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Need for Cognition and its relation to academic achievement in different learning environments

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ABSTRACT

The present study investigates how Need for Cognition (NFC), an individual's tendency to engage in and enjoy thinking, relates to academic achievement in 9th grade students ($N = 3.355$) attending different school tracks to understand whether school track moderates this relation when controlling for student background variables. Using structural regression analyses, our findings revealed small and significant positive relations between NFC and academic achievement in German, French and Math. Relations were strongest in the highest and weakest in the lowest track. No significant track difference between the highest and the intermediary track could be identified; significant differences of small effect size between the intermediary and the lowest track were found in favor of the intermediary track in the relation between NFC and academic achievement in German and Math. These findings underpin the importance of NFC in academic settings, while highlighting that the relation between NFC and achievement varies with the characteristics of different learning environments.

1. Introduction

Need for Cognition (NFC) is a personality trait, most commonly defined as an individual's "tendency to engage in and enjoy thinking" and has an impact on how individuals exercise their cognitive abilities to make sense of their world (Cacioppo & Petty, 1982, p. 116). Since Cacioppo and Petty (1982) introduced the concept, its importance has been discussed in a multitude of different research fields, ranging from social and cognitive psychology to medicine, marketing, and law (Cacioppo et al., 1996).

With its focus on how individuals invest their cognitive resources, NFC gained increasing attention in educational research, revealing that NFC relates to cognitive and academic outcome variables such as fluid (Fleischhauer et al., 2010) and crystallized intelligence (Hill et al., 2013), academic self-concept (Dickhäuser & Reinhard, 2010; Keller et al., 2016), academic interest (Feist, 2012; Keller et al., 2016), and academic achievement (Ginet & Py, 2000; Grass et al., 2017; Preckel, 2014; Tolentino et al., 1990). Furthermore, NFC explains incremental variance in academic achievement, above other concepts such as academic self-concept or interest (Keller et al., 2016; Luong et al., 2017).

While over the course of the last decades NFC has been identified as an important construct in educational research and especially in tertiary education (Richardson et al., 2012), little is known about its relation to academic achievement in younger students (e.g., secondary education) or students in different learning environments (e.g., school tracks). Therefore, the present study investigates how NFC relates to academic achievement in a sample of 9th grade students ($N = 3.355$, $M(SD)_{age} = 14.57$ (0.66), 50.1% female) attending different school tracks. By exploring NFC in different learning environments, the study aims to enrich the existing literature and to generate first knowledge whether the relation between NFC and academic achievement varies with school tracks. Track differences may be indicative of whether all students are given the possibility to make use of their full academic potential, and hence would allow recognizing potential inequalities in the educational system in relation to tracking.

1.1. Theoretical framework

1.1.1. Need for Cognition in education

In educational research, NFC is associated with various cognitive and academic outcome variables. Several studies have analyzed correlations between NFC and other important constructs in educational research (e.

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g., intelligence, academic self-concept and academic interest). Results indicate that NFC positively relates to general intelligence and to its fluid (intelligence as process) and crystallized (intelligence as knowledge) components (Hill et al., 2013; see Fleischhauer et al., 2010, for no significant relation with crystallized intelligence). When looking at the relation between NFC and motivational constructs such as academic self-concept and academic interest, positive correlations were identified with general and domain-specific academic self-concepts (Dickhäuser & Reinhard, 2010; Keller et al., 2016; Luong et al., 2017) and with general academic interest (Keller et al., 2016). Additionally, the relation between NFC and academic achievement as a central academic outcome variable has been analyzed repeatedly and research findings show positive correlations irrespective of the operationalization of academic achievement. Cacioppo and Petty (1982) already reported a moderate positive correlation between NFC and college entry test scores. A meta-analysis of 217 studies of psychological correlates of university students' academic performance (Richardson et al., 2012) identified a positive correlation of .19 between NFC and grade point average in a total sample of 1.418 students from five studies. For children and adolescents, correlations between NFC and school grades have been analyzed. Whereas NFC shows moderate positive correlations with school grades in children (Ginet & Py, 2000), Preckel (2014) identified weak positive correlations between NFC and school grades in mathematics for adolescents, whereas correlations with grades in German, English, and biology were not significant.

Whereas these correlational findings on the relation between NFC and constructs such as intelligence, academic self-concept, academic interest and academic achievement underline the importance of the construct in educational settings, further studies investigated whether NFC explains incremental variance in academic achievement, over and above other concepts. In a study with samples from 1st to 9th grade students from Finland, Germany, and Luxembourg covering an age range from 6.44 (Grade 1) to 15.37 (Grade 9), Keller et al. (2016) found NFC to explain incremental variance in academic achievement (mathematics and a verbal school subject) when controlling for academic self-concept and interest in the Finnish and Luxembourgish samples. In line with these findings, NFC accounted for small incremental variance in academic achievement when controlling for academic self-concept, learning-orientation, and control motivation in 3rd grade (10 years old), 6th grade (13 years old) and 9th grade (16 years old) students in Finland (Luong et al., 2017).

Besides being related to cognitive and academic outcome variables, NFC shows a number of behavioral correlates that are of direct importance within the classroom. Individuals high in NFC have a general preference for complex over easy tasks (Cacioppo & Petty, 1982). Compared to individuals low in NFC, they perform better when expecting a difficult task (e.g., multiple-solution anagrams; Gülgöz, 2001) and their performance expectancies significantly relate to their actual performance (Reinhard & Dickhäuser, 2009). In a study investigating the relation between NFC and cognitive effort measured by the experimental cognitive effort discounting task, adolescents (mean age of 14.76) with higher levels of NFC displayed a larger willingness to invest effort in a task that can be considered as cognitively challenging (Kramer et al., 2021). For Complex Problem Solving, defined as the "successful interaction with dynamic non-routine tasks through exploration and by integrating newly gained information", NFC explained variability unrelated to differences in reasoning, while correlating positively with exploration time (Rudolph et al., 2018, p. 53). In addition, positive correlations between NFC and the use of self-regulated learning strategies (Cazan & Indreica, 2014) and deeper approaches to learning (Evans et al., 2003) were identified. Individuals high in NFC furthermore report higher implementation rates of desirable difficulties when learning (Weissgerber et al., 2018).

Cacioppo et al. (1996) assume that children develop NFC when encountering cognitive challenges and experiencing feelings of personal satisfaction when mastering them. They further argue that educational settings that foster "cognitive development and feelings of enjoyment, competence and mastery in thinking" are likely to be favorable to the development of NFC (Cacioppo et al., 1996, p. 246). Educational research has recognized the importance of NFC when it comes to cognitive and academic outcome variables. Knowledge on its relation to academic achievement in younger students (e.g., secondary school students) and in different learning environments (e.g., school tracks) remains however scarce.

1.1.2. *School tracks as differential learning environments*

In many countries, the institutional stratification of students into different school tracks is a central characteristic of the educational system. Whereas higher school tracks provide higher school leaving certificates and generally offer an academically oriented curriculum aiming at preparing their students for pursuing university studies, lower school tracks are rather vocationally oriented and students are being prepared for job entry (Buchmann & Park, 2009). The aim of institutional stratification in the educational system is to create enhancing learning environments tailored to the needs of different student groups to facilitate teaching and foster individual development (Baumert et al., 2006; Pfost & Artelt, 2018; Schaltz & Klapproth, 2014). School tracks can thus be understood as differential learning environments offering track-specific learning opportunities to their respective students (Baumert et al., 2006).

With regard to the characteristics of the specific learning environments offered to their students, school tracks differ in instruction quality which is considered as an essential element for the initiation and sustention of insightful learning processes (Baumert et al., 2010). This includes differences in classroom management (e.g., the provision of a structured and low-noise learning environment), teacher support (e.g., the alignment of teaching to individual student needs and goals), and cognitive activation defined as the degree of cognitive challenge and the activation of higher order thinking in teaching (Praetorius et al., 2018).

