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EMPIRICAL ARTICLE

CHILD DEVELOPMENT

The role of metacognitive competences in the development of school achievement among gifted adolescents

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Abstract

Gifted underachievers perform worse in school than would be expected based on their high intelligence. Possible causes for underachievement are low motivational dispositions (need for cognition) and metacognitive competences. This study tested the interplay of these variables longitudinally with gifted and non-gifted students from Germany (N = 341, 137 females) in Grades 6 (M = 12.02 years at t1) and 8 (M = 14.07 years). Declarative and procedural metacognitive competences were assessed in the domain of reading comprehension. Path analyses showed incremental effects of procedural metacognition over and above intelligence on the development of school achievement in gifted students (β = .139). Moreover, declarative metacognition and need for cognition interactively predicted procedural metacognition (β = .169), which mediated their effect on school achievement.

Intellectually gifted children and adolescents usually show an accelerated development of cognitive and verbal abilities and above average achievement in school. However, they differ little from non-gifted children of the same age group in areas such as personality or social and emotional development (Buch et al., 2006). Gifted adults are often professionally successful and rate their life satisfaction at the same levels as non-gifted adults (Rinn & Bishop, 2015; Wirthwein & Rost, 2011). They are also able to make an important contribution to society with their intellectual abilities (Wai, 2014).

Gifted underachievers show an exception to this generally positive development of gifted students. These students are characterized by high intellectual abilities paired with school achievement that is considerably below their cognitive potential (Reis & McCoach, 2000). Apart from negative school outcomes, underachievers often show negative attitudes toward learning and school, a negative self-concept, and emotional and behavioral problems (Sparfeldt et al., 2006). As adults, underachievers receive a lower average income and are at greater risk for health problems and lower subjective well-being compared to gifted achievers and non-gifted persons (Ferrer-Wreder et al., 2014). Given the negative effects of underachievement on the individual student and on society, it is important to explore risk factors for underachievement to create the basis for effective prevention programs. However, despite the theoretical and practical relevance of the problem, informative research on potential causes of underachievement is scarce. Most of the existing studies are based on cross-sectional designs and small samples, which are of little value for understanding how underachievement develops (McCoach & Siegle, 2003; White et al., 2018). In this study, we focus on a lack of metacognitive competences (paired with unfavorable motivational dispositions) as a risk factor of underachievement and test this explanation in a longitudinal design with secondary school students.

In the following, we first provide a brief overview of the definition and proposed explanations for underachievement among gifted students. We then focus on the impact of low metacognitive competences on school achievement as a potential risk factor for the development of gifted underachievement, especially in adolescents. This approach prepares the ground for this study that examined the role of metacognitive competences for underachievement in a longitudinal study.

Underachievement among gifted students

Giftedness is usually operationally defined as having an IQ of 130 or greater in a standardized intelligence test (Carman, 2013), which by definition applies to approximately 2% of the population. Underachievement is derived from this definition of giftedness as showing that (school) achievement is far below the expected levels based on the student's cognitive abilities (McCoach & Siegle, 2003). Estimations based on previous studies assume that around 12% of all gifted students become underachievers during their school career (e.g., Hanses & Rost, 1998). Underachievement also occurs in non-gifted students, but the research mainly focuses on gifted underachievement (Gilar-Corbi et al., 2019). Although most researchers would agree on this general description, the operational definition of underachievement in research is diverse (Reis & McCoach, 2000).

Operational definition of gifted underachievement

One common operationalization is a regression approach in which school achievement is regressed on general intelligence (Gilar-Corbi et al., 2019; Lau & Chan, 2001). Students whose school achievement deviates considerably in the negative direction from the expected school achievement based on their intelligence scores (e.g., 1 *SD*), are defined as being underachievers. Other approaches use cut-off scores such as school achievement beyond the 50th percentile compared to the same age group (e.g., Vlahovic-Stetic et al., 1999). When comparing different approaches, studies have found that nearly the same groups of students based on different selection criteria were defined as being gifted underachievers (Lau & Chan, 2001). Accordingly, the groups of underachievers identified by different selection criteria also showed comparable results on potential risk factors for a negative school outcome such as little knowledge of learning strategies and a low level of self-concept (Gilar-Corbi et al., 2019). Thus, different operationalizations of the discrepancy between cognitive abilities and school achievement in research on gifted underachievement do not seem to have led to different result patterns in the majority of cases.

Some studies that have investigated underachievement have used strict definitions of giftedness with an IQ of 130 or greater, whereas other studies have applied a more liberal criterion with an IQ of 120 or greater (e.g., Obergriesser & Stöger, 2015). As the study of Guldemond et al. (2007) indicated, students with an IQ between 120 and 130 were at the greatest risk for underachievement, whereas students with an IQ below 120 or above 130 managed school more successfully relative to their cognitive abilities. These results suggest that including students with an IQ of 120 or greater in the research of gifted underachievement is appropriate because these students seem to be most affected despite clearly showing above-average cognitive abilities.

The assessment of school achievement also varies between studies. To define underachievement, most studies have used a composite score of school grades of selected subjects such as language, mathematics, and social and natural sciences in different combinations (e.g., Gilar-Corbi et al., 2019; Preckel et al., 2006). Given that mathematics and language are the scholastic domains most closely related to general intelligence (Roth et al., 2015), they seem most appropriate to operationalize a discrepancy between actual school achievement and expected school achievement based on intelligence.

Preckel et al. (2006) noted that most studies use some sort of cut-off score to define underachievement. However, as cognitive abilities and school achievement represent continuous constructs, cut-off scores seem partly arbitrary. Instead, Preckel et al. (2006) favored a continuous approach that uses the residuals of a regression analysis of school achievement on intelligence as a continuous variable as an indicator of underachievement in students.

Causes of gifted underachievement

Prior research has proposed a multitude of individual, family- and school-related causes for the development of gifted underachievement (Baker et al., 1998; Reis & McCoach, 2000). Baker et al. (1998) reported several individual characteristics (which are the focus of our study) as risk factors such as motivational problems, low metacognitive competences, and social and emotional difficulties. Several theoretical approaches have been proposed to account for these findings and to further specify possible mechanisms that explain how intellectual abilities lead to high academic achievement in gifted students and thus identify characteristics that might be risk factors for the development of gifted underachievement. The Munich Model of Giftedness (Heller, 1992) provides such a theoretical explanation. The model assumes that non-cognitive characteristics (test anxiety, coping with stress, control expectations, achievement motivation, and working and learning strategies) and environmental conditions (e.g., home learning environment and classroom climate) moderate the effects of intellectual abilities on achievement and are thus important requirements for the translation of giftedness into exceptional achievement. The authors of the Talent Development in Achievement Domains Model (Preckel et al., 2020) presented a similar argument, emphasizing the importance of different non-cognitive competences at different developmental levels. Preckel et al. (2020) assumed that in the process of becoming an expert in a certain achievement domain, students master consecutive age-dependent developmental levels. High general cognitive abilities are the most important predictor of later achievement for earlier levels, whereas non-cognitive competences become more relevant for later levels. During secondary school, adolescents need increasingly more metacognitive competences for advancement in the chosen domain because the requirements for self-regulated learning rise with expertise level and age. When students specialize in an achievement domain, they must plan, monitor, and regulate their learning activities, for example, research information or plan and structure a class presentation. The same requirement applies to students who wish to improve their school achievement in secondary education.

The theoretical models reviewed above suggest that deficits in metacognitive competences might negatively affect the development of gifted underachievement in late childhood and adolescence. However, the plausibility of this proposal notwithstanding, the literature lacks quantitative longitudinal studies systematically comparing the development of groups of achievers and underachievers. Moreover, as a general concern, most longitudinal studies on underachievement have suffered from very small sample sizes (Steenbergen-Hu et al., 2020; White et al., 2018).

Low metacognitive competences as risk factor for gifted underachievement

The term metacognition has usually been broadly defined and includes all cognitions about cognitions (Flavell, 1979). Originally, the term referred to memory research, for example, judgments of learning in memorizing word lists. Subsequently, the concept was extended to other domains such as reading comprehension.

