   CI [0.15, 0.43], $p < .001$. NFC at T1 was a significant predictor of T2 grades in German,

378   $B = 0.18$, 95% CI [0.05, 0.32], $p = .007$ and physics, $B = 0.22$, 95% CI [0.07, 0.37],

379 $p = .004$. In both cases, models with NFC as predictor together with grades at T1 and

380 ability self-concept were superior to models with grades at T1 and ability self-concept only,

381 German: $\chi^2(1) = 9.31$, $p = .002$, physics: $\chi^2(1) = 13.49$, $p = < .001$.

382   As regards the latent change score models, there was evidence for significant

383 self-feedback for all subjects, all $p < .001$. With regard to the subject-specific ability

384 self-concept, cross-domain coupling with changes in grades was observed for German, $B =$

385 0.28, 95% CI [0.16, 0.40], $p < .001$, $\beta = .36$, and Chemistry, $B = 0.09$, 95% CI [0.00, 0.18],

386 $p = .042$, $\beta = .14$. NFC at T1 showed cross-domain coupling with grades at T2 for

387 German, $B = 0.13$, 95% CI [0.04, 0.21], $p = .005$, $\beta = .17$, Physics, $B = 0.23$, 95% CI [0.13,

388 0.33], $p < .001$, $\beta = .24$, and Chemistry, $B = 0.10$, 95% CI [0.00, 0.20], $p = .047$, $\beta = .13$.

389 Correlated change between grades and the subject-specific ability self-concept was observed

390 for all subjects, while correlated change between grades and NFC was observed for

391 German, Math, and Physics only (see Fig. 1C-F).

392   **Discussion**

393   The present study was conducted to provide new insights into the interplay of

394 academic achievement, motivational variables anf NFC. In a sample of secondary school

395 children, we examined the incremental value of NFC, considering ability self-concept,

396 interest (general and domain-specific), hope for success and fear of failure as well as prior

397 achievement in the prediction of academic achievement (assessed via GPA and grades in

398 German, Math, Physics, and Chemistry). By applying latent change score modelling, we

399 determined the influence of these predictors on the change of academic achievement over

400 onye year. At the same time, we examined mutual influences of change in these variables.

401 The main results are discussed below.

Predictive value of NFC

Concerning associations of all predictors examined and academic achievement, we found typical correlation patterns: In line with former findings (Hailikari et al., 2007; Steinmayr et al., 2019), prior achievement showed a strong relation to GPA at the second time of assessment. Also mirroring previous findings (Steinmayr et al., 2019), among the motivational variables, ability self-concept showed the higest correlations with academic achievement, and this was true for general as well as domain-specific ability self-concept. Furthermore, comparable to associations reported by Ginet and Py (2000) or Luong et al. (2017), moderate to strong associations were found for academic achievement and NFC pointing to the relevance of this variable in the school context.

Interplay of all predictors

The importance of NFC becomes even more apparent when looking at the prediction models: Multiple regression analyses found NFC – with the exception of the prediction of Math and (- (albeit just missing significance) Chemistry grades - to incrementally predict academic achievement over and above prior achievement and the general or domain-specific ability self-concept. A more differentiated picture is provided by the latent change score models. For GPA, German and Chemistry, prior achievement predicted changes in grades, as did general, or domain specific ability self-concept, respectively, and NFC. Concerning Physics, only NFC was found to predict changes in grades for this subject alongside with prior achievement, while for Math grades, prior achievement was the only relevant predictor. All in all and comparable to the results of Lavrijsen et al. (2021), NFC proved to be a valuable predictor that should be considered alongside established motivational variables in order to gain a comprehensive picture of the factors that influence grades.