Cognitive activation is a generic dimension of instruction quality that conceptually relates to NFC. Elements of a cognitively activating instruction are, for example, the activation of students' prior knowledge and the elicitation of thinking by presenting students with challenging tasks and questions and by using didactically diverse (e.g., discursive or collaborative) learning approaches (Praetorius et al., 2018). A number of studies have discussed in how far school tracks differ with regard to cognitive activation, both, from a theoretical and empirical point of view. Descriptive results of the Third International Mathematics and Science Study (TIMSS) that included a videotape classroom study to analyze instruction practices within classrooms in mathematics, indicate that teachers in higher school tracks use more cognitively activating elements in their instruction than teachers in lower school tracks (Klieme et al., 2001). Studies assessing students' perception of cognitive activation however came to mixed results with either no difference or both lower and higher levels of cognitive activation in lower school tracks (see Schiepe-Tiska, 2019). With regard to task complexity, tasks in higher school tracks are more likely to foster analytical and critical-thinking and teachers tend to encourage their students to exchange on broad and complex topics using a variety of didactical approaches (Gamoran & Berends, 1987; Oakes, 1987). In contrast, instruction in lower school tracks is often conceptually simplified, less theoretical, slow-paced and repetitive (Baumert et al., 2006). Instructional tasks (e.g., structured written work, memorization) expose students to fragmented and basic knowledge on school topics instead of encouraging an in-depth reflection on more complex content (Van Houtte, 2004). For physics, it has been found that cognitively activating tasks are more frequent in higher school tracks (accounting for 10.3% in the total share of tasks) than in lower school tracks (2.8%) with the difference between tracks being statistically significant (Schabram, 2007). For mathematics, class works in higher school tracks require students to apply mathematical reasoning more frequently than class works in lower school tracks (Jordan et al., 2008). When looking at language lessons, students in higher school tracks are often required to learn a second foreign language and the focus is more on literature, whereas language lessons in lower school tracks are rather aimed at fostering basic linguistic skills (Becker et al., 2012; Klieme et al., 2008) and are, thus, less complex and cognitively activating.

When looking at classroom management, higher school tracks have higher levels of classroom discipline in comparison to lower school tracks, making it easier for teachers to establish a clearly structured and low-noise learning environment (Klieme et al., 2001; Schiepe-Tiska, 2019), which can be a precondition for the successful implementation of cognitively activating instruction.

Besides cognitive activation and classroom management, teacher qualification is another important aspect in which school tracks differ. While teacher training for higher school tracks often focuses on subject-specific content knowledge and on preparing students for further academic studies, teacher training for lower school tracks tends to have a more practical-oriented approach and a stronger pedagogical orientation (Baumert et al., 2010; Neumann et al., 2007; Schiepe-Tiska, 2019). Considering that a teacher's professional knowledge is an "important resource in facilitating the provision of varied, challenging, and motivating learning opportunities" (Baumert et al., 2010, p. 146), teachers in higher school track are potentially better prepared to offer cognitively activating learning opportunities to their students, when compared to lower track teachers. Based on previous research findings (e.g., Baumert et al., 2010; Retelsdorf et al., 2010), Guill et al. (2017, p. 44) describe that teachers in higher school tracks provide a "cognitively more activating instruction, for example by encouraging students to discuss and validate different solution paths of a specific task instead of training one correct solution" due to their greater content knowledge.

1.1.3. Cognitive and academic outcomes in different school tracks

School tracks relate to cognitive and academic outcomes of students. Regarding the influence of school tracks on cognitive development, several studies reported differences in intelligence gains, with students in higher tracks showing consistently higher gains than students in vocational tracks even when controlling for prior intelligence and socio-economic status (SES). Furthermore, students receiving more years of formal education or attending a more academically oriented secondary education showed greater gains in general intelligence than students completing only compulsory or vocational education (Härnqvist, 1968). Academic track attendance has positive effects on both general and fluid intelligence and a smaller, but still positive effect, on crystallized intelligence (Gustafsson, 2001). In vocational tracks however, only weak effects (both positive and negative) on intelligence have been identified while controlling for initial differences in grades and SES. Becker et al. (2012) explored the effects of tracking on students' intelligence in the German educational system characterized by a high level of stratification in secondary school. Controlling for individual and social background variables, students in the higher track showed a larger increase in intelligence than students in lower tracks. In a similar study, after four years of tracking, students in the higher track attained significantly higher intelligence scores than students in the lower tracks (Guill et al., 2017).

In addition, a number of studies analyzed the relation between school tracking on academic achievement. Among 9th grade students with a mean age of 15.8 ($SD = 0{,}7$) in Germany, students in the lower track performed less well compared to students in the intermediary and academic track (Brunner, 2006). In secondary school students in Luxembourg ($M(SD)_{\text{age}} = 12.50\ (0.5)$), students attending the academic track performed significantly better in German and French than students attending the vocational track, even after controlling for previous academic achievement (Schaltz & Klapproth, 2014). Also, in reading development, German students (from about 11 to 14 years) in the higher track performed better and showed a significant increase of decoding speed over time when compared to students in lower tracks (Retelsdorf et al., 2012). Other studies additionally explored if the achievement gap between school tracks widens over the years. Whereas Schneider and Stefanek (2004) found no evidence for a widening achievement gap, Becker et al. (2006) reported significant differences in academic achievement gains in the subject of mathematics in 7th and 8th grade students in Germany in favor of academic track students.

1.1.4. NFC and the potential impact of differential learning environments

The person-environment fit approach states that individuals "perform best in contexts that are a better fit with their habitual behavior tendencies and worst in contexts that are counter to these tendencies" (Kashdan & Yuen, 2007, p. 261). The level of fit between the needs of a person and the opportunities provided by a certain environment (Eccles et al., 1993) is, therefore, central for understanding the relationship between different variables such as NFC and academic achievement. Already in 1996, Cacioppo et al. discussed that certain characteristics of educational settings might elicit the development of NFC (e.g., support of good problem-solving skills or students' enjoyment, competence, and mastery in thinking) whereas other characteristics might hamper NFC (e.g., high levels of control, time pressure or dominance of external reward systems). However, up to now the potential impact of differential learning environments (e.g., school tracks) on the relation between NFC and academic achievement has not been addressed in research.

The assumption that differential learning environments have an impact on the relation between NFC and academic achievement is supported by empirical findings of behavioral correlates of NFC (e.g., preference for complex tasks, usage of self-regulated learning strategies and of deeper approaches to learning; von Stumm & Ackerman, 2013). It is further supported by assumptions of the person-environment fit approach (for more details see 1.1.1 Need for Cognition in Education) and especially by previous research applying the person-environment fit approach to constructs related to NFC. Kashdan and Yuen (2007) investigated interaction effects between students' curiosity and perceived school quality on academic success with high school students in Hong Kong. They found some support for a person-environment fit approach to curiosity with curious students performing better in educational settings characterized by intellectual challenge and support for their own values and preferences in learning. Similarly, with regard to creativity, predictive power in academic achievement was considerably higher in classrooms where teachers rewarded creativity more strongly (Freund & Holling, 2008). Therefore, the present study aims to understand whether differential learning environments that are known to vary in aspects such as task complexity or learning opportunities offered to their students (as described in more detail in 1.1.2 School Tracks as Differential Learning Environments) have an impact on the relation between NFC and academic achievement (see 1.2 The Present Study for detailed research questions and hypotheses).

1.1.5. Tracking in Luxembourg

In the Luxembourgish educational system, secondary school is ability tracked and divided into the so-called *enseignement secondaire classique* (highest school track preparing students for academic studies) and the *enseignement secondaire général* (Lenz & Heinz, 2018). Within the *enseignement secondaire général*, students are either allocated to the *voie d'orientation* (intermediary track preparing students for professional life or further academic studies) or the *voie de préparation* (lowest track preparing students that had not acquired sufficient skills in primary schools for joining the intermediary track or for starting a vocational training). The decision on a student's track allocation was taken by an orientation council consisting of teachers and psychologists during the last year of primary school and was based on academic achievement in German, French and Mathematics (as communicated in students' end-of-cycle reports and in the form of results from common tests taking place at the national level), the parents' opinion, and the results of psychological tests (MENJE, 2016). Previous national and international reports (Boehm et al., 2016; Hadjar et al., 2018; Martin et al., 2014) show that students in the three tracks differ both with regard to academic achievement and personal background variables (e.g., gender, SES, language, and migration background). Whereas female students are usually overrepresented in highest track, students from low SES families, a home language other than the language of instruction and a migration background are overrepresented in the lowest track. Extensive differences in academic achievement (e.g., PISA 2015 competency scores) exist between tracks. Whereas the difference between the lowest and the intermediary track ranges from 89 to 113 points, the difference between the intermediary and the highest track varies between 104 and 118 points (Boehm et al., 2016). Considering the international PISA metric with a mean of 500 and a standard deviation of 100 (OECD, 2016), competency levels between students in adjacent school tracks in Luxembourg are separated by about one PISA standard deviation, indicating a difference of two to three school years.

1.2. The present study

The present study investigates the relation between NFC and academic achievement in different tracks of the Luxembourgish secondary school system. While NFC is a well-established construct in educational research and especially in higher education, knowledge on the relation between NFC and academic achievement in younger students and in different learning environments remains scarce. The present study therefore aims at answering the following research questions:

a) Does NFC relate to academic achievement in a sample of 9th graders?

