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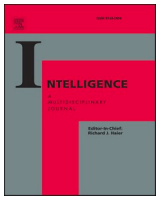

How socioeconomic status affects a child's education – Investigating objective and subjective factors involved in shaping educational success in Germany

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ABSTRACT

Differences in educational trajectories between social backgrounds can only be partially explained by differences in cognitive abilities and are therefore considered educational inequalities. In this study, multiple constructs involved in the prediction of educational success were investigated in a joint approach to specify their unique contributions and to identify mechanisms associated with how socioeconomic status (SES) influences education. Multiple regression analyses were conducted on $N = 2273$ children (aged 10 to 12). The effect of SES on educational success was found to function via two mechanisms: First, the effect of school grades and home environment on the assignment to secondary school was moderated by SES showing stronger influence at higher SES levels. In contrast, being conscientious exerted a stronger influence for low SES children. Second, high SES children were more likely to display characteristics that positively affected their academic performance (e.g., higher self-perceived ability, educational aspiration, cognitive abilities). Overall, the disadvantage of children with low SES can be explained by the central findings that (1) school grades played a lesser role for low SES children in their recommendation for further educational paths after primary school, and (2) high SES children showed higher self-perceived abilities and higher educational aspirations unrelated to their cognitive abilities which was associated with higher educational success. Why these mechanisms occur and where they originate should be further investigated considering additional factors.

1. Introduction

1.1. The influence of cognitive abilities and socioeconomic status on educational success

Cognitive abilities and parental socioeconomic status (SES) are both major factors in predicting educational trajectories including school performance and educational success. The main conclusions from an extensive body of research are (1) Children who grew up in a household with higher SES ($\bar{r} = 0.25$) and children with higher cognitive abilities ($\bar{r} = 0.53$) show better school performance within a certain school type and are more likely to receive an educational recommendation to attend a higher secondary school type than children with lower social status or lower cognitive abilities (Deary et al., 2007; Ditton et al., 2005; Harwell et al., 2017; Kriegbaum et al., 2018; OECD, 2018; Roth et al., 2015; Sirin, 2005; White, 1982). (2) The effect of SES on school performance can only partly be explained by differences in children's cognitive abilities between families with different SES (Bukodi et al., 2014; Gil-Hernández, 2019; Paulus et al., 2021; von Stumm, 2017). (3) Even when controlling for children's cognitive abilities, children with higher SES still achieve better school grades, more often receive a recommendation for as well as attend upper secondary school compared to children with lower SES (Arnold et al., 2007; Gil-Hernández, 2019; von Stumm, 2017).

While the direct effect of cognitive abilities on educational success is plausible, the unique and remaining effect of parental SES on educational success independent of cognitive abilities is still not fully understood. In fact, the independent effect of SES on children's academic chances and actual performances could be interpreted as an inequality in educational opportunities. It is possible that high SES parents are more likely to support a child's academic development and that parental and child behaviours, resources, and home environment differ across SES backgrounds, contributing to differences in educational success. This

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approach is e.g. reflected in the family process model (Davis-Kean, 2005; Yeung et al., 2002). This model assumes that parental SES impacts parental behaviour as well as a child's achievement, and that the influence of SES on a child's achievement is additionally mediated by this parental behaviour (Davis-Kean, 2005). Furthermore, the influence of educationally relevant constructs on educational success could be moderated by SES (see Fig. 1). On the one hand, the effect could be amplified so that high SES children benefit to a greater extent (Matthew effect hypothesis), on the other hand, low SES children could profit more from the prevalence of an educationally beneficial construct (resource substitution hypothesis) (Damian et al., 2015). The Matthew effect could, for example, be due to the finding that teachers evaluate families with low social status more adversely than families with high social status, resulting in these students achieving lower grades or recommendations in school (Batruch et al., 2023; Doyle et al., 2023; Olczyk et al., 2023).

Considering further that despite the predictive power of SES and cognitive abilities, more than half of the variation in educational success remains unexplained, other factors must also play an important role in influencing children's education. Despite the vast literature on factors influencing educational success, these are mostly investigated (1) individually or jointly with only one of the two predictors (SES or cognitive abilities) and (2) with respect to only one educational outcome. Consequently, potential overlapping effects cannot be identified. This study therefore analyses two educational outcomes (primary school grades and educational recommendation for secondary school) and multiple predictors including SES and cognitive abilities in a joint approach, while also focusing on two possible mechanisms (moderation and mediation). Although the two outcomes are related, for the allocation of educational recommendations, teachers should also consider e.g. learning development and behaviour in addition to school grades (Sekretariat der Ständigen Konferenz der Kultusminister, 2015), so different mechanisms may be at play here. This educational tracking of students is present in many educational systems and can take place at different ages and in different forms (between- vs. within-school tracking) (OECD, 2004). In Germany, students are already assessed at a rather young age (around age 10) for the type of secondary school and on the recommendation of teachers, which makes it possible to analyse these decision-making processes and possible influencing factors on educational tracks early. Moreover, examining additional factors that have already been shown – considered alone – to influence educational success seems to be a promising approach to better understand *how* educational inequalities develop. Here, aspects of *family characteristics* as well as *child characteristics* are outlined in more detail in the sections below.

1.2. Family characteristics influencing educational success in children

Regarding SES, financial resources in particular are seen as a benefit of higher SES. However, there are also softer characteristics of the family that are related to a child's education and can be influenced by SES (Garrett-Peters et al., 2016). These aspects may include parental characteristics and behaviours on the one hand and the family environment in which a child grows up on the other. It has been shown, for example, that parental educational aspirations or expectations are intertwined with SES and related to children's academic achievement as well as educational attainment ten years later (Benner et al., 2016; Boonk et al., 2018; Fan & Chen, 2001; Hill & Tyson, 2009; Tan et al., 2020). A higher SES appears to be associated with higher parental expectations for their children's educational attainment (Benner et al., 2016; Davis-Kean, 2005). Moreover, higher parental expectations seem to benefit children with a higher SES more than low SES children (Benner et al., 2016). High SES families are also more likely to display a better home literacy environment than families with low SES (van Steensel, 2006). Home literacy environment, reading at home, children's reading behaviour, and parental literacy activity with the child are related to better reading skills in children (Aikens & Barbarin, 2008; Boonk et al., 2018; Davis-Kean, 2005; Hemmerechts et al., 2017; van Bergen et al., 2017; van Steensel, 2006). Children's reading behaviour even appears to have a positive impact on their academic achievement (Davis-Kean, 2005). In addition to these more objective measures such as time spent reading, the subjective perception of the family environment can also contribute to educational success. Children who grow up in a household with a low quality of home environment are more likely to perform worse in school than children from a household with a high quality of home environment (Berry et al., 2016; Garrett-Peters et al., 2016; Hanscombe et al., 2011). A poor quality of home environment or a high level of household chaos is characterized by high levels of subjectively perceived noise, crowding, and traffic within the home (Matheny et al., 1995). In a home with high levels of household chaos, children more often live with low SES parents and show lower cognitive abilities (Deater-Deckard et al., 2009; Garrett-Peters et al., 2016; Hart et al., 2007; Johnson et al., 2008; Matheny et al., 1995; Petrill et al., 2004). Taken together, these family characteristics explained up to 31 % of the variance in educational success, with a correlation of $\bar{r} = 0.29$ for educational expectations (Benner et al., 2016), $\bar{r} = 0.18$ for literacy activity (van Bergen et al., 2017), and $r = 0.45$ for quality of home environment (Berry et al., 2016). So far, these characteristics have not been investigated together, so that their unique share of variance in explaining educational success is an open issue.