By applying latent change score modelling, we were also able to gain insights into the interplay of prior achievement, ability self-concept, and NFC. For all three variables, their

level at the first measurement occasion predicted changes at the second time of assessment. Changes in NFC could also be predicted by prior achievement (with the exception of Physics) while for changes in ability self-concept, prior achievement was only predictive for GPA and German grades. Furthermore, concerning correlated change, the amount of change in grades at the second measurement occasion correlated with changes in ability self-concept for GPA and all subjects, that is, changes in grades were accompanied by changes in ability self-concept and vice versa. This is a plausible interplay as ability self-concept is subject to change through feedback and the experience of success or failure (e.g., Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Spinath & Spinath, 2005). The same association was observable for changes in grades and NFC in German, Math and Physics. Thus, change in grades was accompanied by greater change in the enjoyment of and motivation for thinking, particularly in these subjects. Changes in ability self-concept and NFC, in turn, were correlated for GPA and Chemistry. Taken together, this lends support to self-enhancement and skill-development processes for both, ability self-concept and NFC. While the interplay of academic achievement and the ability self-concept is well-confirmed (Marsh & Craven, 2006; Marsh & O'Mara, 2008; Möller, Retelsdorf, Köller, & Marsh, 2011), to our knowledge, this has not yet been demonstrated for NFC as well. School achievement and NFC appear to mutually strengthen or weaken each other. Therfore, fostering NFC at school can therefore be an essential part of ensuring that children can develop their intellectual potential to the full. The findings of Meier et al. (2014) support this assumption: for the attendance of a gifted class, the level of NFC played a pivotal role even after controlling for cognitive ability or ability self-concept.

Limitations and further directions

Some limitations of our study have to be noted. We assessed all data in a convenience sample, and while it was large enough to have adequate power to detect small to medium correlations, it was not representative for the German population of adolescents.

Furthermore, there were missing values in the data and we had to impute them in order to raise power for our analyses. Yet, the FIML approach to treat missing values was shown to lead to adequate estimates for the standard error of regression estimates (Larsen, 2011). Also, we did not have the opportunity to examine the predictive value of intelligence together with the predictors in our study. Although we assessed prior achievement as a relevant predictor also mirroring intellectual potential, further studies should also assess intelligence in order to gain a more comprehensive picture of the interplay of all variables of relevance. Furthermore, because of the trait-character of NFC, hope for success and fear of failure, we did not assess these variables in a domain-specific way. As research concerning NFC could shows that there is also a domain-specific component for this variable (Keller, Strobel, Martin, & Preckel, 2019) which is especially relevant in Math, it could be worthwhile to incorporate domain-specific measures at least of NFC, too. As a last aspect, it would be interesting to longitudinally investigate the potential of NFC together with established motivational variables in school especially in critical stages of school life, for instance when decisions about school tracks are made.

Conclusion

Taken together, the present study shows that NFC is of incremental value when aiming at a comprehensive picture on the prediction of academic achievement. Associations of NFC with grades are comparable or even stronger than for well-established motivational variables. In the prediction of grades over time, NFC could largely consistently prove its predictive value over and above prior achievement. Furthermore, a mutual influence of NFC and academic achievement could be demonstrated with first evidence for skill-development as well as self-enhancement processes taken place in this interplay. To sum up, we propose NFC to be included in models aiming at explaining performance in school. In addition, we deem fostering the general joy of thinking and conquering cognitively challenging tasks a worthwhile endeavour to help children to unfold their potential.

References

APA Publications and Communications Board Working Group on Journal Article
  Reporting Standards. (2008). Reporting standards for research in psychology:
  Why do we need them? What might they be? *American Psychologist*, *63*,
  839–851. https://doi.org/10.1037/0003-066X.63.9.839

Aust, F., & Barth, M. (2018). *papaja: Create APA manuscripts with R Markdown.*
  Retrieved from https://github.com/crsh/papaja

Bless, H., Wänke, M., Bohner, G., Fellhauer, R. L., & Schwarz, N. (1994). Need for
  Cognition: Eine Skala zur Erfassung von Engagement und Freude bei
  Denkaufgaben [Need for Cognition: A scale measuring engagement and
  happiness in cognitive tasks]. *Zeitschrift für Sozialpsychologie*, *25*, 147–154.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of
  Personality and Social Psychology*, *42*, 116–131.