In a first step, the study analyses whether NFC relates to academic achievement in a sample of students in the 9th grade in Luxembourg. Based on studies in similar settings (Keller et al., 2016; Luong et al., 2017), we expect NFC to show a significant positive relation with academic achievement.

b) Does school track moderate the relationship between NFC and academic achievement?

Considering that school tracks relate to cognitive and academic outcome variables (e.g., intelligence, academic achievement) and are also considered as differential learning environments (e.g., instruction quality, teacher qualification), we analyzed whether the relation between NFC and academic achievement differs as a function of school track. Based on the person-environment fit approach, a learning environment with a cognitively activating instruction (e.g., higher task complexity) provided by qualified teachers (e.g., high levels of subject-specific content knowledge) is assumed to result in the best person-environment fit for individuals with high NFC. Considering that these characteristics are typically found in higher school tracks, we expect the overlap between the needs of students high in NFC and the learning environment to be largest in the highest and smallest in the lowest school track (see Fig. 1). Of note, we expect to find high NFC students in all school tracks because NFC is unrelated to the occupational status of adults (Soubelet & Salthouse, 2017), family income (Tolentino et al., 1990), and the SES of students (Preckel & Strobel, 2017). We assume that the relation between NFC and academic achievement is strongest in the highest and weakest in the lowest school track.

c) Does the moderator effect of school track remain significant when controlling for student background characteristics?

While NFC is mostly unrelated to socio-demographic background characteristics (Bertrams & Dickhäuser, 2010; Cacioppo & Petty, 1982; Goodman, 2017; Preckel, 2014; Preckel & Strobel, 2017; Soubelet & Salthouse, 2017; Tolentino et al., 1990), both academic achievement and school tracks have been linked to student background characteristics such as gender (Boehm et al., 2016; Hadjar et al., 2018; Martin et al., 2014; Voyer & Voyer, 2014), SES (Brunner, 2006; Sirin, 2005; White, 1982), language, and migration background (Agirdag & Vanlaar, 2016; Duong et al., 2016; Muller et al., 2014; OECD, 2016) in both national and international studies. Therefore, we analyze whether the moderator effect of school track in the relation between NFC and academic achievement remains significant when controlling for possibly confounding student background characteristics (e.g., gender, SES, language, and migration background).

2. Material and methods

2.1. Participants and procedure

In the Luxembourg School Monitoring Program (ÉpStan, Martin et al., 2014), a full cohort of 9th graders with regular educational pathways in secondary school (no grade repetition or track change) has been assessed resulting in an encompassing cross-sectional dataset of students exposed to their respective learning environment (e.g., highest, intermediary or lowest school track) for the same duration. The ÉpStan aim to create a standardized record of academic achievement in key school areas by analyzing at the beginning of each learning cycle whether the expected educational goals of the previous cycle have been achieved. Ethical approval was not required for this study in accordance with local legislation and institutional requirements, as it involved secondary data-analysis of an existing dataset. The ÉpStan have a proper legal basis and have been approved by the national committee for data protection. Appropriate ethical standards (American Psychological Association, 2017) were respected. Participating children and their parents

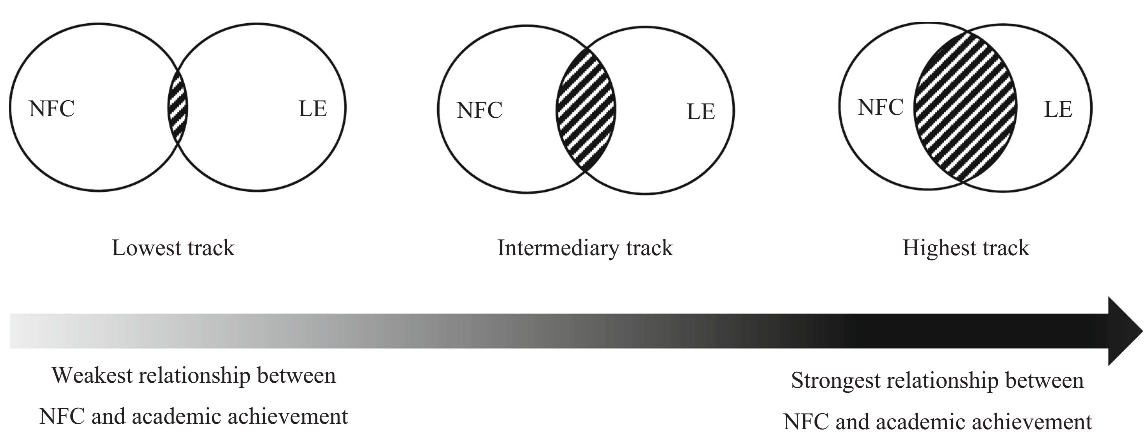

Fig. 1. Overlap between the needs of students high in NFC and the opportunities provided by the learning environment in the three school tracks
Note. LE = Learning environment.

or legal guardians were duly informed before the data collection and had the possibility to opt-out. To ensure students' privacy in accordance with the European Data Protection Regulation, the present analysis was conducted with an anonymized dataset.

Students with missing data on all NFC items ($N = 87$) were excluded, resulting in a sample of $N = 3.355$ students (50.1% female). They were distributed among the three tracks as follows: 34.2% ($N = 1.147$) attended the highest track, 51.7% ($N = 1.736$) the intermediary and 14.1% ($N = 472$) the lowest track. As mentioned before, ability-based tracking is often closely linked to differences in personal background variables (gender, SES, language, and migration background) and these differences have also been identified in the present sample based on student questionnaire information (see Table 1).

Regarding SES, 418 students (12.5%) showed missing data and were distributed among the three tracks as follows: 124 out of 1.147 highest track students (10.8%), 209 out of 1.736 intermediary track students (12.0%) and 85 out of 472 lowest track students (18.0%). No missing data were reported for gender, language or migration background.

2.2. Measures

2.2.1. Need for Cognition

NFC was measured using the 14-item NFC-KIDS scale by Preckel and Strobel (2017), who postulate a nested factor structure of NFC including a general factor *Think*, reflecting an individual's general enjoyment of and engagement in thinking and the two nested factors *Seek* and *Conquer*. While *Seek* is defined as the active behavior of approaching intellectually challenging situations, *Conquer* describes the willingness to expend effort into mastering these challenges. In recent studies, this nested factor model showed a better fit in comparison to other factor structures (e.g., Keller et al., 2016; Luong et al., 2017; Preckel & Strobel, 2017). Answers to the items were given on a 4-point Likert scale ranging from "*not true*" to "*true*". The scale comprises items reflecting both the active behavior of approaching intellectually challenging situations (*Seek*; e.g. "I like it when I get homework that I really have to chew over") and the willingness to expend effort into mastering these challenges (*Conquer*; e.g. "When I don't understand something, I think it through until I've got it"; see Keller et al., 2016). Internal reliability was very good (Cronbach's $\alpha = 0.92$ in the full sample, 0.93 in the highest track, 0.92 in the intermediary track and 0.91 in the lowest track).

2.2.2. Academic achievement

Academic achievement in German (language of literacy instruction) and French (additional language introduced in the second year of primary school) reading comprehension and mathematics was assessed using standardized tests from the ÉpStan (Martin et al., 2014). The ÉpStan tests[1] in German and French reading comprehension assess whether students are able to identify and understand information presented in texts and whether they can analyze/interpret texts and draw conclusions by activating previous knowledge. The ÉpStan test in mathematics includes tasks designed to assess skills with regard to numbers and operations (1), figures of plane and space (2), dependence and variation (3) and data (4). The tests measure academic achievement standards defined by the Luxembourg Ministry of Education and the test difficulty differs based on school tracks. Due to scaling test scores by the means of a unidimensional Rasch model, academic achievement can be compared across tracks. The ÉpStan academic achievement scores have a mean of 500 and a standard deviation of 100.

2.2.3. Student background variables

Student background variables were assessed by a student questionnaire. The *International Socio-Economic Index of Occupational Status* (ISEI; Ganzeboom et al., 1992) was used for the classification of student's SES based on the occupational status of the parents. Within ÉpStan, the highest available ISEI value (HISEI) of either the father or the mother allows a classification of students into high and low SES. The lowest 25% of the distribution are defined as having a low SES and the highest 25% as having a high SES (Muller et al., 2014). Students are considered as having a migration background when both parents were born outside of Luxembourg, irrespective of the students' own country of birth (Muller et al., 2014). As the language of literacy instruction in Luxembourg is German, speaking Luxembourgish or German at home is assumed to provide students with the language resources needed for literacy acquisition in primary school (Hadjar et al., 2018). The ÉpStan differentiates between students speaking Luxembourgish or German with at least one of their parents at home and students that mainly speak another language with their parents.