1.3. Child characteristics

While some of the well-known Big Five personality factors including

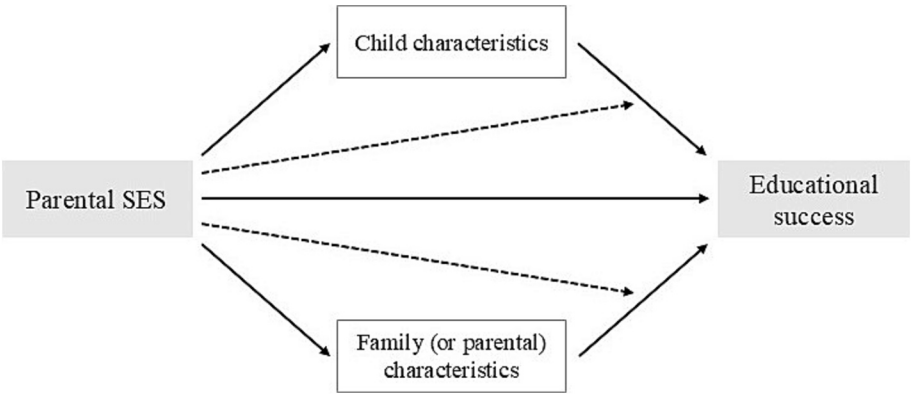

Fig. 1. Conceptual model depicting the mediating and moderating effects.

agreeableness or openness to experience are significantly related to educational success, conscientiousness has been found to be the strongest and most consistent predictor of academic achievement from primary school through university (Arbabi et al., 2015; Brandt et al., 2020; Dumfart & Neubauer, 2016; Laidra et al., 2007; O'Connor & Paunonen, 2007; Poropat, 2009). The magnitude of the relationship appears to be relatively constant from 4th grade onward (Laidra et al., 2007; Poropat, 2009) as well as largely independent of intelligence (Bergold & Steinmayr, 2018; Meyer et al., 2019; Poropat, 2009). Moreover, for school grades as well as standard achievement tests, self-control – as an aspect of self-regulation (Hofmann et al., 2012) – seems to be an important characteristic of a child throughout the school years (Duckworth & Seligman, 2005; Kuhnle et al., 2012; Normandeau & Guay, 1998; Zimmermann & Kitsantas, 2014). This effect persists when controlling for children's cognitive abilities (Duckworth et al., 2012; Hofer et al., 2012).

Motivational aspects of children that influence their school achievement include academic intrinsic motivation (Gottfried, 1990; Lepper et al., 2005; Taylor et al., 2014), learning goals (Hulleman et al., 2010; Miller et al., 1996; Schwinger et al., 2016; Steinmayr & Spinath, 2009), and self-perceived ability (Chamorro-Premuzic et al., 2010; Spinath et al., 2006). As intrinsic motivation increases, academic performance seems to improve throughout the educational pathway (Froiland & Worrell, 2016; Garon-Carrier et al., 2016; Komarraju et al., 2009), while the association with educational success tends to be stronger in high school and university compared to primary school (Taylor et al., 2014). Moreover, research has shown that academic intrinsic motivation, learning goals, and self-perceived ability influence school performance beyond general cognitive abilities and prior school performance (e.g., Gottfried, 1990; Kriegbaum et al., 2015; Marsh & Martin, 2011; Spinath et al., 2006; Steinmayr & Spinath, 2009). A child with high educational expectations or aspirations is also more likely to display a better math performance and achieve a higher level of educational attainment as well as a better grade point average (Beal & Crockett, 2010; Ou & Reynolds, 2008; Widlund et al., 2018). Children's expectations appear to mediate part of the effect that parental educational expectations show on a child's school performance (Pinquart & Ebeling, 2020) but these have hardly been analysed together systematically in their effect on educational success.

1.4. Influencing mechanisms

In this regard, it is also important to study the different, presumably complex ways in which these predictors may affect how SES influences educational success. On the one hand, children with high SES could exhibit more educationally beneficial behaviour or grow up in a more stimulating environment and therefore achieve more educational success (mediation). This educationally beneficial behaviour could be partly due to genetic differences according to SES, as children's cognitive abilities or personality, for example, are inherited to a significant extent (Haworth et al., 2010; Tan et al., 2024; Vukasović & Bratko, 2015). In addition, this genetic predisposition could be supported differently in families depending on SES or certain environments could occur more frequently, so that a more favourable environment in turn could have a direct or interactive positive effect on the development of a trait (gene-environment interplay) (Sauce & Matzel, 2018). The effect of these variables would be direct effects, as high SES children would perform better at school because they are more likely to show positive behaviour, e.g. a higher motivation or literacy activity. This could also be indicated by the finding that some of the factors are related to parental SES in addition to their effect on school performance. Longitudinal mediating effects have already been found for the constructs home learning environment (Joseph et al., 2024), home literacy environment (Aikens & Barbarin, 2008), parental expectations (Davis-Kean, 2005), cognitive abilities (Pearce et al., 2016), and self-regulation (Joseph et al., 2024). On the other hand, certain characteristics could pay off more strongly in high SES children (or negative characteristics less strongly), so that they perform better at school as a result (moderation). A high SES could compensate for factors that would have a negative impact on education, e.g., low cognitive abilities, so that these have less of an impact on educational outcomes than in children with a low SES. At the same time, this effect could indicate that low SES children can compensate for their low SES with positive characteristics, e.g. high cognitive abilities (negative interaction). Or a high SES could enhance the effect of a factor that promotes education, so that this factor pays off more for high SES children than for low SES children (positive interaction). These mechanisms have already been investigated for personality (Damian et al., 2015; Shanahan et al., 2014) and cognitive abilities (Damian et al., 2015; Paulus et al., 2021; von Stumm, 2017). It was found that while the effect of conscientiousness on educational success was higher at lower levels of SES, this effect was no longer present after including cognitive abilities (Damian et al., 2015). For cognitive abilities, Damian et al. (2015) found a positive interaction effect, so that higher SES children benefit more from high cognitive abilities than lower SES children in predicting educational attainment in adulthood, while von Stumm (2017) and Paulus et al. (2021), investigating children, found a negative interaction effect.