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996).
  Dispositional differences in cognitive motivation: The life and times of
  individuals varying in Need for Cognition. *Psychological Bulletin*, *119*(2),
  197–253. https://doi.org/10.1037/0033-2909.119.2.197

Champely, S. (2018). *Pwr: Basic functions for power analysis.* Retrieved from
  https://CRAN.R-project.org/package=pwr

Colling, J., Wollschläger, R., Keller, U., Preckel, F., & Fischbach, A. (2022). Need
  for cognition and its relation to academic achievement in different learning
  environments. *Learning and Individual Differences*, *93*, 102110.
  https://doi.org/https://doi.org/10.1016/j.lindif.2021.102110

Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2007). Intelligence and
  educational achievement. *Intelligence*, *35*(1), 13–21.
  https://doi.org/10.1016/j.intell.2006.02.001

Dickhäuser, O., Dinger, F. C., Janke, S., Spinath, B., & Steinmayr, R. (2016). A

prospective correlational analysis of achievement goals as mediating constructs linking distal motivational dispositions to intrinsic motivation and academic achievement. *Learning and Individual Differences*, *50*, 30–41. https://doi.org/10.1016/j.lindif.2016.06.020

Dickhäuser, O., & Reinhard, M.-A. (2010). How students build their performance expectancies: The importance of need for cognition. *European Journal of Psychology of Education*, *25*(3), 399–409. https://doi.org/10.1007/s10212-010-0027-4

Diseth, Å., & Martinsen, Ø. (2003). Approaches to learning, cognitive style, and motives as predictors of academic achievement. *Educational Psychology*, *23*(2), 195–207. https://doi.org/10.1080/01443410303225

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*, *61*, 101859. https://doi.org/10.1016/j.cedpsych.2020.101859

Elias, S. M., & Loomis, R. J. (2002). Utilizing need for cognition and perceived self-efficacy to predict academic Performance1. *Journal of Applied Social Psychology*, *32*(8), 1687–1702. https://doi.org/10.1111/j.1559-1816.2002.tb02770.x

Evans, C. J., Kirby, J. R., & Fabrigar, L. R. (2003). Approaches to learning, need for cognition, and strategic flexibility among university students. *British Journal of Educational Psychology*, *73*(4), 507–528.

Fleischhauer, M., Enge, S., Brocke, B., Ullrich, J., Strobel, A., & Strobel, A. (2010). Same or different? Clarifying the relationship of Need for Cognition to personality and intelligence. *Personality & Social Psychology Bulletin*, *36*(1), 82–96. https://doi.org/10.1177/0146167209351886

Fleischhauer, M., Strobel, A., & Strobel, A. (2015). Directly and indirectly assessed

Need for Cognition differentially predict spontaneous and reflective information processing behavior. *Journal of Individual Differences*, *36*(2), 101–109. https://doi.org/10.1027/1614-0001/a000161

Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences*, *102*, 74–78. https://doi.org/10.1016/j.paid.2016.06.069

Ginet, A., & Py, J. (2000). Le besoin de cognition: Une échelle française pour enfants et ses conséquences au plan sociocognitif. *L'année Psychologique*, *100*(4), 585–627.

Göttert, R., & Kuhl, J. (1980). AMS — Achievement Motives Scale von Gjesme und Nygard — Deutsche Fassung [AMS — German version]. In F. Rheinberg & S. Krug (Eds.), *Motivationsförderung im Schulalltag [Enhancement of motivation in school context]* (pp. 194–200). Göttingen: Hogrefe.

Grass, J., Strobel, A., & Strobel, A. (2017). Cognitive investments in academic success: The role of need for cognition at university. *Frontiers in Psychology*, *8*, 790. https://doi.org/10.3389/fpsyg.2017.00790

Guay, F., Marsh, H. W., & Boivin, M. (2003). Academic self-concept and academic achievement: Relations and causal ordering. *Journal of Educational Psychology*, *95*, 124–136. https://doi.org/10.1037/0022-0663.95.1.124

Hailikari, T., Nevgi, A., & Komulainen, E. (2007). Academic self-beliefs and prior knowledge as predictors of student achievement in mathematics: A structural model. *Educational Psychology*, *28*, 59–71. https://doi.org/10.1080/01443410701413753

Hattie, J. A. C. (2009). *Visible learning: A synthesis of 800 + meta-analyses on achievement*. Oxford: Routledge.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural*

Equation Modeling-A Multidisciplinary Journal, 6(1), 11–55.

https://doi.org/10.1080/10705519909540118

Huang, C. (2011). Self-concept and academic achievement: A meta-analysis of

longitudinal relations. *Journal of School Psychology, 49*(5), 505–528.

https://doi.org/10.1016/j.jsp.2011.07.001

Hulleman, C. S., Barron, K. E., Kosovich, J. J., & Lazowski, R. A. (2016). Student

motivation: Current theories, constructs, and interventions within an expectancy

value framework. In A. A. Lipnevich, F. Preckel, & R. D. Roberts (Eds.),

Psychological skills and school systems in the 21st century (pp. 241–278). Basel:

Springer International. https://doi.org/10.1007/978-3-319-28606-8_10

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002).