2.3. Data analysis

Descriptive statistics and correlations (SPSS Version 25) were computed for all manifest variables. Regarding missing data for NFC in the descriptive part of the study, manual guidelines were respected (Preckel & Strobel, 2017). To be analyzable, a minimum of 10 out of 14 items had to be answered. For students with no answers on up to four items, missing values were replaced by the mean score of the answered items on the total scale before sum scores were created. Final NFC scores could thus range from 14 to 56.

To handle missing data (NFC, academic achievement and SES) in subsequent analyses, multiple imputation was performed in Mplus 8 (Muthén & Muthén, 2017) and a total of 30 imputed datasets was requested. Before investigating the main research questions, analyses on the factor structure of NFC in the full sample and across school tracks were performed alongside measurement invariance tests using confirmatory factor analysis. The nested-factor structure was identified as best fit in both the full sample and across tracks and scalar measurement invariance was established (see Appendix for more details). For the relationship between NFC and academic achievement, the general factor *Think* (an individual's overall level of NFC) was used as latent variable.

To investigate whether NFC was related to academic achievement (research question a), we applied a structural regression analysis (Model A) to the overall sample and predicted academic achievement in German, French and Math by NFC (see Fig. 2a). To examine whether school track moderated this relationship (research question b), conditional process modeling was used (Hayes & Preacher, 2013) to analyze the mechanism by which the effect of one variable (x) on an outcome variable (y) depended on at least one intermediary variable (w). It thus estimated both the direct and indirect pathways through which x relates to y and hence was appropriate to investigate in how far the relationship between NFC (x) and academic achievement (y) depends on the contextual factor of school track (w). As school track was a categorical variable with more than two categories, the moderator (w) was represented by two dummy variables. For each of these two, an interaction effect with NFC (x) was calculated. If the interaction effect between NFC and school track on academic achievement was significant, it could be concluded that track differences existed (for a visualization see Fig. 2b). To investigate whether the moderator effect of school track remained significant when controlling for student background characteristics (research question c), an additive multiple moderation was performed. In Model C, gender, SES, language, and migration background were added as potential moderators. A visualization of this model (C) with school track (w) and gender (z) as moderators can be seen in Fig. 2c. SES, language, and migration background were added following the same principle.

Following the guidelines for latent variables as antecedent variables in conditional process modeling (Hayes & Preacher, 2013), interaction terms were created by the XWITH command, which instructed Mplus to use the latent moderated structural equations (LMS) approach. With data gathered in a classroom context, the nested data structure was

[1] https://epstan.lu/en/assessed-competences-9/

Table 1
Distribution of personal background characteristics of 9th grade students across tracks.

Track	*N*	Gender		SES		Migration		Language	
		Male	Female	Low	High	Yes	No	Other	Lux/Ger
Highest	1.147	45.5%	54.5%	9.2%	50.6%	32.7%	67.3%	26.4%	73.6%
Intermediary	1.736	49.5%	50.5%	26.5%	13.8%	54.1%	45.9%	51.8%	48.2%
Lowest	472	62.1%	37.9%	40.8%	3.4%	69.1%	30.9%	67.8%	32.2%

Note. *N* = Number of students. SES = Socio-economic status. Students in the lowest 25% of the study sample's SES distribution are considered as having a low SES and students in the highest 25% as having a high SES. Students are considered as having a migration background when both parents were born outside of Luxembourg, irrespective of the students' own country of birth. Students are grouped into speaking either Luxembourgish or German (Lux/Ger) with at least one of their parents at home or another language (Other).

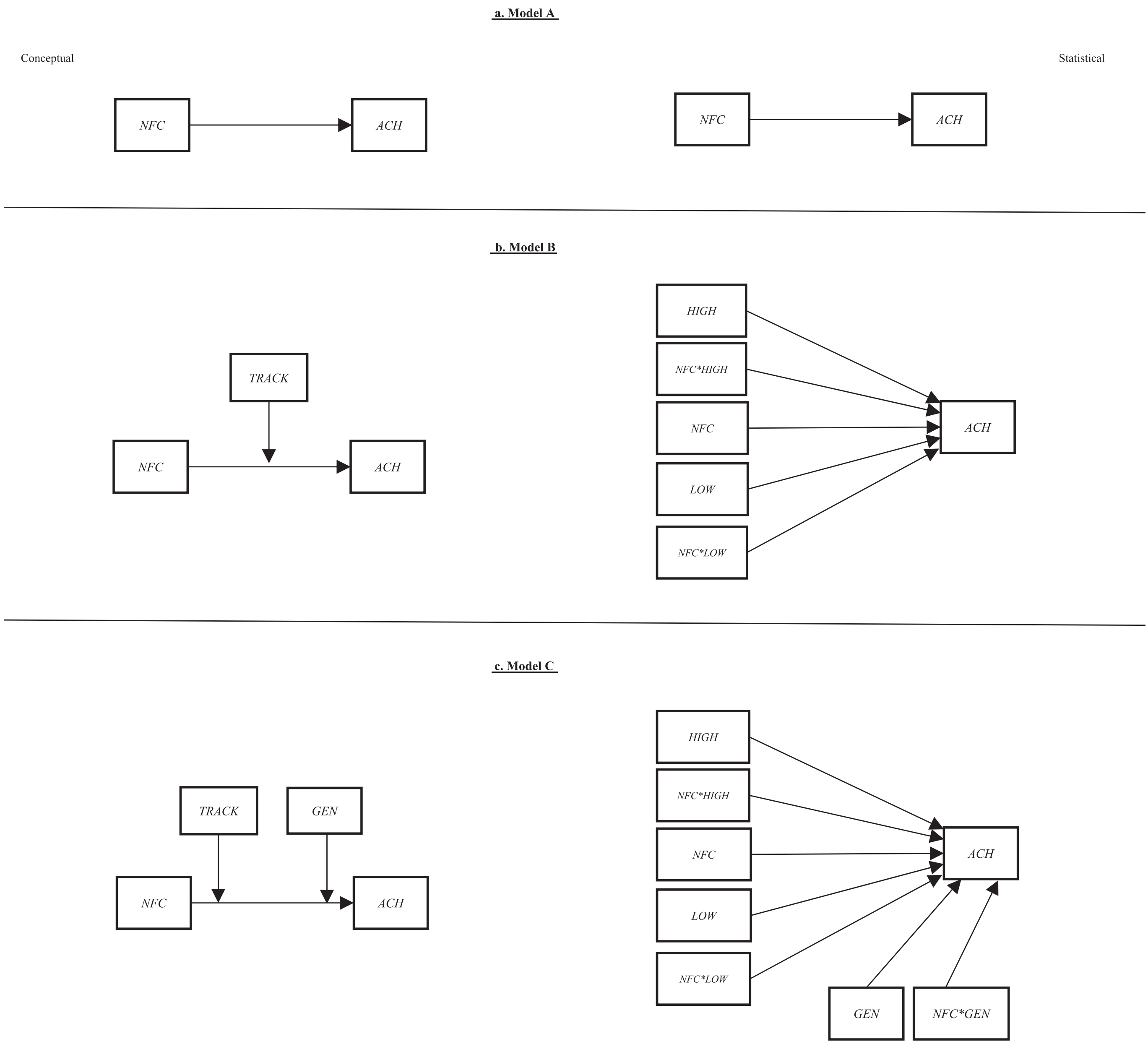

Fig. 2. Conceptual and statistical representations of a simple structural regression (2a. Model A), a simple moderation (2b. Model B) and an additive multiple moderation (2c. Model C)
Note. The figure shows the conceptual model on the left and the statistical model on the right (based on Hayes & Preacher, 2013; Stride et al., 2015). ACH = academic achievement in one of the three domains of German, French or Math. TRACK = school track. HIGH = dummy variable for the highest school track. NFC*HIGH = interaction term between NFC and highest school track. LOW = dummy variable for the lowest school track. NFC*LOW = interaction term between NFC and lowest school track. GEN = gender. NFC*GEN = interaction term between NFC and gender.

taken into consideration by the ANALYSIS = COMPLEX setting using class membership as cluster variable. To interpret model fit, robust x^2 statistic, root mean square residual (RMSEA), comparative fit index (CFI), standardized root mean square residual (SRMR), and Akaike's Information Criterion (AIC for models with latent interaction terms, see Little et al., 2006) were used. Rules of thumb for the goodness-of-fit interpretation were based on Schermelleh-Engel et al. (2003). For the classification of effect sizes, Cohen's (1988) guidelines were used.