Structure of metacognitive competences

Metacognitive competences can be subdivided into declarative metacognitive knowledge and procedural metacognitive competences (e.g., Schneider & Löffler, 2016). Declarative metacognitive knowledge includes general knowledge about the influence of person, content, and strategy variables on learning processes (Flavell & Wellman, 1977). Procedural metacognitive competences refer to metacognitive activities while working on a specific task. They are further differentiated into monitoring and control processes. Monitoring involves the surveillance of one's current learning process, for example, predicting one's performance on a later test, whereas control refers to the regulation of the learning process, for example, allocating more study time to difficult text passages (Nelson & Narens, 1990, 1994).

Declarative metacognitive knowledge is often assessed via questionnaires (e.g., Edossa et al., 2018). Studies have found that declarative metacognitive knowledge about reading predicted the further development of reading comprehension in late elementary and secondary school to a small but significant degree (Edossa et al., 2018; van Kraayenoord & Schneider, 1999). Procedural metacognitive competences are always assessed in a specific achievement domain such as reading comprehension (van der Stel & Veenman, 2014). In the research of procedural metacognitive competences, offline and online measures are differentiated (Veenman et al., 2014). Offline measures refer to students' responses before or after completing a specific task. An example would be ratings of comprehension after reading a text. Online measures detect metacognitive processes during task completion, for example, recording eye movements or reading times. Meta-analyses have shown that procedural metacognitive competences had a small to moderate incremental effect on achievement performance apart from general cognitive abilities (Dent & Koenka, 2016; Ohtani & Hisasaka, 2018). The results of these studies indicated that online measures are more closely related to achievement than offline measures (Ohtani & Hisasaka, 2018). In addition, there might be a developmental effect. Procedural metacognitive competences seem to benefit school achievement, especially in secondary school (Dent & Koenka, 2016).

Measurement of metacognitive competences in reading research

In this study, we focus on metacognitive competences during reading comprehension given that reading comprehension is an important prerequisite for school success in secondary school (e.g., Savolainen et al., 2008). Reading comprehension, especially of expository texts, is not only relevant for language classes but also for learning processes in other school subjects such as mathematics, science, and social studies (e.g., Korhonen et al., 2012). In elementary school, teachers explain every new content in detail and repeat it during class, whereas in secondary school, students are required to be more self-reliant. They are required to read text passages in books (e.g., original sources in history), restudy content only briefly introduced in classes (e.g., reread the explanation of a mathematical proof in their schoolbooks), and review information they had not fully understood in class.

In the research on reading comprehension, the inconsistency paradigm is often applied as a measure of offline and online procedural metacognitive competences (e.g., Baker & Anderson, 1982; Hacker, 1997; Helder et al., 2016; Zabrucky & Ratner, 1986). While reading a text, readers continuously build a coherent mental representation of the text content (Kintsch, 1998). Inconsistencies within a text, such as logical errors, interfere with the smooth construction of a reader's mental representation, which should trigger monitoring activities. These monitoring activities, in turn, can initiate effortful and time-consuming repair processes to resolve the inconsistency, such as lingering at inconsistent sentences or making regressions to earlier parts of the text. Offline measures of inconsistency monitoring require participants to specify whether an inconsistency occurs within a text, for example, by underlining the inconsistency. In contrast, online measures compare reading times for inconsistent and consistent target sentences (e.g., Baker & Anderson, 1982; Helder et al., 2016; Zabrucky & Ratner, 1986).

Most studies using the inconsistency paradigm are based on narrative texts (e.g., Helder et al., 2016; van der Schoot et al., 2012). However, Zabrucky and Ratner (1992) found that younger adolescents have more difficulty detecting inconsistencies in expository compared to narrative texts. In contrast to narrative texts, expository texts vary in structure and require proficient language skills because they consist of no plot to which the reader can connect everyday experiences or a protagonist with which the reader can identify. It is thus considered more demanding on readers to comprehend expository compared to narrative texts (Mar et al., 2021). The comprehension of expository texts is especially important for school achievement and learning success (Savolainen et al., 2008). The detection of inconsistencies in expository texts has been shown to explain differences in reading comprehension abilities in students regardless of their intelligence (Soto et al., 2020). Thus, this study focused on expository texts to examine the relevance of the ability to detect inconsistencies for school achievement.

Research using the inconsistency paradigm also indicates that offline and online measures might represent different aspects of metacognitive monitoring. Good and poor readers perform similarly well on online measures, whereas poor readers seem to exhibit more problems than good readers when asked to report inconsistencies after reading (Baker & Anderson, 1982; Helder et al., 2016; Zabrucky & Ratner, 1992). Ehrlich et al. (1999) showed that poor readers performed equally well as good readers in detecting inconsistencies online but failed to show self-regulative activities like rereading text passages. Good readers reread difficult text passages more frequently during reading (Zargar et al., 2019).

Metacognitive competences in gifted students

To the best of our knowledge, no research exists comparing metacognitive competences of gifted and non-gifted students in reading comprehension. However, studies on metacognitive competences in memory research have found differences between the two groups. These findings indicate that declarative metacognitive knowledge is associated with cognitive abilities as shown by gifted students exhibiting a greater knowledge about learning strategies and applying them more aptly in learning processes than non-gifted students, at least until late elementary school (Carr et al., 1996; Chan, 1996; Schwanenflugel et al., 1997). In adolescence, these differences might diminish because ceiling effects occur in declarative metacognitive knowledge during the course of elementary school (Alexander & Schwanenflugel, 1996). In contrast, most studies do not support a general superiority of gifted over non-gifted students in procedural metacognitive competences. Bouffard-Bouchard et al. (1993) found that gifted and non-gifted students applied learning strategies equally often, but gifted students used the strategies more effectively, which led to a greater learning success. In contrast to this finding, Carr et al. (1996) and Alexander et al. (1995) reported no differences in monitoring competences between gifted students and non-gifted students. They argued that procedural metacognitive competences bear relatively independent from general cognitive abilities and are thus an incremental predictor of achievement.

Very few studies have compared underachieving gifted students to achieving gifted students on metacognitive competences. Yet, this research supports the idea that metacognitive competences are to some degree independent of cognitive abilities. Baker et al. (1998) found that in Grades 4–8 the individual organization of learning processes, such as the allocation of study time, was the single best predictor of gifted underachievement in a model that included individual, family, and school characteristics as predictors. Likewise, Dittrich (2014) identified difficulties with organizational (e.g., planning homework) and learning skills and learning strategies (e.g., taking notes) as predictors of the downgrading of students within the first 3 years of the academic track in Dutch secondary schools. In a questionnaire study, gifted underachievers reported significantly less self-regulatory strategies compared to gifted achievers (McCoach & Siegle, 2003). More precisely, underachievers indicated using less frequently text-reduction strategies like creating mind maps, underlining important phrases, taking notes, or writing summaries of learning texts (Obergriesser & Stöger, 2015). Gifted underachievers in middle school also benefited less from a strategy training than gifted achievers (Muir-Broaddus, 1995).

Studies including non-gifted underachievers indicated that a lack of learning strategies negatively affected school achievement (Castejón et al., 2016). Declarative metacognitive knowledge had an incremental effect on school achievement while controlling for cognitive abilities, which partly explained underachievement in adolescents regardless of their cognitive abilities (Veas et al., 2015). Therefore, the extent that metacognitive competences have an effect on school achievement specifically in gifted students and whether the lack of such competences plays a role in gifted underachievement and negative school outcomes remains unclear.

Metacognitive competences as mediator between motivational components and achievement

To date, the conditions that may lead to deficits in metacognitive competences in underachievers compared to achievers remain unclear. An explanation might, in part, lie within metacognitive activities being exertive and requiring purposeful efforts by the students. Thus, motivation is needed to acquire learning strategies and apply them to learning processes. Ford et al. (1998) found in undergraduate students that mastery orientation as a trait motivational component led to more metacognitive activities during practice tasks, which in turn led to superior demonstration of knowledge in a test afterward. A study by Veas et al. (2015) with secondary school students showed similar results. Metacognitive competences mediated the effects of motivational factors on school achievement beyond the effect of intellectual abilities.

