FAMILY BACKGROUND OR LANGUAGE DISADVANTAGES? FACTORS FOR UNDERACHIEVEMENT IN HIGH STAKES TESTS

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As in many countries, socially disadvantaged learners achieve substantially lower than their classmates in German mathematics classrooms. For the German language context, still little is known about the degree and the mechanisms how multilingualism, SES, immigrant status, language proficiency and other background variables impact the (under-)achievement in mathematics. For specifying the most relevant factors, the presented study explored the data of 1495 high stakes tests. By analysis of variance, academic language proficiency in the language of assessment turned out to be more relevant than other background factors. First explanations for these results can be given by linguistic item analysis and clinical interviews that show typical language demands.

Impact of different background factors

In many countries, social disparities in achievement raise equity issues when the educational systems fail to decrease disadvantages of underprivileged students. In Germany, social disparities in mathematics achievement have mainly been discussed with reference to two (overlapping) groups of students: multilingual immigrant students and students with low SES (socio-economic status). For both groups, the achievement gap became apparent in different large scale assessments in Germany (Bos et al., 2003; OECD, 2007; Werning et al, 2008; Heinze et al., 2009). That is why the official German education statistics has recently introduced immigrant status as relevant factor (besides nationality, a factor with decreasing explanatory power, cf. Bildungsbericht 2012).

Notwithstanding this dominant German attention to immigrant status and SES as relevant factors, results from empirical studies in *other* countries suggest that language proficiency might be an even more relevant background factor for mathematics achievement (Secada, 1992; Abedi, 2006). As Brown (2005) has emphasized, the language proficiency is especially relevant for those achievement tests that follow a literacy approach (like PISA, cf. OECD, 2007) and provide test items in realistic contexts with high linguistic complexity. However, little is known on the *extent* of impact of language proficiency on mathematics achievement in the German language context, especially for literacy-based high stakes tests.

One important literacy-based high stakes test is the central exam in grade 10 that is conducted in Germany's largest federal state North Rhine Westphalia. As the test determines the final middle school degree in mathematics (eventually combined with

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oral exams), it is highly relevant for each student. We therefore investigated the following research questions for the specific German language context:

Q1. *Specification of relevant factors:* Which of the social and linguistic background factors have the highest impact on mathematics achievement in the literacy-based test?

Q2. Understanding the impact of language issues: What kind of language demands pose obstacles for students with language disadvantages?

As will be shown, the quantitative part of our mixed methods study on Q1 provides statistical evidence that language proficiency (in the test language German) has a higher impact on mathematics achievement than SES or immigrant status. This hardly surprising result replicates empirical findings in America and other countries where language issues are regularly investigated (Abedi, 2006; Jorgensen, 2011). However, for Germany, it is a politically and educationally important result that hopefully initiates a more consequent shift of attention to language issues. As a statistical analysis can always only find correlations, but no causal connections, the second, qualitative part on research question Q2 intends to offer explanations for this relevance: For *understanding* the detailed mechanisms how language proficiency impacts achievement, a linguistic item analysis and clinical interviews were conducted to reconstruct the language demands not only in terms of test *fairness* (Abedi, 2006) for linguistically disadvantaged students, but also for specifying what exactly students have to learn for being successful in literacy-based tests.

RESEARCH DESIGN AND METHODS FOR THE MIXED-METHODS STUDY

Design for the quantitative part

Sample. The sample consisted of n = 1495 students from 67 medium streamed mathematics classes, being streamed according to a medium achievement level, in 19 representative comprehensive schools in a metropolitan region in North Rhine Westphalia. In Table 1, we report the composition of the sample with respect to the background variables in view.

Measures for data gathering.

- The dependent variable, *mathematics achievement*, was measured by the score in the high stakes test in grade 10, as summed up from teachers' evaluation sheets. For further statistical analyses, the 27 items were dichotomized and Rasch-scaled for receiving scores on an interval scale (Rost, 2004).
- The *family background* was considered by a questionnaire on students' immigrant status, family languages, age of first contact to German language and other variables. The socio-economic status (SES) was measured by the widely used book scale with pictures (Paulus, 2009).
- *Language proficiency* was measured by two instruments: 1. *reading proficiency* by the reading scales in the parallel central exam of German (in a subgroup of 1066 students being streamed according to medium achievement level in the

language classes), and 2., a more complex construct of *German academic language proficiency* (Cummins, 1986) was assessed by a standardized C-Test (Grotjahn, Klein-Braley, & Raatz, 2002) in a subgroup of 698 students.