Overall, there are a variety of individual and familial aspects that can influence school performance and educational pathways, but these have rarely been considered together. As these factors are likely to be interrelated, it is essential to examine them jointly with cognitive abilities and SES as well as regarding their interplay with SES in order to understand how educational inequalities arise. This could involve, on the one hand, factors playing a varying role depending on SES and, on the other hand, factors explaining the pathways in which SES affects education.

1.5. The aim of the present study

Differences in educational success between children of different social backgrounds can only be partially explained by differences in children's cognitive abilities (Arnold et al., 2007; von Stumm, 2017). As *TwinLife*, whose data was used in this study, is a large, representative sample with a variety of factors relevant to education, an empirical approach was chosen with the aim of integrating the vast amount of existing research attempts and findings. Consequently, the aim was to examine constructs that have shown a consistent effect on educational outcomes in previous research in a joint approach, which allowed the validity to be tested beyond SES and cognitive abilities. In addition, with mediation and moderation, more extensive mechanisms were investigated that have already been identified for some of the included constructs in previous research and might help to understand the emergence of educational inequalities. Moderation was considered in order to uncover the potentially different ways in which the effect of certain predictors vary with the level of SES. In mediation, we tested to what extent these factors might explain the underlying relationship. Specific hypotheses regarding moderation and mediation were kept exploratory, since some of the constructs have hardly been studied together with children's cognitive abilities and parental SES.

The following hypotheses were tested:

(1) The predictors depicted in the categories family characteristics (parental educational aspiration, literacy activity, home environment) and child characteristics (children's educational aspiration, intrinsic motivation, learning goals, self-perceived ability, self-control, conscientiousness) predict (a) school grades and (b) educational recommendations, with the predictors partially overlapping in their effects, after controlling for cognitive abilities and SES as well as school grades for the criterion educational recommendations (main effect). Here, children with higher SES, cognitive abilities, educational aspiration of parents and children, intrinsic motivation, learning goals, self-perceived ability, self-control, conscientiousness, literacy activity, and home

environment (and additionally, for the educational recommendation criterion, higher school grades) achieve better (a) school grades and (b) educational recommendations.
(2) The effect of some predictors on (a) school grades and (b) educational recommendations varies with parental SES (moderation).
(3) The effect of parental SES on (a) school grades and (b) educational recommendations can be explained by some of the predictors (mediation).[1]

2. Method

2.1. Sample

The sample of the present study was taken from the *TwinLife* study. *TwinLife* is a German longitudinal study of approximately 4,100 families with a probability-based sampling design. The study consists of monozygotic and dizygotic same-sex twin pairs divided into four age cohorts (5, 11, 17 & 23 years) and has been conducted yearly from 2014 to 2024. Although more highly educated households are slightly overrepresented, the sample is suitable for analyses of social inequality, as it spans the full distribution of socio-demographic indicators (e.g., education, income) (see Hahn et al., 2016; Lang & Kottwitz, 2017; Rohm et al., 2023). The *TwinLife* study was ethically approved by the German Psychological Society (Deutsche Gesellschaft für Psychologie; protocol number: RR 11.2009) and thus met the ethical standards of the 1964 Helsinki Declaration and its subsequent amendments. The consent of the participants was obtained through informed verbal consent. All data and research materials can be accessed via Gesis. The *TwinLife* data (Diewald et al., 2023) is available for research purposes free of charge after signing a data use agreement.[2] For the present study, the age cohort born in 2003/2004 was used, ranging from age 10 to 12 at the time of the survey (N = 2,086). The analyses also included siblings of twins who were in the same age range (N = 187). Overall, data of N = 2,273 children were available. The data for this study was collected between September 2014 and April 2017, when the first two *TwinLife* surveys took place.

2.2. Measurements

2.2.1. School grades

In Germany, school performance is assessed on a 6-point grading scale from 1 (= excellent) to 6 (= insufficient). Photos of the children's last report card were taken for the *TwinLife* study (N = 1218), or in cases where the report card was not available, parents answered questions about their children's school performance, with grades collected in mathematics and German (N = 713) (Instinske et al., 2022). For the analysis, an average grade was calculated based on the grades in math and German (r = 0.67, p < .001) and then recoded so that a high value corresponded to a high school performance. School grades were treated as an interval-scaled variable.

2.2.2. Educational recommendation

In many educational systems, at a specified point in time, students are divided into different ability groups. Depending on the educational system, this takes place early (around age 10) or late (around age 16) and is either reflected by different school types or different tracks within one comprehensive school (OECD, 2004). In Germany, children are allocated to different school types after primary school at the age of around 10 following an educational recommendation given by their primary school teacher.[3] Students can be recommended for upper, middle, and lower secondary education, or comparable comprehensive schools. While the lower and middle secondary school enable vocational training, upper secondary schools are more academically oriented and enable university access (Eckhardt, 2019). In *TwinLife*, information on children's educational recommendation was provided by the parents (1 = lower, 2 = middle, 3 = upper secondary school). The variable was considered as categorical in all analyses.

2.2.3. Parental socioeconomic status

For the calculation of parental socioeconomic status, we included parental education (ISCED: UNESCO, 2011), parental income (modified equivalence scale of net income: OECD, 2013), and parental occupational class (ISEI; Ganzeboom et al., 1992; EGP: Erikson et al., 1979). For parental education and occupational class, the indicator of each parent was considered. The income variable was cleaned for outliers (upper and lower 1 %) and log-transformed. The total SES score was calculated in a latent factor analysis in Mplus (Version 8.2; Muthén & Muthén, 1998-2017) and residualised for parental age.

2.2.4. Cognitive abilities

To test children's cognitive abilities, the non-verbal "Grundintelligenztest Skala 2" (CFT 20-R [Culture Fair Intelligence Test], Revision; Weiß, 2006) according to Cattell's concept of fluid intelligence was used (Gruber & Tausch, 2015). The CFT 20-R consists of the four subtests "Figural Reasoning" (15 Items), "Figural Classification" (15 Items), "Matrices" (15 Items) and "Reasoning" (11 Items) (Klatzka & Paulus, 2024).

2.2.5. Educational aspiration

To measure parental educational aspiration, parents indicated which school diploma they wish their child to achieve. The answer options were "lower secondary school diploma" (= Hauptschulabschluss), "middle secondary school diploma" (= Realschulabschluss), "upper secondary school diploma" (= Abitur) and "no specific diploma". In addition, we also considered the educational aspiration of the child based on the same question. Because the number of cases regarding the aspiration to achieve a lower secondary school diploma was very small (N = 42 and N = 59), and to adequately consider the ordinal variable in the analyses, educational aspiration was considered as a binary variable (0 = no aspiration for upper secondary school, 1 = aspiration for upper secondary school).

2.2.6. Intrinsic motivation

To assess intrinsic motivation, a subscale of the "Skala zur Erfassung subjektiver schulischer Werte" (SESSW [Scale for Assessing Subjective School Values]; Steinmayr & Spinath, 2010) was used. The scale was designed according to Eccles et al.'s (1983) expectancy-value theory, with the construct "interest" representing a central aspect of intrinsic motivation (Eccles & Wigfield, 2002). In *TwinLife,* the subscale "intrinsic values" for school in general comprises a total of three items (e.g. "I like doing the things I learn in school"). The participants responded on a five-point Likert scale ranging from "does not apply at all" to "fully applies".