3. Results

3.1. Descriptive statistics

Descriptive statistics for NFC, academic achievement and age for both the full sample and across tracks can be found in Table 2. Respecting the manual guidelines for the NFC-KIDS scale (Preckel & Strobel, 2017), sum scores for NFC were created based on which means for the full sample and the three school tracks were computed. With regard to NFC, students in the lowest track showed a similar mean score (35.57) as their peers in the highest track (35.39). Both groups had a higher NFC mean score than intermediary track students (34.59). Results of a one-way ANOVA ($F_{(2,3352)} = 3.288$, $p = .037$) indicate that mean levels in NFC differed significantly between students from the highest and intermediary track, while lowest track students did not differ significantly from the other tracks. However, differences between the means of the full sample and the three tracks (Cohen's $d = 0.04$ for the highest, 0.05 for the intermediary and 0.06 for lowest track respectively) and between the different tracks (Cohen's $d = 0.09$ between the highest and the intermediary track, 0.02 between the highest and the lowest track and 0.11 between the intermediary and the lowest track) can be considered negligible (Cohen, 1988).

Correlations between the main variables in the full sample and within tracks can be found in Table 3. NFC showed weak positive correlations with academic achievement in German (0.09), French (0.10), and Math (0.11) in the full sample. Analyses for individual school tracks revealed significant positive correlations between NFC and indicators of academic achievement in the higher (0.16 to 0.19) and intermediate track (0.09 to 0.14), whereas for the lower track the correlations were not significant.

3.2. Results for the research questions

a) The relation between NFC and academic achievement in the full sample

Results of the structural regression analysis in which academic achievement in German, French and Math was predicted by NFC supported our expectations, that is NFC showed a relation with academic achievement of small effect size that reached statistical significance in German (β = 0.156, *SE* = 0.020, $p \leq .001$), French (β = 0.131, *SE* = 0.020, $p \leq .001$), and Math (β = 0.151, *SE* = 0.022, $p \leq .001$). Model fit was acceptable ($x^2(df) = 1135.965$ (105), CFI = 0.956, RMSEA = 0.054, SRMR = 0.038).

b) School Track as moderator of the relation between NFC and academic achievement

To investigate potential track differences, we analyzed if school track moderated this relationship. Table 4 shows the detailed results for the simple moderation model, in which the intermediary track was the reference group. The direct relation between NFC and academic achievement in all domains remained statistically significant. NFC predicted higher achievement in the highest school track (German: β = 0.367, *SE* = 0.025, $p \leq .001$; French: β = 0.344, *SE* = 0.025, $p \leq .001$; Math: β = 0.382, *SE* = 0.026, $p \leq .001$) and lower achievement in the lowest school track (German: β = −0.380, *SE* = 0.026, $p \leq .001$; French: β = −0.312, *SE* = 0.025, $p \leq .001$; Math: β = −0.362, *SE* = 0.025, $p \leq .001$) with comparable effect sizes when relying on the intermediary track as reference group. With regard to track differences, the interaction effects between NFC and the highest track and between NFC and the lowest track are of central importance. For the interaction effect between NFC and the highest school track (NFC*Highest Track), students from the highest school track differed significantly from students in the intermediary track regarding the relation between NFC and academic achievement in French (β = 0.044, *SE* = 0.016, $p \leq .010$). That is, the relation between NFC and academic achievement in French was significantly stronger in students in the highest track than in students in the intermediary track. The interaction effect between NFC and the highest school track in academic achievement in French was of small effect size. Regarding the relation between NFC and academic achievement in German and Math, no significant differences between the highest and the intermediary track were identified. The results of the interaction effect between NFC and the lowest track (NFC*Lowest Track) also showed, that there were significant track differences in the relation between NFC and academic achievement in German (β = −0.034, *SE* = 0.017, $p \leq .050$), French (β = −0.027, *SE* = 0.013, $p \leq .050$), and Math (β = −0.053, *SE* = 0.014, $p \leq .001$) indicating that the relation was significantly weaker in students in the lowest track when compared to students in the intermediary track. The betas for the interaction effect between NFC and the lowest school track in academic achievement in all three subjects were of small effect size.

c) School Track as moderator of the relation between NFC and academic achievement when controlling for student background characteristics

To analyze whether the moderator effect of school track remained significant when controlling for student background characteristics, we performed an additive multiple moderation model in which gender, SES, language, and migration background were added as potential moderators of the relation between NFC and academic achievement. Table 5 shows the results for this additive multiple moderation, in which the intermediary track was considered as reference group. The direct relations between NFC and academic achievement remained statistically

Table 2
Descriptive statistics of the main variables in the full sample of 9th graders and within tracks.

	Full Sample (N = 3.355)			Highest track (N = 1.147)			Intermediary track (N = 1.736)			Lowest track (N = 472)		
	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
NFC	35.00	8.939	42	35.39	9.225	42	34.59	8.637	42	35.57	9.269	42
German	539.52	100.41	677.04	606.58	79.03	510.59	525.81	82.16	547.46	416.50	73.97	566.69
French	525.52	117.61	938.23	598.49	96.71	700.95	509.99	105.58	766.83	405.25	79.50	696.57
Math	525.88	96.83	679.24	593.13	76.80	535.69	512.31	78.89	614.79	412.33	69.74	387.39
Age	14.57	0.66	6	14.34	0.53	4	14.65	0.69	5	14.79	0.69	3

Note. The table displays means (*M*), standard deviations (*SD*) and range for NFC and academic achievement in German, French and Mathematics. N = number of students. Mean scores for NFC were computed based on the manual guidelines for the NFC-KIDS scale (Preckel & Strobel, 2017; see 2.3 Data Analysis for more details).

Table 3
Correlations between the main variables in the full sample of 9th graders and within tracks.

	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
1. NFC		**<u>.16</u>**	**<u>.19</u>**	**<u>.18</u>**	-.02	.03	**-.07**	-.04		-.01	.04	-.01	.02	.00	-.02	-.01
2. German	**<u>.09</u>**		**<u>.41</u>**	**<u>.31</u>**	**<u>.14</u>**	**<u>.14</u>**	**<u>.15</u>**	**<u>.13</u>**	**<u>.11</u>**		**<u>.20</u>**	**<u>.34</u>**	-.01	.08	**<u>.25</u>**	**<u>.20</u>**
3. French	**<u>.10</u>**	**<u>.51</u>**		**<u>.29</u>**	**<u>.09</u>**	**.07**	**<u>-.24</u>**	**<u>-.17</u>**	**<u>.09</u>**	**.20**		**<u>.20</u>**	-.02	.07	**<u>-.22</u>**	**<u>-.22</u>**
4. Math	**<u>.11</u>**	**<u>.58</u>**	**<u>.50</u>**		**<u>-.28</u>**	**<u>.18</u>**	.02	.04	**<u>.14</u>**	**.36**	**<u>.25</u>**		**<u>-.23</u>**	.04	-.02	-.03
5. Gender	-.03	**<u>.09</u>**	**<u>.10</u>**	**<u>-.14</u>**		**<u>-.08</u>**	.00	-.01	**-.05**	-.03	**.06**	**<u>-.24</u>**		.03	-.03	-.03
6. SES	**<u>.06</u>**	**<u>.37</u>**	**<u>.26</u>**	**<u>.36</u>**	.00		**<u>.27</u>**	**<u>.21</u>**	**<u>.07</u>**	**<u>.14</u>**	.00	**<u>.07</u>**	-.04		**<u>.19</u>**	**<u>.16</u>**
7. Language	**<u>-.05</u>**	**<u>.34</u>**	**<u>-.07</u>**	**<u>.20</u>**	.02	**<u>.37</u>**		**<u>.73</u>**	**-.06**	**<u>.28</u>**	**<u>-.31</u>**	**.06**	-.01	**<u>.31</u>**		**<u>.80</u>**
8. Migration	**-.03**	**<u>.31</u>**	-.04	**<u>.19</u>**	.01	**<u>.34</u>**	**<u>.78</u>**		-.04	**<u>.27</u>**	**<u>-.24</u>**	**.08**	-.00	**<u>.31</u>**	**<u>.78</u>**	

Note. Full sample ($N = 3.355$) is represented in the bottom-half on the left (grey). The highest track ($N = 1.147$) is represented in the top-half on the left (white). The intermediary track ($N = 1.736$) is represented in the bottom-half on the right (grey). The lowest track ($N = 472$) is represented in the top-half on the right (white). German = Academic achievement in German. French = Academic achievement in French. Math = Academic achievement in mathematics. SES = Socio-economic status. The coding for the categorical variables is the following: Gender: 0 = male, 1 = female. Language background: 0 = no Luxembourgish/German spoken at home, 1 = Luxembourgish/German spoken at home. Migration background: 0 = yes, 1 = no.
$p \leq .010$ = boldface and underlined.
$p \leq .050$ = boldface.

