

NEPS SURVEY PAPERS

Nicolas Hübner, Sven Rieger, and Wolfgang Wagner

NEPS TECHNICAL REPORT FOR ENGLISH READING: SCALING RESULTS FOR THE ADDITIONAL STUDY BADEN-WUERTTEMBERG

NEPS Survey Paper No. 10
Bamberg, November 2016

Survey Papers of the German National Educational Panel Study (NEPS)

at the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg

The NEPS Survey Paper Series provides articles with a focus on methodological aspects and data handling issues related to the German National Educational Panel Study (NEPS).

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Contact: German National Educational Panel Study (NEPS) – Leibniz Institute for Educational Trajectories – Wilhelmsplatz 3 – 96047 Bamberg – Germany – contact@lifbi.de

**NEPS Technical Report for English Reading:
Scaling Results for the
Additional Study Baden-Wuerttemberg**

Nicolas Hübner, Sven Rieger, & Wolfgang Wagner

*Hector Research Institute of Education Sciences and Psychology,
University of Tübingen*

E-mail address of lead author:

nicolas.huebner@uni-tuebingen.de

Bibliographic data:

Hübner, N., Rieger, S., & Wagner, W. (2016). NEPS Technical Report for English Reading: Scaling Results for the Additional Study Baden-Württemberg (NEPS Survey Paper No. 10). Bamberg: Leibniz Institute for Educational Trajectories, National Educational Panel Study.

We would like to thank Steffi Pohl and Claus. H. Carstensen for developing and providing standards for the technical reports. In addition, we would like to thank Eve Sarah Müller for her excellent support and valuable feedback. We would also like to thank Natalie Boonyaprasop for proofreading a primary version of this manuscript.

NEPS Technical Report for English Reading: Scaling Results for the Additional Study Baden-Wuerttemberg

Abstract

The National Educational Panel Study (NEPS) is aimed at investigating the development of competences across the entire life span. It also develops tests for assessing different competence domains. In order to evaluate the quality of these competence tests, a wide range of item response theory (IRT) analyses were carried out. This paper describes the data and results of analyses of the English reading competence test that was used in the additional study Baden-Wuerttemberg. The items were originally designed for Grade-10 students but – due to the lack of Grade-12 tests in this domain at the time when the first assessment took place – the items were used in the English reading competence test in all three consecutive waves (2011–2013). The test was based on a subset of items from a test that was administered in the additional study Thuringia. In sum, 4,885 students took the test in these three waves. The English test consisted of 33 items, representing different levels of the Common European Framework of References, ranging from level B1 to C1. A Rasch model was used to scale the data. Item fit statistics and differential item functioning were investigated. The results showed that the items exhibited good item fit and measurement invariance across various groups. However, the reliability was somewhat modest, which might be due to the fact that the item difficulties were rather low compared with the students' competences. The paper also provides some information about the data available in the Scientific Use File, ConQuest- and TAM-syntaxes for scaling the data, and appendices that describe the scaling of each wave separately.

Keywords

item response theory, scaling, English reading competence, Scientific Use File

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1. Introduction

In the National Educational Panel Study (NEPS), different competences are measured coherently across the life span. Tests have been developed for different competence domains. These include, among other things, reading competence, mathematical competence, scientific literacy, information and communication technologies literacy, metacognition, vocabulary, and domain-general cognitive functioning. Weinert et al. (2011) provide an overview of the competences measured in NEPS.

Most of the competence data are scaled with models that are based on item response theory (IRT). Because most of the competence tests were developed specifically for implementation in NEPS, several analyses have been conducted to evaluate the quality of the tests. The IRT models chosen to scale the competence data and the analyses performed to check the quality of the scales are described in Pohl and Carstensen (2012).

This paper presents the results of the English reading competence test in three waves of the additional study Baden-Wuerttemberg. In this study, items developed by the Institute of Quality Development in Education (IQB) were composed for the English reading test used across three consecutive years (2011 through 2013) to test secondary-school students' English reading competences in their final year of Gymnasium (the type of school that leads to upper secondary education and the Abitur). More detailed information about the aims of this study can be found on the NEPS website.¹ Further information about the test can be found in NEPS (2011; 2012).

The present report draws strongly on previous technical reports such as Durchhardt (2015), Pohl, Haberkorn, Hardt, and Wiegand (2012) and Pohl and Carstensen (2012). It includes extracts from these previous reports.

2. Testing English Reading Competence

The framework and item development for the English reading competence tests was led by the Institute for Educational Quality Improvement (IQB) and is described in Rupp, Vock, Harsch, and Köller (2008) and NEPS (2011; 2012). In the following, we will point out specific aspects of the English reading competence paper-and-pencil test that are necessary for understanding the scaling results presented in this paper.