Changes in children's self-competence and values: Gender and domain

differences across grades one though twelve. *Child Development, 73*(2), 509–527.

https://doi.org/10.1111/1467-8624.00421

Keller, U., Strobel, A., Martin, R., & Preckel, F. (2019). Domain-specificity of need

for cognition among high school students. *European Journal of Psychological

Assessment, 35*(5), 607–616. https://doi.org/10.1027/1015-5759/a000437

Keller, U., Strobel, A., Wollschläger, R., Greiff, S., Martin, R., Vainikainen, M.-P.,

& Preckel, F. (2019). A need for cognition scale for children and adolescents.

European Journal of Psychological Assessment, 35(1), 137–149.

https://doi.org/10.1027/1015-5759/a000370

Kievit, R. A., Brandmaier, A. M., Ziegler, G., van Harmelen, A.-L., de Mooij, S. M.

M., Moutoussis, M., . . . Dolan, R. J. (2018). Developmental cognitive

neuroscience using latent change score models: A tutorial and applications.

Developmental Cognitive Neuroscience, 33, 99–117.

https://doi.org/10.1016/j.dcn.2017.11.007

Kriegbaum, K., Becker, N., & Spinath, B. (2018). The relative importance of

intelligence and motivation as predictors of school achievement: A meta-analysis. *Educational Research Review*, *25*, 120–148. https://doi.org/10.1016/j.edurev.2018.10.001

Larsen, R. (2011). Missing data imputation versus full information maximum likelihood with second-level dependencies. *Structural Equation Modeling: A Multidisciplinary Journal*, *18*(4), 649–662. https://doi.org/10.1080/10705511.2011.607721

Lavrijsen, J., Vansteenkiste, M., Boncquet, M., & Verschueren, K. (2021). Does motivation predict changes in academic achievement beyond intelligence and personality? A multitheoretical perspective. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000666

Li, X., Huebner, E. S., & Tian, L. &. (2021). Relations between achievement task values and academic achievement and depressive symptoms in chinese elementary school students: Variable-centered and person-centered perspectives. *School Psychology*, *36*(3), 167–180. https://doi.org/10.1037/spq0000384

Luong, C., Strobel, A., Wollschläger, R., Greiff, S., Vainikainen, M.-P., & Preckel, F. (2017). Need for cognition in children and adolescents: Behavioral correlates and relations to academic achievement and potential. *Learning and Individual Differences*, *53*, 103–113. https://doi.org/10.1016/j.lindif.2016.10.019

Marsh, H. W. (1990). Causal ordering of academic self-concept and academic achievement: A multiwave, longitudinal panel analysis. *Journal of Educational Psychology*, *82*, 646–656. https://doi.org/10.1037/0022-0663.82.4.646

Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multidimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science*, *1*(2), 133–163. https://doi.org/10.1111/j.1745-6916.2006.00010.x

Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic

achievement: Relations and causal ordering. *British Journal of Educational Psychology*, *81*, 59–77. https://doi.org/10.1348/000709910X50350

Marsh, H. W., & O'Mara, A. (2008). Reciprocal effects between academic self-concept, self-esteem, achievement, and attainment over seven adolescent years: Unidimensional and multidimensional perspectives of self-concept. *Personality and Social Psychology Bulletin*, *34*(4), 542–552. https://doi.org/10.1177/0146167207312313

Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development*, *76*(2), 397–416. https://doi.org/https://doi.org/10.1111/j.1467-8624.2005.00853.x

McClelland, D. C., Atkinson, J. W., Clark, R. A., & Lowell, E. L. &. (1953). *The achievement motive.* New York: Appleton-Century Crofts.