Data analysis procedures. Different statistical analysis procedures were applied for operationalizing the impact of different factors. The most direct approach is to split the sample into groups of privileged, medium and disadvantaged students with respect to different background factors and language proficiency. The difference of mean scores in the mathematics tests gives a first operationalization for finding the highest impact (see Table 1).

An analysis of variance (one-way ANOVA) was used to test for significant differences in the mean scores between three groups for each background factor (language proficiency, SES, immigrant status...), the privileged, medium and disadvantaged students. The ANOVA was also used to determine the explained variance, i.e. the proportion to which each factor accounts for variance. The explained variances for the interval-scaled factors reading proficiency and German academic language proficiency were also calculated by a regression analysis.

Design for the qualitative part of the study

For understanding how language issues impact the success of item solution, a linguistic item analysis was conducted with respect to lexical, morphological and syntactic specificities and typical challenges (Gürsoy et al., 2013).

In order to reconstruct which of the linguistic specificities pose most obstacles for students, clinical interviews were organized with 20 students with language disadvantages and 20 with high academic language proficiency. In these interviews, students' solution processes were videotaped and accompanied by prompts to verbalize the mental processes for "cracking the code" (Zevenbergen, 2000) of the item texts. The videos were partly transcribed and interpretatively analysed with respect to typical obstacles and ways to overcome them. Due to space restrictions, we cannot show these ongoing analyses in details here, but only sketch selected insights.

SELECTED RESULTS

Language proficiency as most relevant factor

Table 1 shows the composition of the sample according to different background variables and language proficiency. Although achievement gaps appear between the privileged and disadvantaged groups for each factor, the sizes of the gaps vary considerably: The mean score in the mathematics test is slightly higher for the privileged group's mean compared to the disadvantaged group for the factors immigrant status (difference 46.2-40.9 = 5.3), SES (3.8), and age of first contact to German (6.8). In contrast, for German academic language proficiency, the difference of mean scores is nearly a standard deviation (13.0) and slightly lower for reading proficiency (9.7) in the subgroup with higher mean score. The big differences for academic language proficiency translate into an achievement gap between grade 3 and nearly grade 5 (1 being excellent, 5 being failed): For a score of 37 points, a grade 5 was attributed, for a score of 50 points, a grade 3.

Factor	**Specification of groups**	**Distribution of groups**	**Mean score** (max. 85) m (SD)	**Difference**
Whole sample	*67 medium streamed classes*	*n = 1495*	*43.5 (13.6)*	
Immigrant	1st generation (student immigrated)	152 (10.3 %)	41.3 (13.6)	
status	2nd generation (parents immigrated)	623 (42.1 %)	40.9 (13.5)	5.3
(n=1480)	no / 3rd generation	705 (47.6 %)	46.2 (13.0)	
Socio-economic	low SES	509 (34.1 %)	41.9 (14.0)	
Status	medium SES	488 (32.7 %)	42.9 (12.9)	3.8
(n=1493)	high SES	496 (33.2 %)	45.7 (13.4)	
Age of first contact	first German after age of 3 years	289 (19.4 %)	39.5 (13.7)	
to German	first German before age of 3 years	538 (36.2 %)	42.2 (13.5)	6.8
(n=1486)	only German monolingual	659 (44.3 %)	46.3 (13.0)	
German Academic	low C-Test	235 (33.7 %)	37.3 (13.4)	
language proficiency	medium C-Test	233 (33.4 %)	44.2 (12.6)	13.0
(C-Test in selected	high C-Test	230 (33.0 %)	50.3 (11.4)	
classes; n = 698)	*all C-Tests*	*698 (100 %)*	*43.9 (13.6)*	
German reading	low reading proficiency	365 (34.2 %)	40.3 (12.9)	
Proficiency	medium reading proficiency	405 (38.0 %)	46.6 (12.6)	9.7
(in medium streamed language	high reading proficiency	296 (27.8 %)	50.0 (12.5)	
classes; n = 1066)	*all reading tests*	*1066 (100 %)*	*45.4 (13.3)*	

Table 1**.** Distribution and Differences between groups

These results on the initial test scores are confirmed by the analysis of variance with the rasch-scaled measures: For all five factors, the group differences between underprivileged and privileged groups appear as highly significant ($p < 0.001$ in all 5 F-tests). However, whereas the family background factors (immigrant status, SES, and age of first contact to German) account for only 1 % to 3 % of the variance, the explained variance of German academic language proficiency is much higher with 14 % in the regression analysis. Remark that this value is quite high for a quite homogenous group of students (all being in medium streamed mathematics classes).