2.2.7. Learning goals

The assessment of learning goals was taken from the "Skalen zur Erfassung der Lern- und Leistungsmotivation" (SELLMO [Learning and achievement motivation scales]; Spinath et al., 2012). To measure learning goals, three items were adapted from the original scale (e.g. "At

[1] The hypotheses and the research and analysis plan were pre-registered in the Open Science framework. Any changes to the analysis plan were outlined and explained in the paper. [https://osf.io/brzkv/files/m2et7]

[2] See https://dbk.gesis.org/dbksearch/SDesc2.asp?DB=D&no=6701 for more information on the *TwinLife* data.

[3] Despite the fact that this educational recommendation is generally of high relevance, the binding nature of this educational recommendation can differ among the federal states in Germany (Sekretariat der Ständigen Konferenz der Kultusminister, 2015).

school, I am interested in…" "learning something interesting") and were answered on a five-point Likert scale ranging from "does not apply at all" to "fully applies".

2.2.8. Self-perceived ability

To assess children's self-perceived ability, a shorter form of the subscale absolute self-perceived ability of the "Skalen zum akademischen Selbstkonzept" (SESSKO [Scales on the academic self-concept]; Dickhäuser et al., 2002) was used. The three items included, for example, the statement "I am [not talented/talented] … in school" and were answered on a five-point Likert scale.

2.2.9. Self-control

Self-control was measured with three items taken from the "Messung dispositioneller Selbstkontroll-Kapazität" (SCS-KD, [Measurement of dispositional self-control capacity]; Bertrams & Dickhäuser, 2009), a German adaptation of the short form of the Self-Control Scale (Tangney et al., 2004). For example, the scale contained the item "I do certain things for fun, even if they are bad for me". The items were answered on a five-point Likert scale that ranged from "not at all true" to "completely true". Children's self-control in *TwinLife* was only surveyed one year later, but the construct of self-control appears to be stable over time from 10 to 13 years (Hay & Forrest, 2006).

2.2.10. Conscientiousness

Children rated their personality using the short version of the Big Five Inventory (BFI-S; Gerlitz & Schupp, 2005). The three items "I see myself as someone who…" "does a thorough job", "tends to be lazy", and "does things efficiently" were applied to measure conscientiousness. The scale ranged from "does not apply to me at all" to "applies to me perfectly" and was answered on a 7-point Likert scale.

2.2.11. Literacy activity

In *TwinLife*, children reported how often they read books and talk about books with their parents on a 5-point scale ranging from "not at all" to "(almost) daily". This item was adapted from the Pairfam study (Pairfam Group, 2021). To adequately consider the ordinal variable in the analyses and not overload the already complex model with multiple binary variables and interactions, literacy activity was coded as a binary variable using a median split (0 = no literacy activity; 1 = literacy activity at least once a month). The correlations with SES and educational outcomes were comparable between the categorical and binary predictor (SES: categorical $r = 0.18$, $p < .001$; binary $r = 0.18$, $p < .001$; school grades: categorical $r = 0.11$, $p = .007$; binary $r = 0.08$, $p = .050$; educational recommendation: categorical $r = 0.16$, $p < .001$; binary $r = 0.15$, $p < .001$).

2.2.12. Home environment

To measure the quality of home environment, the "Confusion, Hubbub and Order (CHAOS) Scale" (Matheny et al., 1995) was used with a total of six items (e.g. "We are usually able to stay on top of things"). The items were answered by the children on a five-point Likert scale ranging from "not true at all" to "exactly right".

2.3. Analyses

In a first model, multiple regression analyses were performed for the outcomes primary school grades and educational recommendations, taking into account the clustering of the data.[4] Cognitive abilities, SES, family characteristics, and child characteristics were included as predictors, as well as school grades for the outcome educational recommendation. In a next step, interaction terms including SES and each of the predictors were included. For mediation analyses, a single analysis was performed for each of the variables; in a next step, each significant mediator ($p < .05$) was included in the multiple mediation analyses. All analyses were conducted using Mplus (Version 8.2; Muthén & Muthén, 1998-2017). The analysis code is available in the supplementary material.

The predictors SES, cognitive abilities, intrinsic motivation, learning goals, self-perceived ability, self-control, conscientiousness, and home environment were all modelled as latent factors. Latent factor analyses were conducted to derive an overall score for each construct. All predictors except for the binary variables educational aspiration and literacy activity were mean-centred. In *TwinLife*, the twins were asked about their most recent report card. As the survey runs over several months and the twins were at the educational transition to secondary school, some provided their primary school report card ($N = 685$), while others already had their secondary school report card ($N = 1246$), meaning that their secondary school grades were collected. As the primary and secondary grades are not comparable and therefore cannot be analysed in a joint approach, we decided to use only information on primary grades, despite the high number of missing values. To avoid sampling bias, children with secondary school grades were also included in the analysis with a missing value for school grades. Therefore, the number of missing values of primary school grades and educational recommendation was relatively high (69.9 % and 22.7 %, respectively). To account for the particularly high percentage of missing data by study design for these variables, full information maximum likelihood (FIML) estimation was applied. Since the missingness was not completely at random (MCAR), in a next step it was tested whether the sample with missing values differed from the sample with available values. Children with available primary school grades or missing educational recommendations tended to be younger, in lower grades, from lower SES families and showed lower cognitive abilities. The variables in which the samples differed were included as auxiliary variables. To check for robustness, various analyses were carried out, which are included in the supplementary material (Tables S3-S6).

3. Results

3.1. Descriptive statistics and intercorrelations

The descriptive statistics are summarized in Table 1, and the intercorrelations in Table 2. Given a total of 2273 participants (51.4 % female), 64.2 % received a recommendation for upper secondary school. The mean recoded school grade was 4.48, which corresponded to a grade between the second best (= good) and third best grade (= satisfying) of a total of six different grade levels. Parental SES correlated significantly with school grades ($r = 0.366$, $p < .001$) and educational recommendation ($r = 0.320$, $p < .001$), but also with variables of family characteristics, such as home environment ($r = 0.100$, $p < .001$).

3.2. Moderation

The results from the moderation analyses can be found in Table 3. Due to high multicollinearity with SES, the interaction terms of educational aspirations of children ($r = 0.89$), educational aspirations of parents ($r = 0.88$), and literacy activity ($r = 0.78$) with SES were excluded from the analyses (Shrestha, 2020). For the moderated multiple regression analysis with the criterion school grades, SES ($\beta = 0.18$; $p < .001$), cognitive abilities ($\beta = 0.30$; $p < .001$), parental educational aspiration ($\beta = 0.22$; $p = .001$), educational aspiration of children ($\beta = 0.09$; $p = .042$) and self-perceived ability ($\beta = 0.15$; $p < .001$) showed significant value in the prediction of school grades while the remaining predictors (i.e., conscientiousness, intrinsic motivation, learning goals, self-control, home environment, and literacy activity) displayed no significant explanatory power. With higher cognitive abilities,

[4] Multilevel regression analyses proved to be a poor fit for the data and research question, so the option cluster = familyID and type = complex was used, which takes the clustering of the twins and siblings into account.