A highly relevant factor for superior academic performance is need for cognition, which is defined as a person's tendency to engage in and enjoy abstract thinking and problem solving (Cacioppo & Petty, 1982) and could be interpreted as a general indicator of academic interest and learning motivation. A high need for cognition potentially leads to more intellectual investment when working on cognitively demanding tasks. Meta-analytic findings on intellectual investment indicate significant correlations of need for cognition with intelligence and with academic performance (von Stumm & Ackermann, 2013). Need for cognition as an indicator of intellectual investment adds a motivational component to the concept of giftedness. Findings suggest that gifted achievers usually exhibit a greater need for cognition than non-gifted students and that need for cognition is positively correlated with complex problem solving (Rudolph et al., 2018). Gifted underachievers, in contrast, exhibit lower motivation and set themselves less ambitious learning goals (e.g., Figg et al., 2012; McCoach & Siegle, 2003; see also White et al., 2018). Research has indicated that a low need for cognition was the largest predictor of underachievement in an investigation of various non-cognitive traits such as fear of failure, conscientiousness, and achievement motivation (Preckel et al., 2006). In sum, a lack of need for cognition as an indicator of trait motivational components and intellectual investment might partly explain why gifted underachievers often exhibit less metacognitive strategy use than gifted achievers because the use of metacognitive strategies is an active and effortful cognitive process.

Rationale of the present study

In this study, we investigated the influence of metacognitive competences on the development of school achievement in gifted and non-gifted adolescents with a longitudinal design (two measurement points nearly one school year apart), focusing on the role of metacognitive competences in explaining gifted underachievement in secondary school. We therefore examined school achievement (reading and arithmetic performance) and metacognitive competences of gifted and non-gifted students. The Talent Development in Achievement Domains Model (Preckel et al., 2020) suggests that at the beginning of school, general cognitive abilities are most relevant for performance, whereas in secondary school, additional characteristics such as metacognitive and self-regulatory competences as well as interest and motivation become more important for excelling in a domain. In this study, we examined students in Grades 6 and 8 of the German academic track secondary school system. These grade levels are shortly after the transition from elementary to secondary school and thus appear to be especially critical for the development of underachievement in gifted students.

The review of previous research indicates that metacognitive competences are a relevant predictor of school achievement in adolescents regardless of their cognitive abilities (Edossa et al., 2018). Procedural metacognitive competences especially seem to have an incremental effect on the development of different academic domains in secondary school apart from previous knowledge or cognitive abilities (Ohtani & Hisasaka, 2018). In this study, we focused on procedural metacognitive competences in the domain of reading comprehension of expository texts as an important prerequisite of school achievement in secondary school, not only in language classes but also in various other school subjects such as mathematics, science, and social studies (Savolainen et al., 2008).

Results of studies using the inconsistency paradigm to investigate procedural metacognitive processes during reading comprehension indicate that offline measures, such as the explicit naming of a detected inconsistency, pose a greater challenge on students than online measures such as a slow-down of reading time in inconsistent sentences (Helder et al., 2016; Zabrucky & Ratner, 1992). Thus, offline measures seem to be more sensitive in measuring metacognitive monitoring, especially in the upper performance range.

Declarative metacognitive competences also show an effect on reading achievement in adolescents, although the effect seems smaller than the effect of procedural metacognitive competences (Alexander & Schwanenflugel, 1996). Finally, studies with gifted students and especially with gifted underachievers suggest that a lack of metacognitive competences could also cause or increase the development of gifted underachievement (Baker et al., 1998; Obergriesser & Stöger, 2015).

The main focus of this study lies on metacognitive competences as a risk factor for gifted underachievement. Accordingly, we longitudinally investigated the role of declarative and procedural metacognitive competences on the development of school achievement of gifted adolescents. In addition, motivational trait factors such as a low need for cognition are often discussed as a possible cause for low school achievement of gifted students (Preckel et al., 2006). We assumed that procedural metacognitive competences might (at least) partly mediate the influence of need for cognition and declarative metacognitive knowledge about learning strategies on school achievement in gifted students (Ford et al., 1998; Veas et al., 2015).

In our study, we addressed these research questions with regard to adolescents with an IQ of 120 or greater because these students carry the greatest risk of becoming an underachiever (Guldemond et al., 2007).

In summary, we tested the following confirmatory hypotheses for this study:

1. Online and offline procedural metacognitive competences predict the development of school achievement of adolescents regardless of their cognitive abilities and in addition to the effects of earlier school achievement and general cognitive abilities.
2. The effect of procedural metacognitive competences on the development of school achievement is greater in gifted than in non-gifted students. We tested this hypothesis using an offline measure of procedural metacognitive competences because we expected the offline measure to be more sensitive in the upper performance range than an online measure.
3. Procedural metacognitive competences mediate the effect of declarative metacognitive competences and need for cognition on the development of school achievement in gifted students.

Generally, we took a continuous approach to investigate underachievement in this study. Additionally, on an exploratory basis, we compared gifted underachievers to gifted achievers (underachievement vs. achievement as dichotomous variable) on metacognitive competences. For these analyses, we defined underachievers as students who were gifted (IQ ≥120) and yet achieved lower in school than expected (≥1 *SD*) based on their reading and arithmetic score (regression-based criterion).

METHODS

Power and required sample size

We conducted a power analysis with G*Power (Faul et al., 2009) for the two most complex hypotheses. We assumed a small size ($f^2 = .04$) for the incremental effect of metacognitive competences on school achievement above prior school achievement and intelligence in the overall sample (Hypothesis 1). A total sample size of 265 participants was needed to find this effect (at $\alpha = .05$ and $1 - \beta = .90$). We further assumed a small to medium effect size ($f^2 = .10$) for the incremental effect of the number of detected inconsistencies above prior school achievement in gifted students (Hypothesis 3). A sample size of 108 in the subsample of gifted students was needed to detect such an effect (at $\alpha = .05$ and $1 - \beta = .90$). The estimated required sample sizes should also ensure sufficient power for all other hypotheses, assuming small to medium effect sizes.

Participants

A sample of 341 adolescents (204 males, 137 females) participated in this longitudinal study with two measurement points. At the beginning of the study, all participants attended Grade 6 ($n = 169$; age: $M = 12.02$ years, $SD = 0.55$ years) or Grade 8 ($n = 172$; $M = 14.07$ years; $SD = 0.49$ years) of the German academic track secondary school system (Gymnasium; starting with Grade 5). All students mastered German at a native-speaker level. No information could be collected on the ethnicity of the participants because the permission to collect this information in German schools was not given. The participants attended 35 classes at nine different schools located in three federal states of Germany (Baden-Wuerttemberg, Bavaria, Hessen). Thirteen of these classes offered programs for only gifted students. The other classes included students of different ability levels.

To identify gifted students, we disregarded the schools' ability grouping (regular vs. gifted). Instead, the participants completed a standardized intelligence test (Prüfsystem für Schul-und Bildungsberatung für 6. bis 13. Klassen-revidierte Fassung [Testing system for school and educational counseling for Grades 6 to 13-revised version]-PSB-R 6–13; Horn et al., 2004). With a mean IQ of 114.97 ($SD = 12.04$), the participants in this study showed above-average cognitive abilities. We defined giftedness in this study in accordance with the results of Guldemond et al. (2007) as having an IQ ≥120, which corresponds to a percentile rank of 90. The mean IQ of the 129 gifted students was 127.02 ($SD = 6.47$), the mean IQ of the 196 non-gifted students was 107.03 ($SD = 7.33$) and significantly lower than that of the gifted students, $t(323) = -25.84$, $p < .001$, $d = 2.86$. Sixteen students did not take part in the intelligence test (for information about the handling of missing data, see section *Data Preparation and Analyses*). Note that the results of intelligence tests include a confidence interval such that the label (gifted or non-gifted) in rare individual cases might not be accurate, and thus intellectual abilities of a few students in this study might be over- or underrated.