Meier, E., Vogl, K., & Preckel, F. (2014). Motivational characteristics of students in gifted classes: The pivotal role of need for cognition. *Learning and Individual Differences*, *33*, 39–46. https://doi.org/10.1016/j.lindif.2014.04.006

Meyer, J., Fleckenstein, J., & Köller, O. (2019). Expectancy value interactions and academic achievement: Differential relationships with achievement measures. *Contemporary Educational Psychology*, *58*, 58–74. https://doi.org/10.1016/j.cedpsych.2019.01.006

Möller, J., & Köller, O. (2004). Die Genese akademischer Selbstkonzepte [The genesis of academic self-concepts]. *Psychologische Rundschau*, *55*(1), 19–27. https://doi.org/10.1026/0033-3042.55.1.19

Möller, J., Retelsdorf, J., Köller, O., & Marsh, H. W. (2011). The reciprocal internal/external frame of reference model: An integration of models of relations between academic achievement and self-concept. *American Educational Research Journal*, *48*(6), 1315–1346. https://doi.org/10.3102/0002831211419649

Müller, K. (2020). *Here: A simpler way to find your files.* Retrieved from
  https://CRAN.R-project.org/package=here

Murray, H. A. (1938). *Explorations in personality.* Oxford University Press.

Olson, K. R., Camp, C. J., & Fuller, D. (1984). Curiosity and need for cognition.
  Psychological Reports, 54(1), 71–74. https://doi.org/10.2466/pr0.1984.54.1.71

Preckel, F. (2014). Assessing Need for Cognition in early adolescence: Validation of
  a german adaption of the Cacioppo/Petty scale. *European Journal of
  Psychological Assessment, 30*(1), 65–72.
  https://doi.org/10.1027/1015-5759/a000170

R Core Team. (2018). *R: A language and environment for statistical computing.*
  Vienna, Austria: R Foundation for Statistical Computing. Retrieved from
  https://www.R-project.org/

Revelle, W. (2018). *Psych: Procedures for psychological, psychometric, and
  personality research.* Evanston, Illinois: Northwestern University. Retrieved from
  https://CRAN.R-project.org/package=psych

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of
  university students' academic performance: A systematic review and
  meta-analysis. *Psychological Bulletin, 138*(2), 353–387.
  https://doi.org/10.1037/a0026838

Robbins, S. B., Lauver, K., Le, H., Davis, D., Langley, R., & Carlstrom, A. (2004).
  Do psychosocial and study skill factors predict college outcomes? A
  meta-analysis. *Psychological Bulletin, 130*, 261–288.
  https://doi.org/10.1037/0033-2909.130.2.261

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal
  of Statistical Software, 48*(2), 1–36. Retrieved from
  http://www.jstatsoft.org/v48/i02/

Roth, B., Becker, N., Romeyke, S., Schäfer, S., Domnick, F., & Spinath, F. M.

(2015). Intelligence and school grades: A meta-analysis. *Intelligence*, *53*, 118–137. https://doi.org/10.1016/j.intell.2015.09.002

RStudio Team. (2016). *RStudio: Integrated development environment for R.* Boston, MA: RStudio, Inc. Retrieved from http://www.rstudio.com/

Schiefele, U., Krapp, A., & Winteler, A. (1992). Interest as a predictor of academic achievement: A meta-analysis of research. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 183–212). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Schöne, C., Dickhäuser, O., Spinath, B., & Stiensmeier-Pelster, J. (2002). *Die Skalen zur Erfassung des schulischen Selbstkonzepts (SESSKO) — Scales for measuring the academic ability self-concept.* Göttingen: Hogrefe.

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2012). *A 21 word solution.* https://doi.org/10.2139/ssrn.2160588

Soetaert, K. (2018). *Shape: Functions for plotting graphical shapes, colors.* Retrieved from https://CRAN.R-project.org/package=shape

Spinath, B., & Spinath, F. M. (2005). Development of self-perceived ability in elementary school: The role of parents' perceptions, teacher evaluations, and intelligence. *Cognitive Development*, *20*(2), 190–204. https://doi.org/https://doi.org/10.1016/j.cogdev.2005.01.001

Steinmayr, R., & Spinath, B. (2009). The importance of motivation as a predictor of school achievement. *Learning and Individual Differences*, *19*(1), 80–90. https://doi.org/10.1016/j.lindif.2008.05.004

Steinmayr, R., & Spinath, B. (2010). Konstruktion und erste Validierung einer Skala zur Erfassung subjektiver schulischer Werte (SESSW) - [Construction and first validation of a scale for the assessment of subjective values in school]. *Diagnostica*, *56*, 195–211. https://doi.org/10.1026/0012-1924/a000023