These findings show that also in the investigated high stakes test, language proficiency has a higher impact on mathematics achievement than family background alone. The next section gives selected insights into the *quality of language demands* from the ongoing linguistic and interview analysis. Although being only roughly sketched, they offer first clues for explaining the statistical findings.

“Cracking the connections” as a crucial language demand in many items

On a first sight, the length of the texts or unknown isolated words are the immediately visible characteristics of mathematical item texts in literacy-based tests. However, Zevenbergen (2000) emphasized by the metaphor “cracking the code” that the linguistic and cultural challenges for disadvantaged students are usually more complex than isolated unknown words. In our analysis, one specific aspect of this “code” of academic language was most striking for which we analogize the metaphor to "cracking the connections". By this, we mean decoding linguistic means that signify *relevant mathematical or textual relations in the item texts on sentence and text level.*

On the sentence level, cracking connections appeared for example in the following item on functional dependencies between fuel consumption and speed of vehicles. The sentence in Item (2) is typical for the academic test language: It is quite short, does not contain many *lexical* demands, but it is *morphologically* and *syntactically* highly complex.

Fuel consumption
The fuel consumption for vehicles is specified by the consumption in liters (l) for a distance of 100 km. The fuel consumption of a car depends on the speed. The diagram shows the fuel consumption for a car that drives in the highest gear. That is why the graph starts at 70 km/h.
(1) What speed does the car have on average, when it consumes 11 l for 100 km?
(2) How many percent is the consumption for 180 km/h over the consumption for 100 km/h? Write down your calculation. [very literal translation from German]

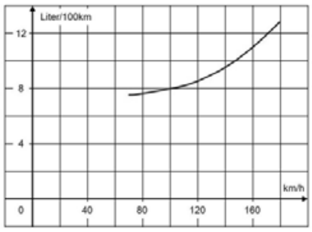

Figure 1. Exemplary test item from the central exam NRW 2012

Three mathematical relations have to be reconstructed: consumption for 180 and consumption for 100 as prompts to find the functional values f(180) and f(100) in the graph, and the percentage of growth from f(100) to f(180), i.e. (f(180) – f(100))/f(100). These different relations are linguistically encoded in three nested prepositional attributes "for 180 km/h", "for 100 km/h" "how many percent … over". Before finding an adequate mathematization, students have to decode these linguistic constructions. Although the technical demands are not high for grade 10 students, only 12 % of all 1495 students succeeded to decode and solve the item, more specifically 6 % of the group with low academic language proficiency and three times more of those with high academic language proficiency (19.2 %).

The interviews show that even students with high language proficiency first struggle with cracking these connections, whereas students with language disadvantages tend to capitulate and consider only partial information on selected relations, for example only assigning functional values or only calculating percentages. It seems to be this focus on partial information instead of the central relations that hinders them to overcome the obstacle of cracking connections.

In the linguistic item analysis of all items, the relevance of linguistic means for expressing connections was also reflected quantitatively by a significantly higher frequency of prepositions in the mathematics tests (10 % of all words were prepositions) compared to the German language tests (6-7 % of all words). It thus appears to be a specificity of mathematical texts.

On the text level, cracking connections appear especially when students have to find relevant information for the questions in other parts of the task (in text, diagram, table,…). Students with language disadvantages seem to have greater difficulties in keeping the track of cohesive connections when signified by linguistic means from the academic register. With respect to the text level, test fairness could be increased by avoiding too implicit cohesive connections (cf. Gürsoy et al., 2013, for more details)

Conclusion and Consequences

Not the family background, but the language proficiency matters most for achievement in the investigated literacy-based high stakes test. With respect to the linguistic complexity of the items, this result is not surprising. It is nevertheless important as it serves as motor for further research on details of language demands. Already, the item analysis and first interviews helped to explain these quantitative patterns by reconstructing "cracking connections" as a language demand which seems to be typical for school mathematics. We currently continue the interview analysis and started a DIF-analysis for finding further crucial language demands. Although the study on research question *Q2* is still ongoing, the findings on research question *Q1* call for consequences in three different areas (see below).