Table 1
Descriptive statistics for educational recommendation, school grades, parental SES, cognitive abilities, educational aspiration of parents (P) and children (C), home environment, literacy activity, intrinsic motivation, learning goals, self-perceived ability, self-control, and conscientiousness.

	Manifest factor		Latent factor		Cronbach's α	N
	M	*SD*	*M*	*SD*		
Age	11.00	0.39	–	–	–	2273
Grade level	5.57	0.60	–	–	–	2037
School grades	4.48	0.83	–	–	0.80	685
Parental SES	–	–	0.04	0.87	–	1761
Cognitive abilities	32.40	7.21	0.02	0.85	0.69	2105
Home environment	22.93	4.06	0.00	0.85	0.58	1997
Intrinsic motivation	11.53	2.28	0.03	0.85	0.79	2227
Learning goals	12.12	2.02	0.03	0.81	0.72	2149
Self-perceived ability	11.61	1.94	0.03	0.84	0.68	2217
Self-control	9.23	2.63	0.00	0.78	0.55	1418
Conscientiousness	15.26	3.31	0.04	0.80	0.54	2225
		Male			Female	
Sex		48.6 %			51.4 %	2273
	Lower secondary school		Middle secondary school		Upper secondary school	
Educational recommendation	6.4 %		29.3 %		64.2 %	1756
		No upper secondary school			Upper secondary school	
Educational aspirations (P)		22.5 %			77.5 %	2002
Educational aspirations (C)		19.0 %			81.0 %	1993
		None			Once a month or more often	
Literacy activity		40.3 %			59.7 %	2159

Notes. 2273 individuals were included in the analysis. Descriptive statistics were calculated using mean values (= *M*) and standard deviations (= *SD*) of the sum score and the latent factor. Scores for school grades ranged from 2 to 6, for cognitive abilities from 8 to 53, for intrinsic motivation, learning goals, and self-control from 3 to 15, for self-perceived ability from 4 to 15, for conscientiousness from 4 to 21, and for home environment from 6 to 30. The latent factor of SES ranged from −2.50 to 2.31.

Table 2
Correlations for educational recommendation, school grades, parental SES, cognitive abilities, educational aspiration of parents (P) and children (C), intrinsic motivation, learning goals, self-perceived ability, self-control, conscientiousness, literacy activity, and home environment.

		2	3	4	5	6	7	8	9	10	11	12	13
1	Educational recommendation	0.75***	0.32***	0.42***	0.59***	0.11***	0.15***	0.49***	0.03	0.09***	0.21***	0.06*	0.10***
2	School grades		0.37***	0.51***	0.51***	0.09*	0.08	0.41***	0.08	0.14***	0.37***	0.19***	0.22***
3	SES			0.29***	0.24***	0.10***	0.18***	0.26***	−0.06**	0.00	0.08***	−0.02	−0.04
4	Cognitive abilities				0.33***	0.08***	0.07**	0.29***	−0.03	0.02	0.20***	0.08**	0.02
5	Educational aspiration (P)					0.13***	0.11***	0.64***	0.08***	0.11***	0.23***	0.09**	0.12***
6	Home environment					.	0.16***	0.13***	0.21***	0.21***	0.21***	0.21***	0.28***
7	Literacy activity							0.10***	0.15***	0.14***	0.12***	0.05	0.12***
8	Educational aspiration (C)								0.04	0.06**	0.18***	0.05	0.10***
9	Intrinsic motivation									0.58***	0.39***	0.08**	0.43***
10	Learning goals										0.37***	0.15***	0.40***
11	Self-perceived ability											0.17***	0.42***
12	Self-control												0.23***
13	Conscientiousness												

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

educational aspiration of parents and children, and self-perceived ability, children tended to have better school grades. In addition, no interaction term showed a significant effect. The model explained $R^2 = 42.7$ % ($p < .001$) of the variance. This model and all subsequent models were saturated, so that no model fit is available.

For the regression analysis with the criterion educational recommendation, cognitive abilities ($\beta = 0.08$, $p = .016$) and school grades ($\beta = 0.69$, $p < .001$) showed predictive power as expected. In contrast, parental SES ($\beta = 0.06$, $p = .062$) showed no significant effect. Parental educational aspiration ($\beta = 0.18$, $p < .001$), children's educational aspiration ($\beta = 0.07$, $p = .048$), the interaction of SES and school grades ($\beta = 0.15$, $p = .001$), the interaction of SES and home environment ($\beta = 0.07$, $p = .025$) as well as the interaction of SES and conscientiousness ($\beta = -0.09$, $p = .002$) revealed additional explanatory power. With higher school grades, cognitive abilities, and educational aspiration of children and parents, children were more likely to receive a higher educational recommendation. The lower parental SES, the smaller the effect of school grades and home environment, and the greater the effect of conscientiousness on educational recommendation. The model explained $R^2 = 82.1$ % ($p < .001$) of the variance.

3.3. Mediation

To test whether the effect of SES on education is mediated by the predictors examined, single mediator analyses were conducted. Next, all significant mediators were analysed in a joint model. The results are shown in Figs. 2 and 3 (for detail, see supplementary material Tables S1-S2). For the criterion school grades, cognitive abilities ($b = 0.12$, $p < .001$), parental educational aspiration ($b = 0.10$, $p < .001$), educational aspiration of children ($b = 0.07$, $p < .001$), and self-perceived ability ($b = 0.02$, $p = .009$), partly mediated the effect of parental SES. In the joint analysis, all included mediators, i.e. cognitive abilities ($\beta = 0.09$, $p <$

Table 3
Standardised regression estimates (β) of the moderated regression analyses.