Table 4
Results of the simple moderation model (B) analyzing the relation between NFC and academic achievement with school track as moderator.

	German		French		Math	
	β	*SE*	β	*SE*	β	*SE*
NFC	0.134***	0.023	0.084***	0.025	0.142***	0.024
Highest track	0.367***	0.025	0.344***	0.025	0.382***	0.026
Lowest track	−0.380***	0.026	−0.312***	0.025	−0.362***	0.025
NFC*Highest track	0.012	0.017	0.044**	0.016	0.006	0.019
NFC*Lowest track	−0.034*	0.017	−0.027*	0.13	−0.053***	0.014

Note. $N = 3.355$ students. The intermediate track functions as the reference group for both the highest and the lowest track. NFC = Need for Cognition. With regard to model fit, Model B showed an AIC of 223323.098.
* $p \leq 0.050$.
** $p \leq 0.010$.
*** $p \leq 0.001$.

Table 5
Results of the additive multiple moderation model (C) analyzing the relation between NFC and academic achievement with school track and student background characteristics as moderator*s*.

	German		French		Math	
	β	*SE*	B	*SE*	β	*SE*
NFC	0.119***	0.031	0.039	0.038	0.136***	0.037
Highest track	0.300***	0.024	0.363***	0.023	0.357***	0.025
Lowest track	−0.348***	0.025	−0.318***	0.024	−0.364***	0.025
Gender	0.033*	0.016	0.054**	0.018	−0.193***	0.016
SES	0.049**	0.018	0.112***	0.020	0.074***	0.018
Language	0.141***	0.023	−0.264***	0.026	−0.014	0.022
Migration	0.056*	0.024	−0.011	0.024	0.035	0.022
NFC*Highest track	0.012	0.019	0.032	0.017	0.009	0.020
NFC*Lowest track	−0.037*	0.017	−0.015	0.014	−0.044**	0.015
NFC*Gender	−0.011	0.017	−0.001	0.014	−0.025	0.017
NFC*SES	−0.011	0.017	0.011	0.020	0.002	0.020
NFC*Language	0.041	0.025	−0.027	0.027	−0.019	0.025
NFC*Migration	−0.016	0.026	0.063**	0.023	0.032	0.025

Note. $N = 3.355$ students. The intermediate track functions as the reference group for both the highest and the lowest track. NFC = Need for Cognition. SES = socio-economic status. The coding for the categorical variables is the following: Gender: 0 = male, 1 = female. Language background: 0 = no Luxembourgish/German spoken at home, 1 = Luxembourgish/German spoken at home. Migration background: 0 = yes, 1 = no. With regard to model fit, Model C showed an AIC of 241583.854. This higher value compared to Model B (see Note of Table 4) indicated a worse model fit, which is likely due to the inclusion of the mainly non-significant interaction terms between NFC and student background variables. When compared to Model B, Model C explained more variability in academic achievement in all three subjects.
* $p \leq 0.050$.
** $p \leq 0.010$.
*** $p \leq 0.001$.

significant, except for academic achievement in French in the intermediary track. In line with the findings from the simple moderation model, the effect size of the relation was strongest in the highest and weakest in the lowest track. None of the interaction effects between NFC and student background variables were significant, except for the interaction effect between NFC and migration background (NFC*Migration) in the relation with academic achievement in French ($\beta = 0.063$, $SE = 0.023$, $p \leq .010$) showing a small effect size. When controlling for student background characteristics, the relation between NFC and academic achievement showed no significant track differences between the highest and the intermediary track (NFC*Highest Track). Previously significant track differences of small effect size in academic achievement in French were thus no longer identified. With regard to the interaction effect between NFC and the lowest school track (NFC*Lowest Track), track differences in the relation between NFC and academic achievement in German ($\beta = -0.037$, $SE = 0.017$, $p \leq .050$) and Math ($\beta = -0.044$, $SE = 0.015$, $p \leq .001$) remained significant indicating a significantly weaker relation in the lowest than in the intermediary track. The betas for the interaction effect between NFC and the lowest school track in academic achievement in German and Math were of small effect size**.** The track difference in the relation between NFC and academic achievement in French was no longer statistically significant.

4. Discussion

In educational research, NFC offers explanations for individual differences in the investment of cognitive resources and in cognitive and academic outcome variables such as intelligence (Fleischhauer et al., 2010), academic self-concept (Dickhäuser & Reinhard, 2010; Keller et al., 2016) and academic achievement (Grass et al., 2017; Keller et al., 2016; Luong et al., 2017; Preckel, 2014). However, little is known about the relation of NFC and academic achievement in secondary school students and in different learning environments. Therefore, the present study investigated how NFC relates to academic achievement in a full cohort of 9th grade students in different school tracks ($N = 3.355$). The objectives were to analyze the relation between NFC and academic achievement (structural regression), to investigate whether school track moderates this relation (simple moderation) and whether this moderation remains significant when controlling for possibly confounding student background variables (additive multiple moderation).

Our findings revealed significant positive relations of small effect size between NFC and academic achievement in German, French, and Math. Relations were strongest in the highest and weakest in the lowest school track. Significant track differences between the highest and the intermediary track in favor of the highest track were identified for the relation between NFC and academic achievement in French but not Math or German. Significant differences between the intermediary and lowest track in favor of the intermediary track were found for the relation between NFC and academic achievement in all three subjects. All interaction effects between NFC and school tracks were of small effect size. Based on the controversial discussion of Cohen's (1988) guidelines for the classification of effect sizes in certain research areas (Gignac & Szodorai, 2016; Lovakov & Agadullina, 2021) and findings that these classifications “bear almost no resemblance to findings in the field” (Bosco et al., 2015, p. 439) of applied psychology, small effect sizes for the relation between personality traits such as NFC and academic achievement as a product of different predictors (e.g., cognitive ability, class climate and other motivational constructs such as academic self-concept or academic interest) can however be regarded meaningful from an applied perspective. When controlling for possibly confounding variables, there were no significant differences in the relation between NFC and academic achievement between the highest and the intermediary school track. However, significant track differences of small effect size between the intermediary and the lowest school track for the relation between NFC and academic achievement in German and Math (but not French) remained significant.

4.1. Discussion of the descriptive statistics

Descriptive statistics of NFC and academic achievement offered insights into how these variables are distributed and correlate with each other in both the full sample of 9th grade students and across subsamples of students attending different school tracks. In line with previous national and international studies (Boehm et al., 2016; Hadjar et al., 2018; Martin et al., 2014), students in the three school tracks differed in their mean level of academic achievement, with students in the highest school track performing better than their peers in the intermediary and the lowest tracks. Descriptive statistics furthermore allowed a comparison of the students' mean level of NFC across school tracks. Students in all tracks had similar mean levels of NFC and students with high NFC levels were present in all three school tracks. These results are in line with the findings of Preckel and Strobel (2017) and based on the present study, it can be assumed that students in lower school tracks have the same potential as students from the other school tracks when it comes to their NFC. With regard to correlations between NFC and academic achievement, the present study identified small positive correlations with academic achievement in all three subjects (e.g., German, French and Math) and adds to similar findings from previous studies (Ginet & Py, 2000; Luong et al., 2017; Preckel, 2014; Richardson et al., 2012). By looking at different school tracks, the findings of the present study extend the existing knowledge on the relation between NFC and academic achievement by revealing significant positive correlations between NFC and academic achievement in German, French and Math in the highest and the intermediary track, whereas correlations were not significant in the lowest school track.

4.2. Discussion of the results for the main research questions

4.2.1. NFC and academic achievement

Results of a structural regression analysis in which academic achievement in German, French and Math was predicted by NFC indicated small and statistically significant relations in all three domains and are thus in line with our expectations. While NFC and its relation to academic achievement has predominantly been analyzed in higher education (e.g., Cacioppo & Petty, 1982; Grass et al., 2017; Richardson et al., 2012; Tolentino et al., 1990), cross-sectional studies found that the relation between NFC and academic achievement seems to be growing more important in later school years (Keller et al., 2016; Luong et al., 2017). Congruent with assumptions from the investment theory (Ackerman, 1996; von Stumm, 2012), the relation between investment traits such as NFC and academic achievement is expected to increase once individuals are encountering more complex cognitively challenging situations. The curricula and academic expectations of higher school years (Luong et al., 2017) that are especially likely to be found in higher school tracks could potentially explain the importance of NFC in secondary school. Whereas studies often found NFC to be important for academic achievement measures including both mathematical and verbal school subjects, they gave no details on the relation between NFC and the individual subjects (Ginet & Py, 2000; Luong et al., 2017). When looking at academic achievement in different school subjects separately, previous research comes to mixed conclusions. While positive relations between NFC and academic achievement in math were consistently found, nonsignificant relations in domains such as Biology, English and German were identified by Preckel (2014). In a study analyzing the relation between NFC and both mathematics and verbal school subjects, NFC however predicted incremental variance in academic achievement in both mathematics and verbal school subjects (Keller et al., 2016). The findings of the present study thus strengthen the importance of NFC when it comes to academic achievement in verbal school subjects.