Design

The study consisted of two measurement points. The first measurement point (t1) was in late spring in 2019 (with the participants attending Grade 6 or Grade 8). The second measurement point (t2) was 8.37 months later (*SD* = 1.42) in early spring in 2020 (with the participants attending Grade 7 or Grade 9, respectively). Only six of the nine schools could participate in t2 ($N_{t2} = 222$). German schools were required to close for longer periods because of the COVID-19 pandemic in 2020. Thus, completing the second part of the tests was not possible in all schools. The resulting dropout was completely at random with regard to all relevant measures of this study, which are listed in the section *Materials and Test Instruments.*

At both measurement points, the participants finished the required tasks on two consecutive school days. Trained student research assistants administered all tasks to groups of 10–20 students whose parents had signed a consent form before. At t1, the participants worked on the intelligence test, a reading test, an arithmetic test, a reading strategy test (declarative metacognitive knowledge), an inconsistency task, a calibration task (procedural metacognitive competences), and an updating task (executive functioning). They also responded to several questionnaires about personality characteristics. At t2, the participants repeated all tasks except for the intelligence test because intelligence is assumed to be quite stable in adolescents (Schneider et al., 2014). Additionally, the participants finished a working memory and a reading span task at t2. In the following section, we only address the tests and materials that were relevant for the research presented in this paper.

Materials and test instruments

Intelligence

To measure participants' intelligence, we applied the PSB-R 6–13 (Horn et al., 2004), which is a German-language intelligence test, based on Thurstone's multiple factor model of intelligence (Thurstone, 1931). The PSB-R 6–13 is a paper-and-pencil group test and takes about 50 min including instructions. The test consists of three subscales (verbal ability, reasoning, focused working) and a composite score. The Verbal Ability subscale comprises three subtests—vocabulary, word fluency, and word comparison. The Reasoning subscale comprises three subtests with number, letter, and figural sequences and a task of spatial thinking. The Focused Working subscale comprises two tasks of processing speed. In the sample of this study, Cronbach's α based on the nine subtests was .72, which is acceptable (Cronbach, 1951).

School achievement

To assess school achievement, the participants completed a reading comprehension test and an arithmetic test.

As an indicator of reading comprehension, we used the LGVT 5–12+ (Lesegeschwindigkeits- und -verständnistest für die Klassen 5–12 [Reading speed and comprehension test for Grades 5 to 12], Schneider et al., 2017). The LGVT 5–12+ measures text-level reading comprehension combined with reading speed. The participants read an expository text of 1989 words. Every few sentences a word was missing and the participants were prompted to underline the best fitting word out of three options. Participants' task was to complete as many items as possible within 6 min. For each correct item the participants received two points. For each incorrect item one point was deducted. In this study, the retest reliability (stability) of the LGVT 5-12+, reported for the sample of 209 children (aged 10.08–15.25 years at t1), was .79.

As an indicator of math achievement, we used the subtest KRW (Konventions- und Regelwissen [Conventions and rules knowledge] of the Deutscher Mathematiktest für neunte Klassen ([German mathematics test for ninth grade], Schmidt et al., 2012). The KRW consists of 50 arithmetic tasks with a number range of mostly 0–20. The participants' task was to answer as many items as possible within 3½ min. The test was designed to assess students in Grade 9, but Ennemoser et al. (2011) argued that the test is also suitable for Grades 5–8 to measure students' knowledge of arithmetic rules and its rapid application to routine tasks. The participants received one point for each correct item. The retest reliability reported for a sample of 205 students (aged 10.08–15.25 years at t1) was .83.

To create a composite score of school achievement, we *z*-standardized the scores of the LGVT 5–12+ and the KRW and averaged both for each measurement point.

Metacognitive competences

This study used two measures of metacognitive competences: a knowledge test of reading strategies (declarative metacognitive competences) and a task assessing monitoring and control processes during reading comprehension (procedural metacognitive competences).

To measure (conditional) knowledge about reading strategies, participants completed the WLST 7–12 (Würzburger Lesestrategie-Wissenstest für die Klassen 7–12 [Würzburg reading strategy knowledge test for Grades 7–12], Schlagmüller & Schneider, 2007). The WLST 7–12 is a situational judgment test that describes six scenarios. Participants' task is to rate the utility of a number of different reading strategies (e.g., look up unknown words, paraphrase sections) in each of the six scenarios.

The participants' ratings are scored by comparing them to normative ratings provided by experts. In the sample of this study, Cronbach's α was .80, which indicates a good internal consistency of the scale (Cronbach, 1951).

To measure procedural metacognitive competences, we created an error detection task based on the inconsistency-detection paradigm as suggested by Baker and Anderson (1982; see also Hacker, 1997; Helder et al., 2016). For the error detection task, participants read nine short expository texts (92–98 words) on the computer screen. The texts were based on articles from websites for children and were shortened and rewritten for the study. Each text described an action sequence, for example, a craft instruction or an explanation of how hiccups occur. A text example is available in the repository of the Open Science Framework (https://osf.io/2nfvg/?view_only=01e8f5ac21184bbba275a3bfecee6b34). We chose expository texts because they resemble learning requirements at school the most.

We created an inconsistent and a consistent version of each text. These versions were the same except for one word, which led to a logical contradiction in the inconsistent version. For example, a craft instruction described ways of how to fold a paper and then said it was now smaller (consistent version) or larger (inconsistent version) than before. No specific prior knowledge was necessary to complete the task because the information to detect the semantic inconsistencies was provided by the texts. The critical words that were different between consistent and inconsistent text versions were chosen such that they were familiar to young adolescents. According to the Childlex database (Heister et al., 2011), which provides frequencies of words in books for children and adolescents of certain ages, the frequencies of the words in the consistent and inconsistent text versions were comparable, $t(16) = -.02$, $p = .985$.

At the beginning of the task, the participants read a sample of inconsistent text so that they could adapt to the general procedure of the task at the computer screen. When they failed to detect the inconsistency, it was highlighted and explained to them to ensure that all participants understood the meaning of an inconsistency.

After the sample text, six texts (randomly selected for each participant) were presented in the inconsistent and three in the consistent version. The text order was also randomized for each participant. The sentences were presented successively on a computer screen with the remaining text masked (self-paced reading), so that we could measure the reading times for each sentence. To ensure that participants would read the texts, they were told that they would be required to provide a brief answer to a question about general text information (irrelevant for the inconsistency) after each text. Afterward, participants indicated whether there was an inconsistency in the text and, if so, in which sentence the inconsistency occurred.

First, we counted the number of detected inconsistencies as an offline indicator of procedural metacognitive competences. Second, we analyzed reading times on target sentences as an online indicator of procedural metacognitive competences. With the R package lme4 (Bates et al., 2015), we extracted the individual slopes of reading time for each participant from a linear mixed model. In the linear mixed model, reading times for the target sentences served as the criterion. There were no fixed effects, but we estimated the model with random intercepts of participants and texts and random slopes of participants for the consistency of the target sentences. The random slope for each participant represented the slow-down in reading time for inconsistent target sentences compared to consistent target sentences. The random intercept represented the individual reading speed of each participant. Greater intercepts indicated that the participants put more time in reading the target sentences.

Need for cognition

Need for cognition was assessed with a 13-item shortened version of the 19-item questionnaire proposed by Preckel (2014). The participants read statements like *I like situations in which I can achieve something with careful thinking* and rated the extent that the statements applied to themselves on a 5-point scale. The questionnaire is designed for children and adolescents aged 10 years or older. In the sample of this study, Cronbach's α was .87, which indicates a good internal consistency (Cronbach, 1951). For the following analyses, we used the aggregated sum of all 13 items.

Data preparation and analyses

We applied path analyses with Mplus 7 (Muthen & Muthen, 2012) to investigate the longitudinal structure of relations between metacognitive competences and school achievement. All variables were included as manifest variables.