	School grades		Educational recommendations	
	Direct effect	Interaction effect (x parental SES)	Direct effect	Interaction effect (x parental SES)
School grades	–	–	0.69***	0.15**
SES	0.18***	–	0.06	–
Cognitive abilities	0.30***	−0.04	0.07*	−0.05
Family characteristics				
Educational aspiration (P)	0.22***	–	0.18***	–
Home environment	−0.03	0.03	0.03	0.07*
Literacy activity	−0.02	–	0.04	–
Child characteristics				
Educational aspiration (C)	0.09*	–	0.07*	–
Intrinsic motivation	−0.07	0.03	0.05	0.05
Learning goals	0.03	−0.02	−0.04	−0.03
Self-perceived ability	0.15***	0.02	−0.02	0.03
Self-control	0.07	0.05	−0.04	−0.01
Conscientiousness	0.09	−0.01	0.00	−0.09**
R^2	42.7 %***		82.1 %***	

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

.001), parental educational aspiration (β = 0.06, $p < .001$), educational aspirations of children (β = 0.02, $p = .049$), and self-perceived ability (β = 0.01, $p = .020$), remained significant. The total indirect effect of SES was $B = 0.17$ ($p < .001$) and the total effect of SES $B = 0.33$ ($p < .001$). The direct effect of SES on school grades was still significant (β = 0.18, $p < .001$), so the mediation was partial. The explained variance was $R^2 =$

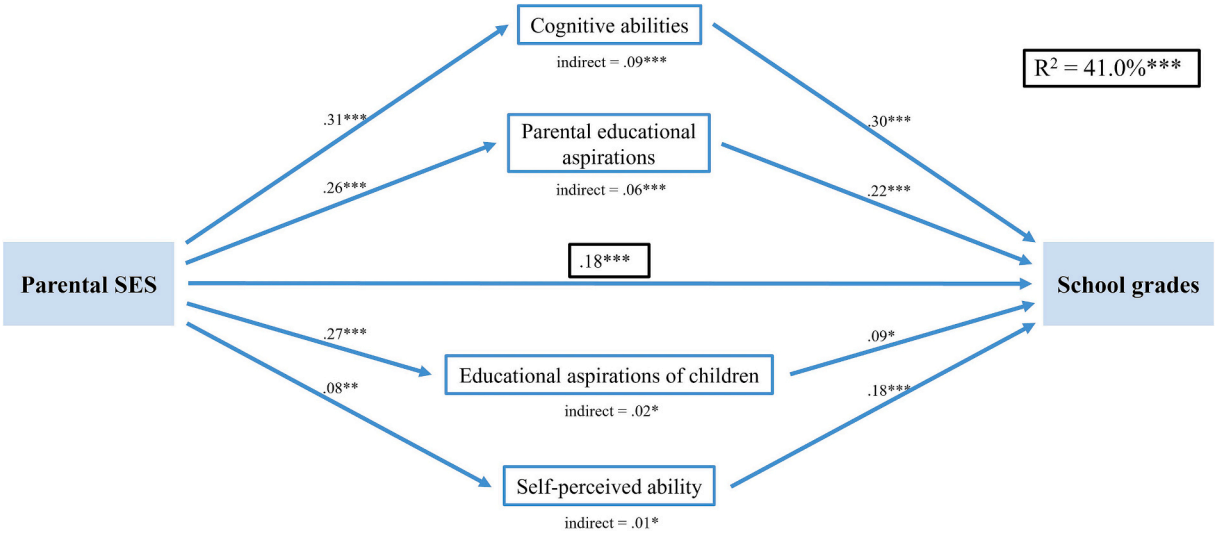

Fig. 2. Multiple mediation analysis with standardised coefficients and the outcome school grades (* $p < .05$, ** $p < .01$, *** $p < .001$).

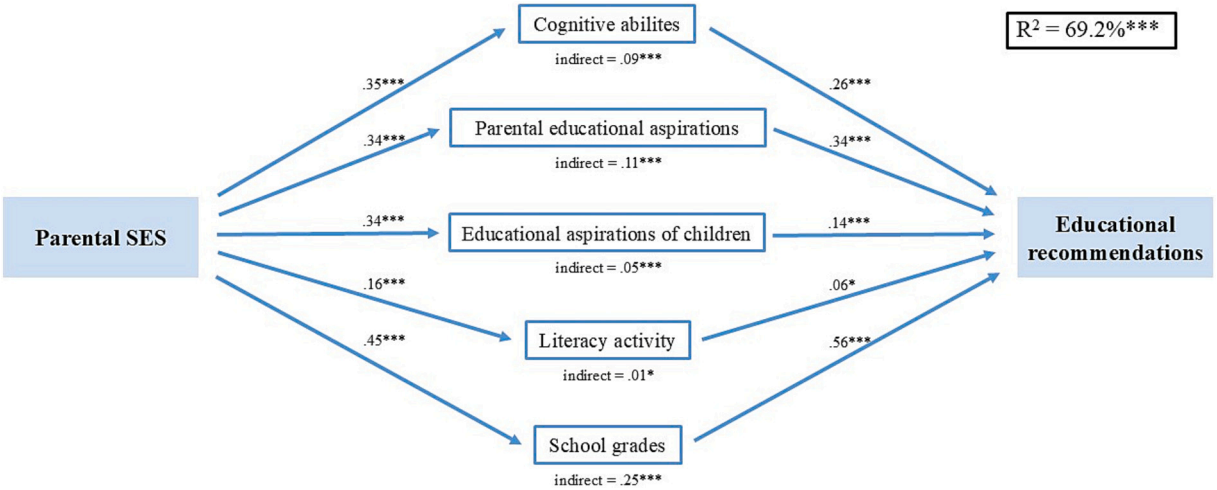

Fig. 3. Multiple mediation analysis with standardised coefficients and the outcome educational recommendations (* $p < .05$, ** $p < .01$, *** $p < .001$).

41.0 % ($p < .001$).

For the criterion educational recommendation, the effect of parental SES was mediated by cognitive abilities ($b = 0.33$, $p < .001$), school grades ($b = 1.34$, $p < .001$), parental educational aspiration ($b = 0.41$, $p < .001$), educational aspiration of children ($b = 0.31$, $p < .001$), self-perceived ability ($b = 0.04$, $p = .013$), home environment ($b = 0.02$, $p = .024$), and literacy activity ($b = 0.04$, $p = .001$). In the multiple mediation analyses, the significant mediators were cognitive abilities ($\beta = 0.09$, $p < .001$), school grades ($\beta = 0.25$, $p < .001$), parental educational aspiration ($\beta = 0.11$, $p < .001$), educational aspiration of children ($\beta = 0.05$, $p < .001$), and literacy activity ($\beta = 0.01$, $p = .039$) with a total indirect effect of $B = 1.82$ ($p < .001$) and a total effect of SES of $B = 1.75$ ($p < .001$). The direct effect of SES was no longer significant ($\beta = -0.02$, $p = .594$), so the effect of SES on educational recommendations was fully mediated. The explained variance of educational recommendation was $R^2 = 69.2$ % ($p < .001$).

4. Discussion

In this study, multiple factors that have been shown to affect educational outcomes in previous research, such as school grades and educational recommendation, were jointly examined. While almost all predictors outlined in the categories family characteristics and child characteristics were significantly associated with the educational outcomes, in the analyses only the most robust predictors parental SES, cognitive abilities, and educational aspiration of parents and children as well as self-perceived ability for the outcome school grades and school grades for the outcome educational recommendation, accounted for an independent amount of variance in predicting school grades or educational recommendations. In contrast to previous studies (Berry et al., 2016; Hulleman et al., 2010; Kuhnle et al., 2012; Poropat, 2009; Taylor et al., 2014; van Bergen et al., 2017), self-control, learning goals, intrinsic motivation, literacy activity, home environment, and conscientiousness did not contribute significantly to any of the educational outcomes. When studied in a joint approach with other indicators for educational success, they showed no incremental validity, and their share of variance seems to be accounted for by the other predictors. Although many of the predictors examined here have already shown incremental predictive validity in previous studies when controlling for mostly either SES, cognitive abilities, or even prior school performance (Benner et al., 2016; Duckworth et al., 2012; Marsh & Martin, 2011; Meyer et al., 2019; Paulus et al., 2021; Spinath et al., 2006; Steinmayr & Spinath, 2009; van Steensel, 2006), these factors have seldom been examined together including SES and cognitive abilities. The results of our study underline the importance of including parental SES as well as cognitive abilities when studying additional factors influencing educational outcomes.