4.2.2. School track as moderator

School tracks relate to cognitive and academic outcome variables (Becker et al., 2012; Brunner, 2006; Guill et al., 2017; Gustafsson, 2001;

Schaltz & Klapproth, 2014) and are considered as differential learning environments which offer track-specific learning opportunities to their students (Baumert et al., 2006). The present study aimed to understand whether school tracks moderate the relation between NFC and academic achievement. Previous research showed that individuals high in NFC have a preference for complex over easy tasks (Cacioppo & Petty, 1982; Gülgöz, 2001; Reinhard & Dickhäuser, 2009), have deeper approaches to learning (Evans et al., 2003), and show higher self-reported implementation rates of desirable difficulties when learning (e.g., self-generation of learning material, self-testing of acquired knowledge; Weissgerber et al., 2018). According to the person-environment fit approach, individuals "perform best in contexts that are a better fit with their habitual behavior tendencies and worst in contexts that are counter to these tendencies" (Kashdan & Yuen, 2007, p. 261). We therefore expected that the learning environment of higher school tracks which is characterized by a cognitively activating instruction, higher task complexity, and qualified teachers with high levels of subject-specific content knowledge would result in the best person-environment fit for individuals high in NFC. Thus, the relation between NFC and academic achievement would be strongest in the highest and weakest in the lowest school track.

Results confirmed our expectations for all three academic achievement domains (e.g., German, Math and French). However, findings were more consistent for differences between the intermediary and the lowest school track than for differences between the highest and the intermediary track. For the highest and the intermediary track, the difference in the relation between NFC and academic achievement was only significant for French and of small effect size, while the relations between NFC and academic achievement differed in all three academic achievement domains between the intermediary and the lowest track. These findings seem to indicate that the characteristics of the higher and intermediate school track positively affect the relation between NFC and academic achievement. This assumption is well aligned with findings from studies applying the person-environment fit approach to constructs related to NFC (e.g., curiosity and creativity). Curious students performed better in educational settings that are characterized by intellectual challenge and that support their own values and preferences in learning (Kashdan & Yuen, 2007). Further, the predictive power of creativity in academic achievement is considerably higher in classrooms where teachers award creativity more strongly (Freund & Holling, 2008). Our findings for NFC and its relation with academic achievement in secondary school can also be interpreted against the person-environment fit approach and indicate that higher school tracks offer a better fitting learning environment to students high in NFC.

Whereas the weaker relation between NFC and academic achievement in lower school tracks is assumed to reflect a mismatch between student needs and the characteristics of a certain learning environment in the person-environment fit approach, trait activation theory offers a further explanation (Tett & Burnett, 2003; Tett & Guterman, 2000). Its basic assumption is that certain personality traits shape performance only when the context activates these traits. Trait activation theory was recently applied to the field of educational research and more specifically to academic performance in different school tracks (Brandt et al., 2020). According to Brandt et al. (2020), characteristics such as instruction quality (e.g., cognitive activation, task complexity) and teacher qualification (e.g., subject-specialized knowledge) are "features of school tracks [that] constitute contextual cues for trait activation, which in turn, produce differential trait-performance relations" (Brandt et al., 2020, p. 252). The authors investigated Conscientiousness and Openness – two constructs with conceptual overlaps with NFC (Furnham & Thorne, 2013; Mussel, 2010; Sadowski & Cogburn, 1997) – assuming that the characteristics of higher school tracks (e.g., more difficult curricula, cognitively activating instruction) render these personality traits more consequential for academic achievement. Findings revealed that Conscientiousness was more strongly related to academic achievement in higher than in lower school tracks (Brandt et al., 2020; trait-performance relations for Openness did in contrast not vary much across school tracks). Trait activation theory would explain the weaker relation between NFC and academic achievement in lower school tracks found in our study with the contextual characteristics of the lower school tracks. For example, the more practical orientation of instruction and the less complex learning contents would not result in a trait activation of NFC and thus, in differential trait-performance relations when compared to higher school tracks.

The results of the present study can, thus, be understood as a first indication that the relation between NFC and academic achievement differs in function of school track. To gain a better understanding on the association between NFC and academic achievement and on characteristics that actively foster the development of NFC in education settings, further studies are needed and their results might in turn allow the formulation of direct implications for the provision of learning environments that foster an individual's tendency to engage in and enjoy thinking (see 4.3 Limitations and Perspectives for Future Research for more details).

4.2.3. *Controlling for student background characteristics*

As students in different school tracks differ with regard to their background characteristics (Boehm et al., 2016; Hadjar et al., 2018; Martin et al., 2014), it is important to understand whether the moderator effect of school track in the relation between NFC and academic achievement remains significant when controlling for these characteristics. Such analyses may indicate if track differences can be explained by the composition of the student population rather than differences in the characteristics of the learning environment (e.g., high-quality instruction, cognitive activation, higher teacher qualification).

With regard to the relation between student background variables and academic achievement, the findings of the present study were in line with previous national and international findings (Boehm et al., 2016; Keller et al., 2014, 2016) that students' background characteristics such as gender, SES, language, and migration background are significantly related to academic achievement in different subjects. When including the control variables into the model to understand whether the moderator effect of school track in the relation between NFC and academic achievement remains significant, relations between NFC and academic achievement in French were no longer significant, while the relations for the other two domains did not change meaningfully. Academic achievement in French was also the only domain in which the direct effect of NFC on academic achievement was not significant in the intermediary track. The significant interaction between NFC and migration on academic achievement in French contributes to academic achievement in French behaving differently than academic achievement in German and Math.

This finding might be specific to the Luxembourgish educational system. Results from the Luxembourg School Monitoring Program (Martin et al., 2014) illustrate that while about 50% of secondary school students do not reach competency level 2 in Math and German, this is the case for 65% in French (Hornung et al., 2014). Also, within tracks, academic achievement in French follows a different pattern. In 2013, 52% and 59% of lowest track students remained below level 1 in Math and German respectively, while this was the case for 71% in French (Keller et al., 2014, pp. 66–67). The distribution of students across competency levels in the different tracks seems to indicate that students in the lowest and to a smaller degree in the intermediary track show less diverse competency profiles in French than in German and Math, while the student distribution across French competency levels in the highest track is more diverse. French has furthermore been identified as the strongest predictor of track allocation among school grades in Math, German and French (Klapproth et al., 2013). Considering these findings, the nonsignificant track difference between NFC and academic achievement in French may be unique to the Luxembourgish multilingual school system.

In sum, controlling for background variables only affected the relations between NFC and academic achievement in French but not in German and Math. The interaction effects between NFC and student background variables were nonsignificant in the relation between NFC and academic achievement in German and Math across all three tracks. Findings for academic achievement in French seem to be highly specific for Luxembourg. These findings seem to indicate that the relation between NFC and academic achievement is not systematically influenced by student background characteristics.

4.3. Limitations and perspectives for future research

An important limitation of the present study lies in the fact that pre-track measures on academic achievement have not been included and that the effect of school track on the relation between NFC and academic achievement is possibly confounded with students' academic achievement before track allocation. In order to address this limitation, future studies should include pre-track measures on academic achievement in their analyses (e.g., by calculating difference scores in academic achievement before and after students were allocated to a specific school track) with the aim of validating the results of the present study. Further studies are needed for formulating actual implications regarding the characteristics of school tracks and their impact on the relation between NFC and academic achievement.

A further limitation is that the data of the present study is cross-sectional. To better understand the development of NFC and how it relates to academic achievement at different stages of primary and secondary education, a longitudinal analysis would be recommended. Such an analysis could confirm the findings of previous cross-sectional studies in which the mean level of NFC was decreasing over grades, while the relation with academic achievement seemed to be growing more important in later school years (Keller et al., 2016; Luong et al., 2017).

The findings of the present study are a first indication that the characteristics of different learning environments (e.g., school tracks) interact with the relation between NFC and academic achievement. Further studies are needed that identify what specific characteristics of the learning environment are fostering or hampering a students' NFC and its impact on their academic achievement or vice versa (e.g., through classroom observations or self-reported student or teacher assessments). In our study, we assumed that higher tracks are characterized by higher levels of cognitive activation, higher task complexity and a higher teacher qualification regarding content knowledge. However, we based our assumptions on findings from countries with similar tracking systems while findings for Luxembourg are missing. Yet, such findings are needed to derive suggestions for the creation of learning environments that foster NFC in the educational setting of Luxembourg.