To examine the role of metacognitive competences for the development of gifted underachievement, we used path analyses with school achievement at t2 as criterion and school achievement at t1 and intelligence as predictors. With this procedure, we could investigate whether metacognitive competences could explain variance in school achievement at t2 in gifted students after controlling for prior achievement and intelligence. Thus, we chose a continuous approach in defining underachievement. That is, the more students underachieve, the more negatively their school achievement develops despite their high cognitive abilities.

To handle missing data, we used full information maximum likelihood estimation because the missings in this study were at random. This procedure, instead of imputing missing values, includes all available information to estimate population parameters (e.g., Enders, 2001). We considered the hierarchical structure of our data (students in school classes) by using the Complex function type and the MLR estimator (maximum likelihood estimation with robust standard errors) in Mplus. This procedure is a model-based aggregated approach, which does not explicitly model parameters and variance components on each level but adjusts the standard errors of the estimated values for a clustered sample (independence of clusters but not of single observations; Muthén & Satorra, 1995).

RESULTS

An overview of the descriptive statistics is shown in Table 1. Bivariate correlations for the overall sample, gifted and non-gifted students, and the complete data set and analyses scripts are available in the repository of the Open Science Framework (https://osf.io/2nfvg/?view_only=01e8f5ac21184bbba275a3bfecee6b34). All significance tests were based on a Type I error probability of .05 (two-tailed tests) unless stated otherwise. In the following path analyses, only standardized coefficients are reported.

Effect of metacognitive competences on school achievement in the total sample

To investigate the influence of procedural metacognitive competences on the development of school achievement (Hypothesis 1) over cognitive abilities, we used school achievement at t1 as a predictor of school achievement at t2 in a path analysis. Additionally, we included other potentially relevant variables (intelligence, grade level, and the exact time span between the measurement points). Only school achievement at t1 ($\beta = .786$, $p < .001$) and intelligence ($\beta = .121$, $p < .001$) were significant predictors. Consequently, we omitted grade and time span between the measurement points in further analyses.

The number of detected inconsistencies and the individual reading times of the participants (individual intercepts) were moderately correlated with each other ($r = .279$, $p < .001$). Participants showing longer reading times detected more inconsistencies. The number of detected inconsistencies and the individual slopes in reading time were also moderately correlated ($r = .227$, $p < .001$). Participants who detected more inconsistencies showed greater differences in reading time between consistent and inconsistent target sentences. The individual slopes of reading time and the participants' intercepts were not significantly correlated ($r = -.031$, $p = .685$).

The number of detected inconsistencies (offline measure) had no incremental effect on school achievement in the overall sample ($\beta = .031$, $p = .350$; see Figure 1a). The explained variance of school achievement at t2 in this model was 73.9%.

In the same model, the individual slopes in reading time (online measure) had a small but significant effect on school achievement at t2 alongside school achievement at t1 and intelligence ($\beta = .073$, $p = .030$; one-tailed-test; Figure 1b). Participants with longer reading times for inconsistent compared to consistent target sentences in the inconsistency task showed greater gains in school

TABLE 1 Means and standard deviations of study variables at t1 and t2 for the overall sample, the gifted subsample, and the non-gifted subsample

	Overall sample	Gifted subsample	Non-gifted subsample
IQ	114.97 (12.04) $N = 325$	127.02 (6.47) $n = 129$	107.03 (7.33) $n = 196$
Reading comprehension t1	43.74 (14.90) $N = 324$	48.67 (16.01) $n = 129$	40.49 (13.17) $n = 195$
Reading comprehension t2	46.24 (14.37) $N = 219$	50.59 (14.58) $n = 95$	42.97 (13.41) $n = 114$
Arithmetic competences t1	27.80 (10.50) $N = 316$	31.20 (11.04) $n = 124$	25.54 (9.60) $n = 185$
Arithmetic competences t2	32.98 (10.20) $N = 220$	36.16 (9.85) $n = 96$	30.80 (9.90) $n = 114$
Declarative knowledge of reading strategies	59.54 (10.30) $N = 314$	61.40 (9.40) $n = 127$	58.27 (10.70) $n = 187$
Number of detected inconsistencies	2.59 (1.56) $N = 297$	2.73 (1.62) $n = 120$	2.45 (1.53) $n = 168$
Individual slopes in the inconsistency task	0.005 (0.013) $N = 301$	0.005 (0.012) $n = 122$	0.004 (0.013) $n = 170$
Need for cognition	43.72 (9.35) $N = 272$	44.50 (10.06) $n = 101$	43.22 (9.02) $n = 162$

Note: IQ (PSB-R), reading comprehension (LGVT 5–12+), arithmetic competences (KRW), declarative knowledge of reading strategies (WLST 7–12), number of detected inconsistencies and individual slopes (self-constructed inconsistency task), need for cognition (Preckel et al., 2006). Sample sizes differ because of missing values.

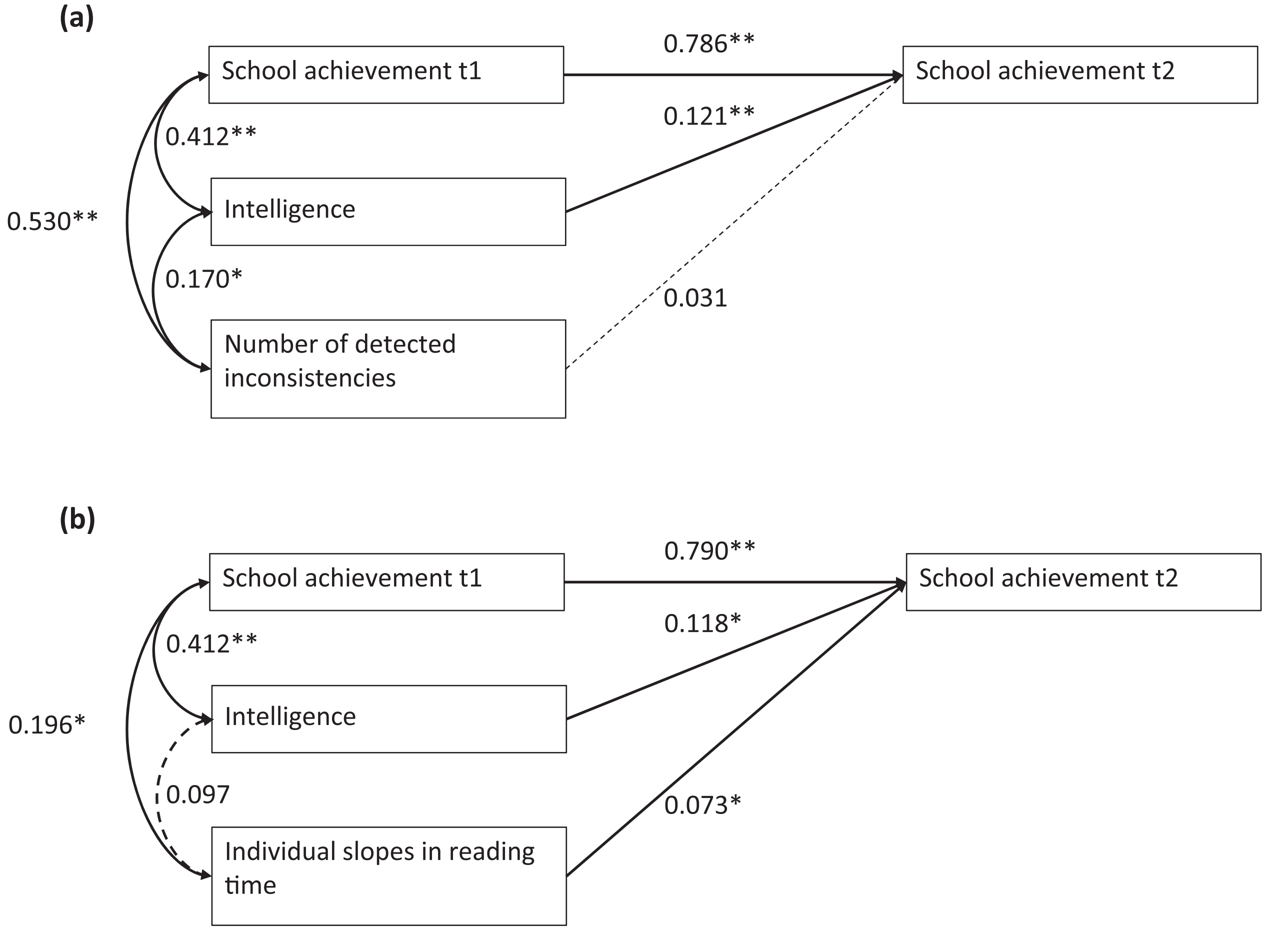

FIGURE 1 Path models with standardized effects of school achievement at t1, IQ, and number of correctly detected inconsistencies (a) or individual slopes in reading time (b) on school achievement at t2 in the overall sample (N = 341). *p < .05; **p < .01

achievement from t1 to t2. The explained variance of school achievement at t2 in this model was 74.5%.