The effect of SES (Harwell et al., 2017; Sirin, 2005) and cognitive abilities (Deary et al., 2007; Roth et al., 2015) on educational outcomes was replicated in this study. While cognitive abilities and SES were interlinked (Bukodi et al., 2014; von Stumm, 2017), SES still accounted for an independent amount of variance in school grades (Gil-Hernández, 2019; von Stumm, 2017). Even after the inclusion of further educational relevant constructs, SES still appeared to play an important role in explaining school grades. With higher SES, children achieved better school grades, which could not be explained by e.g., higher cognitive abilities. For example, high SES children with low cognitive abilities achieved about equally good school grades as low SES children with average cognitive abilities. Teachers may perceive high SES children more positively or implicitly attribute better characteristics to children and parents with higher social status, such as higher intelligence of the child or, due to better financial resources, a more supportive environment at home than families with a lower social status (Doyle et al., 2023; Pit-ten Cate & Glock, 2018). In contrast to previous research (Arnold et al., 2007; van Leest et al., 2021), SES no longer directly significantly contributed to the explanation of educational recommendations. This non-significant effect is presumably due to the inclusion of school grades in the regression, which were already strongly associated with SES, and which was also indicated by the mediation analysis.

In this study, we have investigated more detailed processes of how parental SES in combination with other influential factors might affect a child's educational success. In sum, the effect of SES on education was found to partly function through two distinct mechanisms. First, there were factors (school grades, conscientiousness, and home environment) that were moderated by SES so that they exerted a stronger influence on education at higher or lower levels of SES. Second, children from families with higher SES were more likely to display characteristics that in turn had a positive impact on their academic performance (cognitive abilities, educational aspiration, literacy activity, school grades, and self-perceived ability as mediators). In addition to the well-known finding that cognitive abilities explain part of the relation between SES and educational outcomes (Bukodi et al., 2014; Pearce et al., 2016; von Stumm, 2017), studies have also shown that a higher SES appears to be associated with higher parental educational aspiration (Davis-Kean, 2005), higher aspiration of children (OECD, 2019), and a better home literacy environment (Aikens & Barbarin, 2008), which fits with their mediating role on school grades and educational recommendations found in our analyses.

For children from low SES families, school grades had less of an effect on educational recommendations compared to children from high SES families, which suggests a disadvantage for low SES students rather than an advantage of high SES students. While high SES students seem to be allocated according to their achievement and thus clearly benefit from a good school performance, this is rather less true for low SES students. This result is consistent with the SES bias found in previous research, whereby teachers judge low SES children more adversely (Batruch et al., 2023; Doyle et al., 2023; Olczyk et al., 2023). Furthermore, this finding indicates that for low SES students, other factors are additionally included in the decision-making process of which educational recommendation a child receives. In addition, school grades mediated the effect of SES on educational recommendation, which seems legitimate at first glance. Children who achieve better school grades should receive better educational recommendations. The problem, however, is that these better school grades were most likely not exclusively due to higher academic ability and could be distributed unfairly. Since SES still affected the school grades a child achieved in the multiple regression, it is likely that SES was associated with better school grades for higher SES children independently of the factors considered in this study. In line with this finding, a markedly higher proportion of variance was explained for the outcome educational recommendations than for the outcome school grades, and the effect of SES on educational recommendations was fully mediated, while the effect was only partly mediated for school grades. Since school grades were the only predictor added, more factors than those considered in this study must therefore influence the school grades a child achieves and also further explain the effect of SES on education. For example, school grades may be influenced by other environmental, child or teacher variables, e.g., teacher bias (Batruch et al., 2019). In contrast, conscientiousness showed less influence with increasing SES, so that differences between the SES groups were most pronounced at the lowest levels of conscientiousness. The direction of this effect matches the effect found in Damian et al. (2015), but the effect in the present study remained significant even when cognitive abilities were added. It is likely that a high SES can somehow compensate for low levels of conscientiousness, or since the causal direction in the interaction remains unclear, that high conscientiousness can compensate for low levels of SES. A possible explanation for this interaction effect could also be that teachers' expectations differ depending on the SES of the child. Since teachers based their educational recommendations for high SES children in accordance with their school grades, they did not seem to take other factors strongly into account. For low SES students, however, teachers may implicitly put more emphasis on behavioural characteristics such as conscientiousness,

which had a disproportionate effect on educational recommendations. This could be addressed, for example, by assigning educational recommendations more closely to specific criteria and less at the discretion of the teacher, such as by basing them more closely on school grades. However, as the causality is unclear, both interaction effects must be interpreted with caution and should be analysed further in a follow-up study.

The influence of quality of home environment increased with higher levels of SES, which could implicate that, on the one hand, it could be more critical for high SES children to be able to learn in a quieter environment at home than for low SES children. On the other hand, it could also be that the effect of a low SES is so pronounced that even a good home environment cannot mitigate this influence. It is possible that the effect of a better home environment is only noticeable when high SES is present. As the measure in this study did not capture the full range of home environment, it is not possible to determine which aspect of the home environment contributed to this finding. One possible implication could be to offer more learning spaces outside the parental household. However, this interaction effect should also be investigated in more detail in a subsequent study.

Taken together, the results for two of the constructs (school grades, home environment) suggested a Matthew effect, whereby high SES children benefited more from high levels than low SES children, which could partly explain the emergence or maintenance of educational inequalities. On the other hand, a resource substitution effect was found for the construct conscientiousness, in which low SES children could benefit more from high conscientiousness and thus partially compensated for the effect of a low SES. With regard to the other constructs (educational aspiration, self-perceived ability, cognitive abilities, but also school grades), there was a direct effect, indicating that children of all SES levels benefited from a high level of these constructs. However, three interaction terms (educational aspirations of children, educational aspirations of parents, literacy activity) could not be investigated due to multicollinearity with SES, resulting in unstable estimates.