A further limitation of the present study lies in its one-country sample limiting potential generalizations of the findings. As the data has however been collected in the nationwide Luxembourg School Monitoring Program (Martin et al., 2014), the sample of the present study consists of a full cohort of 9th graders with regular educational pathways in secondary school and has thus to be understood as an encompassing and highly representative cross-sectional dataset. In addition, the tracked school system in Luxembourg is similar in its structure (e.g., early ability-based tracking to multiple tracks) to educational systems of other countries (e.g., Germany, Austria, Belgium, the Netherlands) and it would thus be interesting to analyze and potentially validate our findings in similar educational settings.

Furthermore, the present study has only analyzed the relation between NFC and academic achievement in three school subjects. Despite the fact that by analyzing three school subjects the study includes more subjects than other research in the field, it would be interesting to get a better understanding of how NFC relates to academic achievement in subjects such as science, history, geography or arts in which teaching approaches might be more divers and cognitively activating than in traditional subjects.

Whereas NFC has been established as an important construct in literature, it shows a number of important overlaps with other investment traits such as openness, intrinsic motivation, curiosity or mastery goal orientation (von Stumm & Ackerman, 2013) and in order to generate a better understanding of the construct's embedding alongside other personality and motivational constructs further research on similarities and differences are needed.

Finally, we did not control for all variables that might relate to academic achievement in general (e.g., other motivational constructs such as academic self-concept or academic interest as discussed in Keller et al., 2016; for an overview see Lipnevich et al., 2016) or to the relation between NFC and academic achievement in the different tracks (e.g., cognitive ability, personality traits or social constructs such as class climate and school satisfaction).

5. Conclusion

The present study underpins the importance of NFC in academic settings, while highlighting that the relation between NFC and academic achievement varies with track. The identification of track differences in the relation between NFC and academic achievement implies that the characteristics of higher school tracks are more likely to result in a stronger relation between NFC and academic achievement in secondary school. That is, the tendency to enjoy thinking and to invest onés cognitive resources into learning seems to be more beneficial in higher school tracks than in lower school tracks. Higher levels of cognitive activation, a higher frequency and more extensive assignments, academically challenging experiences and higher levels of teachers' subject-specific content knowledge characterizing higher school tracks in many countries may contribute to the relation between NFC and academic achievement being strongest in the highest and weakest in the lowest school track. Track differences between the lowest and the intermediary school track imply that learning environments with lower levels of cognitive activation, slow-paced and conceptually simplified instruction resulting in a more restricted access to knowledge might on the other hand hamper a positive relation between NFC and academic achievement. To allow all students irrespective of their track allocation to make use of their full academic potential, a better understanding of the potential impact of these characteristics on the development of NFC and the subsequent effect on academic achievement seems indispensable. Overall, the present study underpins the importance of NFC in the educational context by illustrating that NFC relates to academic achievement in the early years of secondary education, an educational setting which has been less addressed by previous research on NFC, while highlighting that this relation varies with the characteristics of different learning environments. The findings of the present study could thus pave the way for more in-depth studies on NFC in different learning environments. These studies could generate important knowledge on how to create school environments that actively foster NFC and provide starting-points for evidence-based policy making in countries with highly stratified educational systems and diverse student populations.

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Declaration of competing interest

None.

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Appendix A. NFC factor structure and measurement invariance

Before investigating the main research questions, analyses on the factor structure of NFC in the full sample and across school tracks were performed. With data gathered in a classroom context, the nested data structure was taken into consideration by the ANALYSIS = COMPLEX setting using class membership as cluster variable. The following three models were analyzed using confirmatory factor analysis: a) a single-factor model (1a), b) a correlated-factor model (1b) with the three factors *Think*, *Seek* and *Conquer*, and c) a nested-factor model (1c) with three uncorrelated latent variables, namely a general factor *Think* on which all 14 items are loading and two specific factors *Seek* and *Conquer* nested under the general factor and on which the items intended to measure the specific factors are loading, respectively (see Fig. A1).

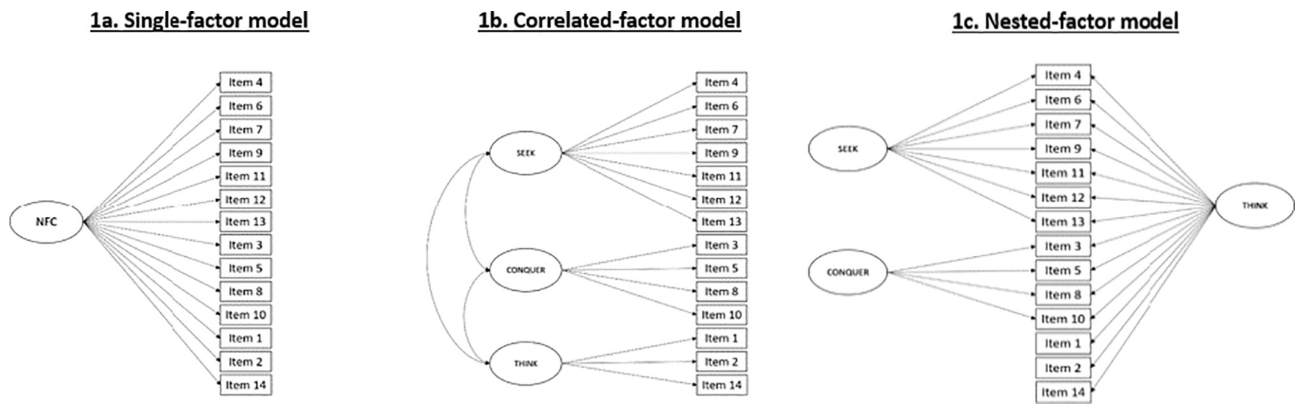

Fig. A1. Single-factor model (SF), correlated-factor model (CF) and nested-factor model analyzed for the NFC-KIDS scale.

With regard to factor structure of NFC in the full sample of 9th graders, the single-factor model yielded an unacceptable fit. While model fit considerably improved for the correlated-factor model, the nested-factor model displayed the best model fit when considering all criteria (see Table A1). Across school tracks, fit indices clearly illustrate that the single-factor model has an unacceptable fit. The correlated factor model shows, just like in the full sample, a considerably better fit with all indices indicating a good or at least acceptable fit. Results however clearly identified the nested-factor model as the best fitting model for all school tracks.

Table A1
Fit indices for single-factor, correlated factor and nested factor models in the full sample of 9th graders and across tracks.

Model		x^2 (df)	RMSEA	CFI	SRMR
SF		2701.952 (77)	0.101	0.859	0.066
CF		1126.007 (74)	0.065	0.944	0.046
NF		631.332 (66)	0.051	0.970	0.026
	Track				
SF	Highest	960.298 (77)	0.100	0.882	0.060
	Intermediary	1461.626 (77)	0.102	0.854	0.068
	Lowest	446.572 (77)	0.101	0.841	0.072
CF	Highest	464.758 (74)	0.068	0.948	0.044
	Intermediary	616.515 (74)	0.065	0.943	0.049
	Lowest	222.979 (74)	0.065	0.936	0.051
NF	Highest	278.881 (66)	0.053	0.972	0.026
	Intermediary	352.704 (66)	0.050	0.970	0.027
	Lowest	176.358 (66)	0.060	0.953	0.041

Note. SF = single-factor model. CF = correlated-factor model. NF = nested-factor model.

In a second step, measurement invariance of the nested-factor model across school tracks was established, allowing a comparison of latent factor means. All model fit indices for configural, metric and scalar invariance can be found in Table A2.

Table A2
Fit Indices for the configural, metric and scalar invariance models across tracks in Grade 9.

					Invariance (vs. configural)	
Model	x^2 (df)	RMSEA	CFI	SRMR	x^2 (df)	ΔCFI
Configural invariance	812.405*** (198)	0.053	0.968	0.029		
Metric invariance	900.288*** (242)	0.049	0.966	0.042	87.883 (44)	−0.002
Scalar invariance	989.866*** (264)	0.050	0.963	0.042	89.578 (22)	−0.003

Note. The analysis was done stepwise, progressing from the least restrictive model (configural invariance) to more restrictive models (metric invariance and scalar invariance). Measurement invariance is considered to be established, when Chen's (2007) cutoff of ΔCFI ≥ 0.01 as a critical value for non-invariance isn't surpassed.
*** $p \leq 0.001$.

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