A model that predicted reading comprehension only (instead of school achievement in general) yielded similar results. The number of detected inconsistencies affected the development of reading competences in the overall sample (β = .084, p = .044) to a small degree in addition to reading competences and intelligence at t1. However, the individual slopes in reading time were not significant predictors of reading competences at t2 (β = .048, p = .233). Note that the estimates are each just above or below the threshold of significance and the regression weights are relatively similar and comparable in the value derived from the model that predicted school achievement in general. The results of the complete model are shown in Figure A3 in the Appendix S1.

Differential effects of metacognitive competences on school achievement in gifted versus non-gifted students

We assumed different effects of offline procedural metacognitive competences in gifted students compared to non-gifted students (Hypothesis 2). To test potential differences in the association between metacognitive competences and school achievement between both groups, we applied a multiple-group comparison (Muthen & Muthen, 2012). The grouping variable was giftedness (IQ ≥120 vs. IQ <120). We tested whether a significant decline of the model fit would occur compared to the original model when the estimates of the effect of metacognitive competences on school achievement were constrained to be equal for both groups. Given the use of the MLR estimator in our analyses, we applied the χ^2-difference test as recommended by Satorra and Bentler (2001) to reveal significant differences of model fit between the original and the restricted model.

When we constrained the path from the number of detected inconsistencies to school achievement at t2 in the original model between gifted and non-gifted students to be equal, the model fit was significantly worse ($\Delta\chi^2(1) = 7.785$, p < .001). In the model for the non-gifted students, the path was near-zero and non-significant (β = −.042, p = .376), whereas in the model for gifted students the path was positive and significant (β = .133, p = .046). Thus, in gifted students, the number of detected inconsistencies had an incremental positive effect on the development of school achievement, whereas we found no effect in non-gifted students.

When we constrained the path from the individual slopes in reading time to school achievement at t2 between gifted and non-gifted students to be equal, no significant change occurred ($\Delta\chi^2(1) = 0.398$, $p = .528$). This result suggests that the individual slopes in reading time had a comparable effect on the development of school achievement in gifted and non-gifted students. In summary, the results for metacognitive competences indicate that the number of detected inconsistencies and the individual slopes in reading time incrementally predict the further development of school achievement in gifted students and that a different relevance of offline measure appears to exist for the prediction of school achievement in gifted compared to non-gifted students.

When focusing on differential effects in the prediction of reading competences only instead of school achievement in general, the fit of the model with the number of detected inconsistencies as predictor significantly decreased when we constrained the paths of the two groups to equality ($\Delta\chi^2(1) = 4.347$, $p = .037$). In the group of gifted students, the path from the number of detected inconsistencies on reading competences at t2 was significant ($\beta = .137$, $p = .008$), but in the group of non-gifted students, the same path was not significantly different from zero ($\beta = .023$, $p = .699$). The effect of the individual slopes in reading time on reading competences at t2 was not significantly different between the two groups ($\Delta\chi^2(1) = 1.824$, $p = .176$). The results are comparable to the results from the models that predicted school achievement in general.

Procedural metacognitive competences as a mediator for the effect of reading strategy knowledge and need for cognition on school achievement in gifted students

The results of the comparison between gifted and non-gifted students in associations between metacognitive competences and school achievement showed an incremental effect of the number of detected inconsistencies on school achievement at t2 for the gifted students and an effect of the individual slopes in reading time on school achievement at t2 for both groups. In the following, we examined whether procedural metacognitive competences mediated the effect of declarative metacognitive knowledge of reading strategies and need for cognition on school achievement in the gifted subsample (Hypothesis 3).

School achievement at t1 was moderately associated with declarative knowledge of reading strategies ($r = .268$, $p = .008$) and with need for cognition ($r = .145$, $p = .003$), and significantly related with the number of detected inconsistencies ($r = .507$, $p < .001$). As in the multiple-group comparison, the number of detected inconsistencies predicted school achievement at t2 ($\beta = .139$, $p = .040$, one-tailed) over the effect of school achievement at t1 ($\beta = .718$, $p < .001$) in the gifted sample (Figure 2a). According to our third hypothesis, declarative knowledge of reading strategies and need for cognition both are essential preconditions for the mastery of procedural metacognitive tasks. The interaction term of declarative knowledge of reading strategies and need for cognition showed a significant effect on the number of detected inconsistencies ($\beta = .169$, $p = .029$). The direct influence of declarative knowledge of reading strategies on the number of detected inconsistencies was also significant ($\beta = .203$, $p = .028$), whereas need for cognition did not explain directly differences in the number of detected inconsistencies. Declarative knowledge of reading strategies had a small indirect effect on school achievement at t2 via the number of detected inconsistencies ($\beta = .028$, $p = .033$). The indirect path from the interaction term to school achievement at t2 failed to reach significance ($\beta = .024$, $p = .068$). The direct paths from declarative metacognitive knowledge and need for cognition to school achievement at t2 were not significant (for all paths, $p > .05$).

The individual slopes in reading time were found to not significantly predict school achievement of gifted students at t2 ($\beta = .079$, $p = .167$) separately from school achievement at t1 ($\beta = .790$, $p < .001$), although the estimated effect size was comparable to the effect size in the overall sample (Figure 2b). The non-significant effect was likely due to the small sample size in the group of gifted children and the associated lower power. The interaction term of declarative knowledge of reading strategies and need for cognition showed a significant effect on the individual slopes in reading time ($\beta = .173$, $p = .050$, one-tailed test). Direct paths from declarative metacognitive knowledge and need for cognition to school achievement at t2 were not significant (for all paths, $p > .05$).

When focusing on the prediction of reading competences only instead of school achievement in general in the subsample of gifted students, the results indicate a comparable mediation effect. The number of detected inconsistencies significantly predicted reading competences at t2 ($\beta = .208$, $p = .007$) and was predicted by the interaction term of need for cognition and declarative knowledge of reading strategies ($\beta = .207$, $p = .018$). In addition, declarative knowledge of reading strategies directly affected the number of detected inconsistencies ($\beta = .206$, $p = .028$). The direct effects of declarative knowledge of reading strategies and need for cognition on reading competences at t2 were not significant. Similar to the model that predicted the school achievement in general, the effects of the individual slopes in reading time ($\beta = .104$, $p = .218$), declarative knowledge of reading strategies ($\beta = -.019$, $p = .865$), and need for cognition ($\beta = .004$, $p = .958$) on reading competences at t2 were not significant. Although the interaction term of declarative knowledge of reading strategies and need