Steinmayr, R., Weidinger, A. F., Schwinger, M., & Spinath, B. (2019). The

importance of students' motivation for their academic achievement - Replicating and extending previous findings. *Frontiers in Psychology, 10.* https://doi.org/10.3389/fpsyg.2019.01730

Steinmayr, R., Weidinger, A. F., & Wigfield, A. (2018). Does students' grit predict their school achievement above and beyond their personality, motivation, and engagement? *Contemporary Educational Psychology, 53*, 106–122. https://doi.org/10.1016/j.cedpsych.2018.02.004

Strobel, A., Behnke, A., Grass, J., & Strobel, A. (2019). The interplay of intelligence and need for cognition in predicting school grades: A retrospective study. *Personality and Individual Differences, 144*, 147–152. https://doi.org/10.1016/j.paid.2019.02.041

Tierney, N., Cook, D., McBain, M., & Fay, C. (2021). *Naniar: Data structures, summaries, and visualisations for missing data.* Retrieved from https://CRAN.R-project.org/package=naniar

Tolentino, E., Curry, L., & Leak, G. (1990). Further validation of the short form of the need for cognition scale. *Psychological Reports, 66*(1), 321–322. https://doi.org/10.2466/PR0.66.1.321-322

Ushey, K. (2021). *Renv: Project environments.* Retrieved from https://CRAN.R-project.org/package=renv

von Stumm, S., & Ackerman, P. (2013). Investment and intellect: A review and meta-analysis. *Psychological Bulletin, 139*, 841–869. https://doi.org/10.1037/a0030746

Wigfield, Allan, & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review, 30*(1), 1–35. https://doi.org/10.1016/j.dr.2009.12.001

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement

722   motivation. *Contemporary Educational Psychology*, *25*(1), 68–81.

723   https://doi.org/10.1006/ceps.1999.1015

724 Xie, Y. (2015). *Dynamic documents with R and knitr* (2nd ed.). Boca Raton,

725   Florida: Chapman; Hall/CRC. Retrieved from https://yihui.name/knitr/

726 Zaboski, B. A., Kranzler, J. H., & Gage, N. A. (2018). Meta-analysis of the

727   relationship between academic achievement and broad abilities of the

728   cattell-horn-carroll theory. *Journal of School Psychology*, *71*, 42–56.

729   https://doi.org/10.1016/j.jsp.2018.10.001

Table 1

Spearman correlations and descriptive statistics of the variables in the analyses on Grade Point Average

	GRD1	ASC1	INT1	HFS1	FOF1	NFC1	GRD2	ASC2	INT2	HFS2	FOF2	NFC2
GRD1	—	.58	.38	.34	-.24	.44	**.75**	.52	.34	.40	-.23	.49
ASC1		*.83*	.49	.37	-.27	.38	.50	**.60**	.32	.34	-.18	.26
INT1			*.88*	.32	-.09	.35	.44	.47	**.65**	.31	-.05	.26
HFS1				*.86*	-.30	.62	.32	.38	.26	**.57**	-.17	.50
FOF1					*.88*	-.42	-.17	-.28	-.14	-.29	**.59**	-.43
NFC1						*.89*	.46	.43	.25	.62	-.32	**.71**
GRD2							—	.53	.34	.41	-.18	.48
ASC2								*.84*	.53	.45	-.25	.46
INT2									*.88*	.31	-.05	.34
HFS2										*.87*	-.28	.66
FOF2											*.90*	-.39
NFC2												*.89*
Mean	3.30	3.55	3.25	2.92	1.86	4.46	3.46	3.62	3.41	2.72	1.71	4.69
SD	0.55	0.54	0.83	0.57	0.61	0.84	0.52	0.56	0.82	0.56	0.61	0.87
Min	2.00	1.75	1.00	1.14	1.00	2.19	2.10	2.25	1.00	1.00	1.00	2.50
Max	5.00	5.00	5.00	4.00	4.00	6.94	5.00	5.00	5.00	4.00	3.71	6.88
Skew	0.17	0.09	-0.27	-0.23	0.45	0.16	0.31	0.33	-0.21	-0.02	0.89	0.07
Kurtosis	-0.09	0.24	-0.37	-0.07	-0.34	0.14	-0.11	-0.14	-0.42	0.17	0.47	-0.45