Consequences for test construction. It is a matter of test fairness to consider each item of a high stakes test or large-scale assessment if it comprises unnecessary language biases and threatens the construct validity (Abedi, 2006; Wolf & Leon, 2009; Martiniello, 2009; Brown, 2005). Sometimes, already small changes in wording can change the characteristic of items, for example by making cohesive connections explicit. However, not all language disadvantages can and should be avoided by test construction. First, some items are difficult for learners with language disadvantages without being linguistically complex, instead, they can contain conceptual demands which the learners do not meet because of longer lasting limits in the acquisition process before the test (Prediger & Wessel, 2013). Second, unnecessary biases must be distinguished from necessary demands of conceptual and linguistic proficiency to which students should get access for the overarching goal of reaching mathematical literacy. This especially applies to complex expressions for mathematical relations that come with items that assess conceptual understanding.

Consequences for research. The relevance of language factors has been proven in many international studies (Abedi, 2006; Secada, 1992) and could here be replicated for the German language context. This finding implies the necessity to include language factors consequently into large-scale assessments for grasping social disparities. Of course, the acquisition of language proficiency highly depends on socially determined learning opportunities. In this sense, Cook-Gumperz (1973) is right to emphasise literacy to be a "socially constructed phenomenon, (and) not simply the ability to read and write" (p. 1) and family background does definitely matter, even if mediated by academic language proficiency. But whereas the identification of SES or immigrant status as relevant factors should have important impacts on the level of *policies* for equity, the identification of language disadvantages of a student can lead to substantial consequences in the *classrooms* and are therefore also highly important for fostering equity.

Consequences for classrooms. Accepting that language proficiency is also socially determined does not imply that language should be eliminated from mathematics classrooms, on the contrary: Especially a literacy-based curriculum (as in North Rhine Westphalia, cf. Barzel, Hußmann, & Leuders, 2004) obliges curriculum designers and teachers to consider more consequently how to prepare *all* students (also those with language disadvantages) for the necessary language demands in literacy-based problems and tests. If social disadvantages are linguistically mediated, this finding offers a good access point to enhance equity by fostering students' academic language proficiency. We therefore need enormous efforts of designing language-sensitive teaching strategies and materials (Thürmann, Vollmer, & Pieper, 2010), especially with a focus on expressing connections (Prediger & Wessel, 2013).

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Language Disadvantages? Factors for Underachievement in High Stakes Tests. In A.M. Lindmeier & A. Heinze (Eds.), Proceedings of the 37th Conference of the International Group for the Psychology of Mathematics Education, Vol. 4, 49Â A C-Test in Albanian and a C-Test in Turkish based on a new deletion principle were devel-oped for 11-13 years old children from ethnic minorities who visit minority language classes once a week. During the development phase of the C-Test we faced a number of difficulties resulting from the dialect variations of the Albanian and the linguistic peculiarities of the Turkish language. The small [Show full abstract] samples of the pre-tests show results whose reliability is satisfac-tory and high. Zeroing In on Family Background. Family income may have a direct or indirect impact on childrenâ€™s academic outcomes. Colemanâ€™s advisory panel refused to sign off on the report, citing â€œmethodological concernsâ€ that continue to reverberate. Subsequent research has corroborated the finding that family background is strongly correlated with student performance in school.Â I then consider the ways in which schools can offset the effects of these factors. Parental Education.Â Positive results have also been observed with respect to student test scores for charter schools in New York City, Boston, Los Angeles, and New Orleans. Small schools of choice might also build the social capital that Coleman considered crucial for student success. Synopsis Not all high ability kids are equally motivated. High ability students vary tremendously in their motivation, even at an early age. Here is a baker's dozen of motivational strategies that parents and teachers can use to re-ignite more. Synopsis Not all high ability kids are equally motivated. High ability students vary tremendously in their motivation, even at an early age.Â Perhaps, in fact, there are as many causes for underachievement as there are gifted students who appear turned off by school and academics. Of course, motivation is very important-really, it is critical for learning to occur. Especially higher-order learning. Motivation is important at all levels of learning and for high-ability students at every age and grade.