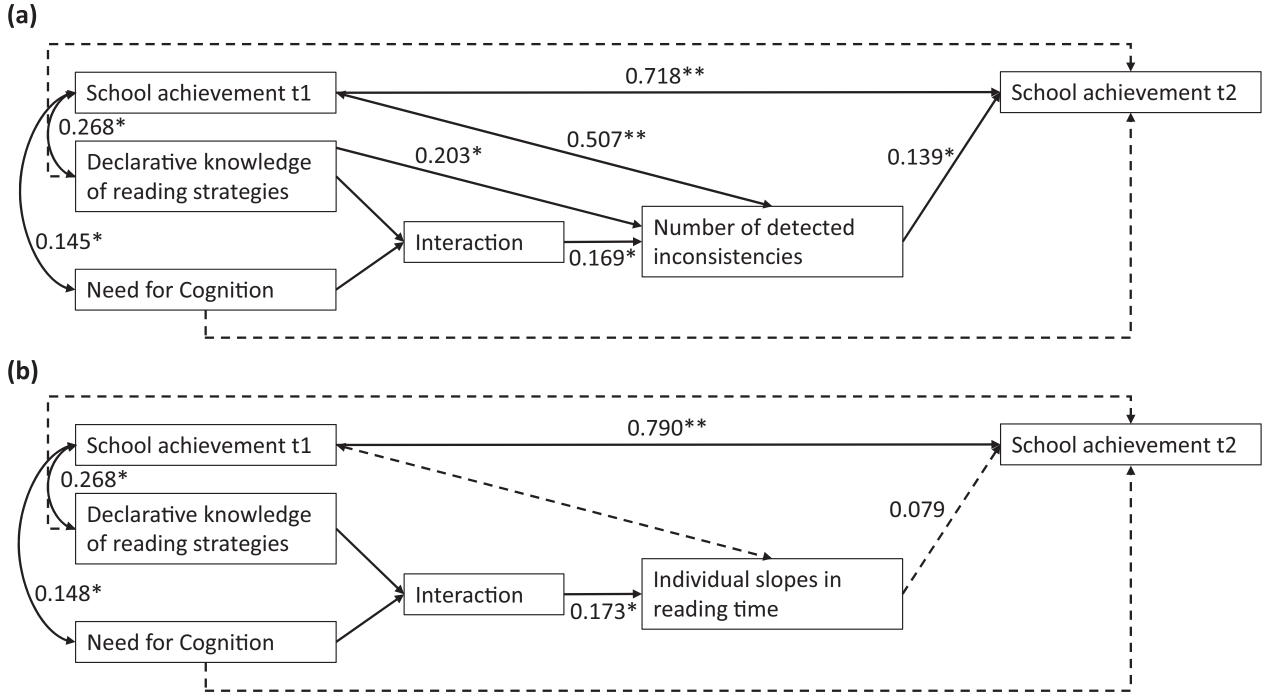

FIGURE 2 Path model with standardized effects depicting the mediation of declarative knowledge of reading strategies and need for cognition on school achievement via the number of detected inconsistencies (a) or via the individual slopes in reading time (b) on school achievement at t2 in the gifted subsample (n = 129). $^*p < .05$; $^{**}p < .01$

TABLE 2 Means and standard deviations of the number of detected inconsistencies and the individual slopes in non-gifted students, gifted achievers, and gifted underachievers at t1

	Non-gifted	Gifted achievers	Gifted underachievers
Number of detected inconsistencies	2.44 (1.53) *n* = 165	2.92 (1.56) *n* = 97	1.96 (1.67) *n* = 23
Individual slopes in reading time	0.004 (0.013) *n* = 167	0.006 (0.012) *n* = 98	0.003 (0.013) *n* = 24

Note: Sample sizes differ because of missing values.

for cognition was at a comparable level as in the model to predict school achievement in general, the path was on the threshold of significance (β = .177, p = .051, one-tailed test). The results of the complete model may be found in Figure A4 in the Appendix S1.

Exploratory analyses: Group comparisons between gifted achievers, gifted underachievers, and non-gifted students

To further explore differences between the groups of gifted achievers and underachievers, we conducted additional exploratory analyses with underachievement as a dichotomous variable. We defined underachievers as participants who were gifted (IQ ≥120) and at the same time achieved lower than expected based on their intelligence in the reading and arithmetic tests. To operationalize this definition of underachievers, we estimated a regression model with IQ as predictor and school achievement at t1 as criterion. Participants whose residuals were more than 1 *SD* below the expected values were categorized as underachievers (n = 23). Table 2 shows the descriptive statistics of the number of detected inconsistencies and the individual slopes in reading time for the three groups (non-gifted, gifted achievers, gifted underachievers).

A univariate ANOVA revealed significant differences between the groups in the number of detected inconsistencies (F(2, 282) = 4.84, p = .009, η^2 = .033). Tukey's post hoc test revealed that gifted achievers detected significantly more inconsistencies compared to non-gifted students (ΔM = 0.48, 95% CI [0.01, 0.95], p = .042) and compared to gifted underachievers (ΔM = −0.96, 95% CI [−1.81, −0.11], p = .022). No significant difference was found in the individual slopes in reading time in the inconsistency task between non-gifted students, gifted achievers, and gifted underachievers, F(2, 286) = 0.99, p = .371, although gifted underachievers descriptively showed the smallest individual slopes in reading time.

DISCUSSION

The purpose of this longitudinal study was to examine the extent and through which mechanisms metacognitive competences affect the development of school achievement in gifted adolescents and, thus, cause or increase the development of gifted underachievement. We analyzed all variables continuously via a regression approach. To address these research questions, we investigated 341 students from the academic track of the German secondary school system at two measurement points, measuring cognitive abilities, school achievement (reading and arithmetic competences), metacognitive competences, and non-cognitive characteristics. For assessing procedural metacognitive competences, we focused on reading comprehension of expository texts as an important prerequisite of learning in secondary school and used the inconsistency paradigm (see Baker & Anderson, 1982) to measure procedural metacognitive competences during reading. The inconsistency task offered an explicit offline measure (number of correctly detected inconsistencies) and an implicit online measure (slow-down in reading time for inconsistent compared to consistent target sentences). For assessing declarative metacognitive competences, we applied an objective test of reading strategies (Schlagmüller & Schneider, 2007).

Our study had three major findings. First, procedural metacognitive competences predicted the development of school achievement in the overall sample (gifted and non-gifted adolescents) when the online measure of procedural metacognitive competences was used (Hypothesis 1). Second, when comparing the associations between metacognitive competences and school achievement between gifted and non-gifted students, offline measures of procedural metacognitive competences moderately affected the development of school achievement in gifted students (Hypothesis 2) but not in non-gifted students. In the online measure, we found no differences between gifted and non-gifted students. Third, when analyzing the interplay between declarative and procedural metacognitive competences on the development of school achievement in gifted students, results showed that high declarative metacognitive knowledge in combination with a high need for cognition led to higher procedural metacognitive competences and thus to an improvement in school achievement over the course of one school year (Hypothesis 3).

Taken together, the findings indicate that low metacognitive competences might indeed be a risk factor for the development of gifted underachievement as shown by the incremental effect of metacognitive competences over general cognitive abilities and former school achievement on the development of school achievement, especially in gifted students. These results are in line with former cross-sectional research that suggests that gifted underachievers often exhibit lower skills in learning strategies and time management than gifted achievers (e.g., Baker et al., 1998; McCoach & Siegle, 2003). In addition, our results expand these former findings to a longitudinal perspective that allows depicting causal paths between different aspects of metacognitive competences and the development of school achievement. Our findings also support theoretical considerations of the Talent Development in Achievement Domains Model (Preckel et al., 2020) that assumes metacognitive competences to be especially important for gifted, adolescent students in secondary school.

In our regression analysis that assessed the predictive power of procedural metacognitive competences on the development of school achievement, we found differences between online and offline measures. Our findings indicate that offline measures seem to be good predictors only in gifted students but not in non-gifted students, whereas we found no differences between gifted and non-gifted students in the predictive value of online measures. In gifted students, the effect of offline measures on the development of school achievement was even greater than the effect of online measures. This finding corresponds with results that suggest that offline measures make greater demands on cognitive abilities (Baker & Anderson, 1982; Helder et al., 2016; Zabrucky & Ratner, 1992). On average, younger and older children and good and poor readers score equally well in online measures of metacognitive competences, but older children and good readers perform better than younger children and poor readers in offline measures. Given that gifted students are usually good readers, offline measures might differentiate better between different levels of metacognitive competences than online measures in gifted adolescents. Our explorative analyses, which compared distinct groups of gifted achievers to gifted underachievers on the basis of a cut-off value instead of a continuous approach, emphasize this point. Gifted underachievers exhibited significantly lower levels of offline procedural metacognitive competences, whereas we found no differences in online procedural metacognitive competences. This finding might be helpful for the development of a diagnostic screening instrument for gifted adolescents to assess certain factors that increase the risk of becoming an underachiever.