The mediation analyses indicated that high SES parents were more likely to have higher educational aspiration, which was in turn associated with better educational outcomes. Parents with higher educational aspiration tend to be more actively involved in their children's academic development, e.g., by providing support, helping with homework, or praising a child's achievement. Previous research has shown that parental aspiration has predictive power on school performance beyond these tangible behaviours of parental involvement, but it is unclear exactly how they further promote a child's academic performance (Fan & Chen, 2001; Hill & Tyson, 2009). Possibly, higher aspiration leads to higher motivation to provide tutoring, exert pressure on teachers or reflect the parent's desire to maintain status, which in turn could affect the child's school behaviour. Furthermore, this finding is in line with the family process model, in which parental characteristics mediate the effect of SES on child achievement and suggests that parental educational aspirations may play a central role in this model. However, as all mediation analyses were cross-sectional, it is important to note that no causal direction of effects can be established. In addition, children with a higher SES showed higher educational aspirations and rated their self-perceived ability as better than children with a lower SES, which in turn explained part of the effect of SES on school grades. This could indicate that high SES children express or possess some kind of self-confidence that is associated with them achieving better school grades. That high SES children show higher self-confidence and self-esteem than low SES children, has already been found in previous research (Filippin & Paccagnella, 2012; Twenge & Campbell, 2002). Furthermore, especially for the factors outlined in the section child characteristics, such as conscientiousness (Hausen et al., 2022), there seemed to be a high degree of communality with self-perceived ability. This could indicate that either the motivational aspects and personality of a child are directly manifested in their self-perceived ability, or that these factors represent a collective aspect that influences school performance. However, although this higher self-perceived ability and these higher aspirations could not be attributed to higher cognitive abilities or better school grades, these still explained part of the educational outcomes. How exactly this confidence emerges should be investigated in future studies. Moreover, it could be sensible to target interventions precisely in those factors in which high and low SES children differ and which affect educational success independent of cognitive abilities and school grades. In addition to promoting reading activities, parents and children from families with a low SES could, for example, be informed specifically about higher education so that they develop more confidence in the children's success at upper secondary level and may feel more capable to support them (Ehlert et al., 2017; Forster & Van De Werfhorst, 2019).

Overall, children from higher SES families seemed to benefit in several ways. On the one hand, high SES children were better able to realise their potential because good school grades paid off considerably more due to an interaction with high SES. On the other hand, children from high SES families showed characteristics, such as higher educational aspiration and higher self-perceived abilities, that could explain part of the effect that SES had on education – independent of cognitive abilities or school grades – so that high SES children seem to be treated preferentially by the education system. The results of this study emphasise that the interplay between SES and the included variables can be complex; they may interact with SES or act as mediators. This study contributes to a better understanding of the emergence and persistence of educational inequalities by analysing the incremental predictive power of important educationally relevant constructs as well as their mechanisms in SES-dependent educational differences jointly and beyond cognitive abilities.

4.1. Limitations and future directions

The main limitation of our study is its cross-sectional design. Since data from the youngest *TwinLife* cohort at the transition to secondary school were not available at the time of this study, we chose to analyse the second youngest cohort. Not all, but some of the constructs might have been influenced by a child's academic performance already or vice versa, so that the direction of effects is not evident, and no causal conclusions can be established. For example, parents and children might have adjusted their educational aspiration based on the child's school performance. The cross-sectional approach also assumes that the relation between the variables is stable over time, which is not necessarily the case, especially for children who are still developing. For the mediation analysis, previous research suggests that cross-sectional mediation analysis could lead to bias in terms of over- or underestimation of effects (Maxwell et al., 2011; Maxwell & Cole, 2007; Mitchell & Maxwell, 2013), although another simulation study has shown that the type 1 error was not inflated (Cain et al., 2018). There are some factors that may indicate reliability of the results. Firstly, SES is a time-stable construct (Hanscombe et al., 2012), and secondly, a longitudinal mediation effect has already been shown for some of the mediators, e.g. cognitive abilities and parental expectations (Davis-Kean, 2005; Pearce et al., 2016). Nevertheless, the results of the cross-sectional mediation analysis must be cautiously interpreted, and we advise that the mediation analysis should be replicated explicitly in a longitudinal design.

Due to the timing of the survey, participants often already provided their secondary school grades as they were asked for their most recent report cards, resulting in a large percentage of missing values for primary school grades. With a high percentage of missing values, the estimates of the parameters could be imprecise, so that the results with the outcome school grades could only be generalisable to a limited extent. If, in addition, unobserved confounders that influenced missingness were not taken into account, this could increase uncertainty of FIML and could lead to biased standard errors and estimates. To minimise the possibility of skewed results, we conducted a number of robustness checks (see supplementary material, Tables S3-S6). Most of the effects

were evident in all robustness checks. Some smaller effects (in particular children's educational aspirations) varied in their significance. The interaction effects found were largely comparable in their effect size but were not significant in all analyses. Although the possibility of bias cannot be ruled out completely, the robustness checks indicated the robustness of the results.

Because *TwinLife* is a large, comprehensive study designed to capture all aspects of social inequalities, many constructs were assessed using short scales, in some cases with as few as three items. This brevity resulted in low internal consistencies for some constructs (e.g., conscientiousness $\alpha = 0.54$, self-control $\alpha = 0.55$), so that random measurement error may have attenuated the observed effects and may even have contributed to non-significant effects (e.g., self-control). Furthermore, some short scales may not cover the full range of a theoretical construct and thus construct validity may be limited, so its impact on educational outcomes may be underestimated. For example, the CHAOS scale does not capture all aspects of the home environment, e.g. learning opportunities, so that neither the specific influence of these non-included aspects could be assessed, nor could the full range of the home environment be estimated. With regard to conscientiousness, this short measure did not allow the facets (e.g., productiveness or responsibility) to be considered. We therefore recommend investigating these associations using more extensive and differentiated measures in order to clarify their specific role in educational success.

The effect of parental SES might also be underestimated, as the social resources associated with SES were not included in the construct, as well as due to range restriction, as especially in the younger cohort used in this study, highly educated households are slightly overrepresented (Lang & Kottwitz, 2017). In addition, the selection of the included constructs was limited by the available measures in the *TwinLife* study.

Finally, it is important to emphasise that migration background can also be an influencing factor that contributes to educational inequality. As the present study focused on parental SES and was already extensive, migration background was not included. In addition, the effect of migration background has shown to be somewhat inconsistent and can partly be explained by SES (Azzolini & Barone, 2013; Batruch et al., 2023; Dustmann et al., 2012). Nevertheless, it should be noted that the results may be oversimplified by this non-inclusion and that future research could benefit from including this factor.

4.2. Conclusion

When jointly considering predictors linked to educational outcomes, only educational aspiration of parents and children as well as self-perceived ability affected a child's educational success over and above parental SES, cognitive abilities, and school grades. Mechanisms of educational inequality were identified at the crucial point of educational transition to secondary school. Firstly, educational recommendations for low SES children were less dependent on school grades than for high SES children. Secondly, high SES students showed higher levels of parental and higher educational aspiration themselves as well as self-perceived ability independent of cognitive abilities, which was associated with better educational outcomes, although the causal effect as well as exactly how this emerges remains unclear. Future research should investigate factors that lead teachers to assess low SES students less favourably in order to develop possible interventions.

CRediT authorship contribution statement

Lena Paulus: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Frank M. Spinath:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition. **Elisabeth Hahn:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.intell.2025.101970.

Data availability

Data will be made available on request.

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