Note. $N = 193\text{-}259$ due to missings; $p < .05$ for $|r_s| > .18$; coefficients in the diagonal are Cronbach's α, bold-faced coefficients give the 53-59 week retest reliability; GRD = Grade Point Average, ASC = Overall Ability Self-Concept, INT = Overall Interest in School, HFS = Hope for Success, FOF = Fear of Failure, NFC = Need for Cognition at measurement occasion 1, and 2, respectively

Table 2

Results of the multiple regression of academic achievement measured at T2 on predictors measured at T1

	B	SE	$CI.LB$	$CI.UB$	β	p
Intercept	0.488	0.231	0.034	0.941	.906	.035
GPA	0.606	0.061	0.485	0.726	.616	< .001
Ability Self-Concept	0.116	0.054	0.010	0.222	.117	.031
Interest	0.057	0.031	-0.005	0.118	.087	.072
Hope for Success	-0.028	0.050	-0.126	0.070	-.029	.578
Fear of Failure	0.013	0.039	-0.063	0.089	.015	.733
Need for Cognition	0.089	0.040	0.012	0.167	.140	.024

Note. $N = 276$; coefficients are unstandardized slopes B with their standard errors SE and 95% confidence intervals ($CI.LB$ = lower bound, $CI.UB$ = upper bound), β is the standardized slope and p the respective p-vcalues

Table 3

Multiple regressions of subject grades at T2 on predictors at T1

	B	SE	$CI.LB$	$CI.UB$	β	p
German						
Intercept	0.374	0.300	-0.214	0.962	.465	.213
Grade German	0.506	0.063	0.382	0.629	.499	< .001
Ability Self-Concept German	0.289	0.072	0.147	0.430	.294	< .001
Interest in German	-0.022	0.052	-0.124	0.079	-.027	.668
Hope for Success	-0.129	0.089	-0.303	0.045	-.091	.145
Fear of Failure	-0.044	0.061	-0.165	0.076	-.033	.470
Need for Cognition	0.183	0.068	0.050	0.316	.192	.007
Math						
Intercept	1.498	0.517	0.484	2.512	1.368	.004
Grade Math	0.493	0.089	0.318	0.667	.461	< .001
Ability Self-Concept Math	0.057	0.122	-0.182	0.295	.052	.643
Interest in Math	0.041	0.084	-0.124	0.207	.043	.625
Hope for Success	-0.083	0.140	-0.357	0.191	-.043	.552
Fear of Failure	-0.184	0.111	-0.401	0.033	-.102	.097
Need for Cognition	0.091	0.107	-0.118	0.300	.070	.392
Physics						
Intercept	-0.234	0.381	-0.979	0.512	-.252	.539
Grade Physics	0.533	0.064	0.407	0.658	.590	< .001
Ability Self-Concept Physics	0.062	0.096	-0.126	0.249	.066	.521
Interest in Physics	-0.035	0.068	-0.169	0.099	-.044	.610
Hope for Success	0.116	0.109	-0.098	0.330	.071	.288
Fear of Failure	0.117	0.092	-0.063	0.298	.076	.204
Need for Cognition	0.217	0.076	0.068	0.366	.197	.004
Chemistry						
Intercept	0.583	0.348	-0.098	1.265	.703	.093
Grade Chemistry	0.554	0.054	0.448	0.661	.633	< .001
Ability Self-Concept Chemistry	0.088	0.069	-0.048	0.223	.112	.205
Interest in Chemistry	-0.011	0.056	-0.120	0.098	-.016	.839
Hope for Success	-0.006	0.089	-0.180	0.168	-.004	.943
Fear of Failure	0.051	0.082	-0.111	0.213	.037	.536
Need for Cognition	0.122	0.062	-0.001	0.244	.124	.051