Former studies have considered low metacognitive competences and a lack of motivation and learning goals as independent causes of underachievement (e.g., Obergriesser & Stöger, 2015). In contrast to these studies, our results imply that the two constructs might act in concert in the development of underachievement. Differences in declarative metacognitive competences uniquely explained differences in procedural metacognitive competences in gifted students. However, we found that a combination of low declarative metacognitive competences and a low need for cognition additionally explained low procedural metacognitive competences, which in turn hindered the development of school achievement. These findings correspond to the results of Veas et al. (2015), who found similar patterns, with metacognitive competences mediating the influence of goal setting on learning success in non-gifted students. As an indicator of long-term motivation and interest, we used need for cognition (Preckel, 2014), which was the largest non-cognitive predictor of underachievement in the study by Preckel et al. (2006). In our analyses, need for cognition had no direct effect on school achievement but its effect was mediated via procedural metacognitive competences. In conclusion, gifted students apparently need declarative metacognitive knowledge (e.g., knowledge about reading strategies) and long-term aspirations to engage in effortful cognitive activities to master demands on procedural metacognitive competences (e.g., monitoring and controlling the process of reading comprehension and learning from texts), which consequently lead to better learning results.

For this study, we made methodological decisions that need to be kept in mind when comparing the present results to those of other studies. For example, we applied the inconsistency paradigm to measure procedural metacognitive competences in the domain of reading comprehension, which is an important prerequisite of school achievement in secondary school. The inconsistency paradigm is a well-established instrument in the research of (meta-)cognitive processes during reading comprehension (e.g., Baker & Anderson, 1982; Hacker, 1997), but it has not been widely used in the field of research on giftedness and underachievement. The latter research field has often investigated procedural metacognitive competences by assessing memory processes or by administering questionnaires (see Alexander et al., 1995). Previous research on differences in procedural metacognitive competences in memory tasks between gifted and non-gifted children have suggested that gifted children have no performance advantage over non-gifted children and that procedural metacognitive competences seem to be quite independent of intelligence (Alexander et al., 1995; Carr et al., 1996). Our findings partly contradict these results. Gifted achievers significantly outperformed non-gifted students in the offline measures of procedural metacognitive competences, probably because of methodological reasons. The aforementioned studies mainly used calibration tasks (i.e., retrospective judgments of learning) to measure procedural metacognitive competences. Soto et al. (2020) suggested that the performance in specific tasks that require monitoring, as it is required in an inconsistency task, might be more strongly associated with the achievement in reading comprehension than retrospective judgments of learning, which are used in calibration tasks.

For our study, we chose a reading comprehension task to measure procedural metacognitive competences because reading comprehension seemed to be especially relevant for achievement in secondary school. The findings of this study support this view. We conducted all analyses with school achievement in general and reading competences only as criterion. The results of both analyses were comparable, especially with regard to the influence of metacognitive competences and need for cognition on the scholastic development of gifted students. The pattern of results thus emphasizes the role of metacognitive competences in dealing with expository texts for school success. One critique of our method could be that the number of detected inconsistencies and the slow-down in reading time might reflect general reading competences. However, our results showed that the offline measure retrieved from the inconsistency task was moderately positively correlated with the intercept of reading times, suggesting that the more time students took for reading (and possibly monitoring the reading process) the more inconsistencies they detected. The online measure of metacognitive competences was not associated with the intercept of reading times, indicating that the slow-down in reading time for inconsistent compared to consistent target sentences was independent of general reading speed. Instead, slowing-down the reading process at relevant (in this case inconsistent) text parts seemed to serve a purpose compared to reading more slowly overall. Furthermore, in our longitudinal analyses, we controlled for former school achievement and thus for general reading abilities. Another concern of the inconsistency task might be that the extent that the task measures certain types of procedural metacognition, such as monitoring or control (Nelson & Narens, 1994), remains unclear. The number of detected inconsistencies clearly reflects the monitoring process during reading comprehension because the students were asked to report detected inconsistencies after reading, but the slope of reading times between inconsistent and consistent text provides little information of the extent that the measure captures monitoring or control processes. The slow-down in reading time while reading an inconsistent target sentence might reflect the monitoring of the construction of a mental representation of the text content (Kintsch, 1998), which leads to a slow-down in reading difficult text passages, but it might also partly reflect an attempt to control the comprehension process by rereading the sentence or specific words. Our research design did not address this distinction. More fine-grained process measures, for example, based on eye-tracking during reading, might be helpful to find an answer.

As in many studies in this field, our sample included students from classes dedicated to teaching gifted children. We opted to recruit these students to ensure having enough gifted students in the sample. We found gifted achievers and underachievers in regular classes and in these classes for gifted children. We also controlled for the clustering of students in school classes. Nevertheless, a disproportionate number of students with an above average need for cognition or school achievement could have participated in the study, which would have restricted the variance of these variables. Moreover, studies that examined the identification rate of gifted students indicate an error probability in correctly detecting gifted students with intelligence tests (Reis & McCoach, 2000), for example, the Wechsler Intelligence Scale for Children (4th ed.), which has a detection rate of 93% of all previously identified gifted students (Erden et al., 2020). When interpreting the results of this study, the reader should also note that all of the students participating in our study attended the academic track of the German secondary school system. Consequently, the overall achievement level in the sample was above average for their age cohort, and thus the actual differences between gifted and non-gifted students might have been underestimated in the study.

In conclusion, the results of this study offer a new perspective on the development of school achievement in gifted adolescents and on the causation of gifted underachievement. More precisely, this study extends former research of cross-sectional studies and theoretical considerations to a longitudinal design over the course of one school year and depicts the influence of different aspects of metacognitive competences on school achievement. Additionally, it applies methods of reading comprehension research to gifted students and thus reveals mechanisms by which low metacognitive competences might explain the development of gifted underachievement.

Further research that replicates correlational patterns found in our study with an experimental design would be beneficial. Based on the results of this study, a training of metacognitive competences could be developed for gifted underachievers as a means to close the gap with their achieving peers. A well-constructed and evaluated training would be a promising approach in preventing and treating underachievement given the few programs that exist (Steenbergen-Hu et al., 2020). Programs especially addressing secondary school students rather than younger children seem promising in preventing or reversing underachievement, as indicated by greater effect sizes for older age groups (Steenbergen-Hu et al., 2020). The need for metacognitive strategies is not required of gifted primary school students because learning is often easy for them. As our results suggest, a combination of declarative (direct instruction) and procedural (exercises) elements seems especially promising in a metacognitive training. Interventions to increase the knowledge and application of learning strategies for primary school students have been found to be effective (Obergriesser & Stöger, 2015). Thus, a similar approach in promoting metacognitive strategies also seems promising. In addition, a training to promote metacognitive strategies in secondary school would be expected to show transfer effects on the development of school achievement because the need for effective metacognitive strategies to improve school achievement is higher in older students compared to primary school students. The effect might also increase the students' training motivation. Moreover, research using eye movement to track the reading processes might help in further investigating the role of the slopes in reading time between consistent and inconsistent sentences in procedural metacognitive processes. Finally, the Talent Development in Achievement Domains Model (Preckel et al., 2020) suggests different individual characteristics and environmental factors that influence the emergence of excellent performance in different achievement domains at different periods in life. Investigating metacognitive competences in various achievement domains would be informative to further learn the extent and optimum age that metacognitive competences might be important for the prediction of achievement.

DATA AVAILABILITY STATEMENT

Testing materials are available from the first and the second author upon request. The complete data set and analysis scripts are available in the repository of the Open Science Framework (OSF) (https://osf.io/2nfvg/?view_only=01e8f5ac21184bbba275a3bfecee6b34).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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