Note. $N = 271\text{-}275$; coefficients are unstandardized slopes B with their standard errors SE and 95% confidence intervals ($CI.LB =$ lower bound, $CI.UB =$ upper bound), β is the standardized slope and p the respective p-vcalues
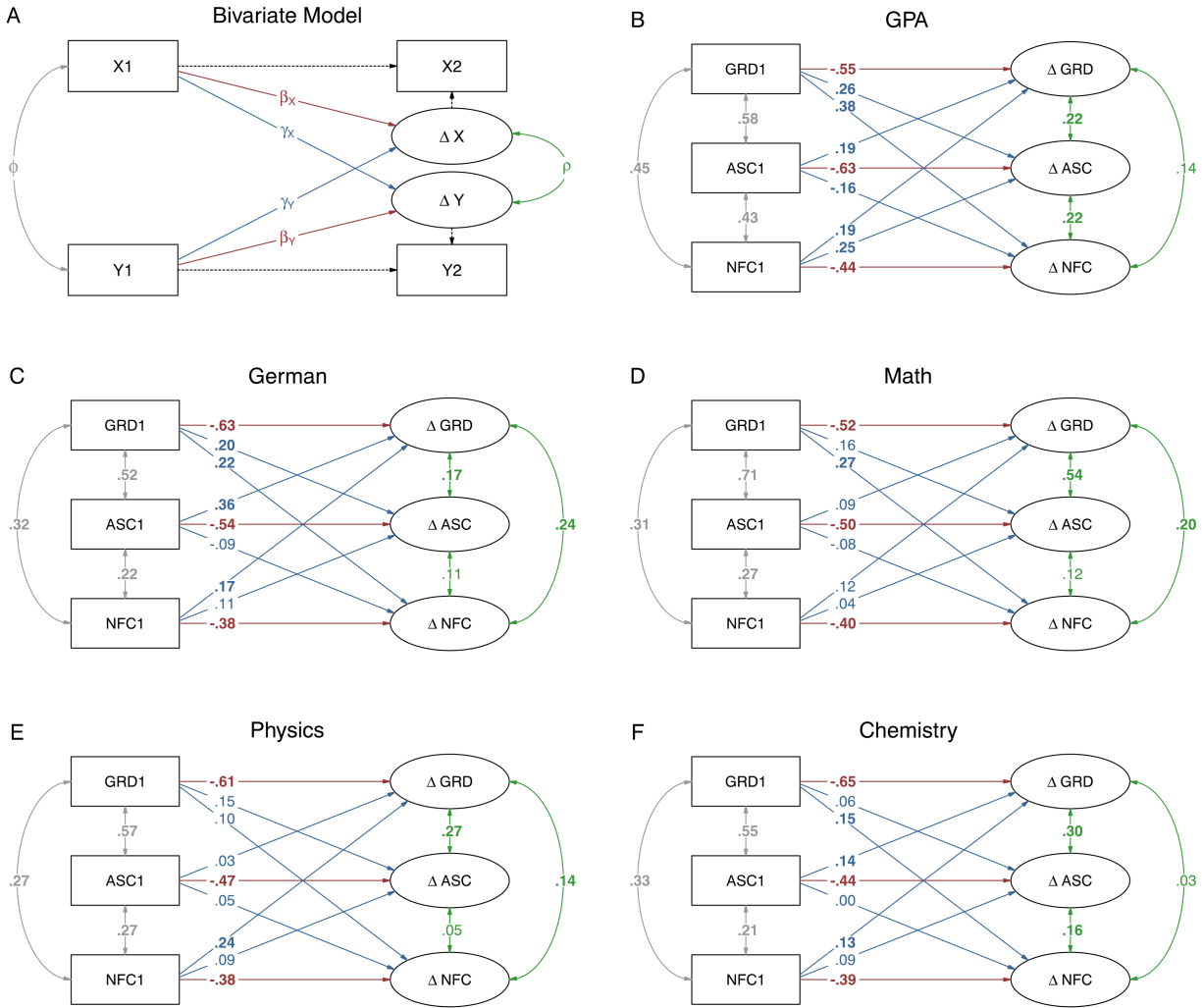
Figure 1. Latent change score models. (A) Example of a bivariate latent change score model (for details see text); legend to lines: dotted = loadings fixed to zero, red = self-feedback β, blue = cross-domain coupling γ, grey = correlation ϕ of predictors at T1, green = correlated change ρ; (B) Grade Point Average (GPA) and (C) to (F) subject-specific changes in grades at T2 (indicated by prefix Δ) as predicted by their respective T1 levels as well as by Need for Cognition (NFC) and (overall as well as subject specific) Ability Self-Concept (ASC) at T1; coefficients are standardized coefficients.