The items are arranged in units. Thus, on the test, students must usually read one or more texts and must subsequently answer multiple test items related to it. All items were developed by trained experts and corresponded to the National Educational Standards and the Common European Framework of Reference (NEPS, 2011; 2012). Item difficulties range between the levels B1 and C1.

There are three types of response formats on the English reading test. These are simple multiple choice (MC), complex multiple choice (CMC), and multiple matching (MM) items. For MC

¹ <https://www.neps-data.de/en-us/datacenter/studydocumentation/additionalstudybadenwuerttemberg.aspx>

items, the test taker has to choose the correct answer out of several—usually four—response options. For CMC tasks, a number of subtasks with three response options are presented. MM items require the test taker to match a specific sentence, phrase, or word to a text or part of a text.

Tables 1 and 2 show how the difficulty levels of the GER and response formats are distributed across the items.

Table 1

Content Areas of the Items on the English Test

| Content area | Frequency |
|-----------------------|------------------|
| Level B1 | 5 |
| Level B1/B2 | 4 |
| Level B2 | 16 |
| Level C1 | 8 |
| Total number of items | 33 |

Table 2

Response Formats of the Items on the English Test

| Response format | Frequency |
|-------------------------|------------------|
| Single multiple choice | 5 |
| Complex multiple choice | 8 |
| Multiple matching | 20 |
| Total number of items | 33 |

3. Data

A description of the design of the study, the sample, as well as the instruments that were used can be found on the NEPS website.² A total of 4,885 participants took the English reading test: 1,283 in 2011 (Wave 1), 2,391 in 2012 (Wave 2), and 1,211 in 2013 (Wave 3). All subjects gave at least one valid answer so that for every subject, one competence score was estimated.

4. Analyses

This section briefly describes the analyses that were computed; these included inspecting the various missing responses, scaling the data, and examining the psychometric quality of the test.

4.1 Missing Responses

There are different types of missing responses in competence test data. These include missing responses due to a) invalid responses, b) omitted items, c) items that test takers did not reach, and d) items that are missing by design. Missing responses provide information about how well the test worked (e.g., time limits, whether participants understood the instructions, how participants handled different response formats), and they need to be accounted for in the estimation of item and person parameters. We thoroughly inspected the occurrence of missing responses per person. This provided an indication of how well the test takers coped with the test. We then examined the occurrence of missing responses per item in order to obtain some information about how well the items performed. In addition, information was available about whether students did not take the English reading test (e.g., due to student tardiness) but did take at least one of the other competence tests (mathematics, biology, or physics). This missing code is referred to as e) missing by non-participation.

4.2 Scaling Model

In order to estimate the item and person parameters for English reading competence, a Rasch model (Rasch, 1960/1980) was used and estimated in ConQuest 4.2.5 (Wu, Adams, & Wilson, 1997).

Item parameters are estimated difficulties for dichotomous variables in the Rasch model. Ability estimates for English competence were estimated as weighted maximum likelihood estimates (WLEs; Warm, 1989). Person parameter estimation in NEPS is described by Pohl and Carstensen (2012a), whereas the data available in the SUF are described in Section 7.

Plotting the item parameters in relation to the ability estimates of the persons was used in order to judge how well the item difficulties were targeted toward the test persons' abilities (see Figure 5). The test targeting provides some information about the precision of the ability estimates at different levels of ability.

² <https://www.neps-data.de/de-de/datenzentrum/datenunddokumentation/zusatzstudiebaden-w%C3%BCrttemberg/dokumentation.aspx>

4.3 Checking the Quality of the Scale

The items used on the English reading competence test were originally constructed for Grade-10 students. To ensure that the test featured appropriate psychometric properties in the sample of secondary-school students as well, the quality of the test was examined again with several analyses.

The item fit of dichotomous items was examined by analyzing them via a Rasch model (Rasch, 1960/1980), the weighted (or “infit”) mean square (WMNSQ), the respective t-value, and correlations between the item scores and the total score. In accordance with Pohl and Carstensen (2012), items with a WMNSQ > 1.15 (t-value > |6|) were considered to have a noticeable item misfit, and items with a WMNSQ > 1.20 (t-value > |8|) were considered to have a considerable item misfit, and their performance was further investigated. Correlations between an item score and the total score (equal to the discrimination as computed in ConQuest) greater than 0.3 were considered good, greater than 0.2 acceptable, and below 0.2 problematic. Overall, the judgment of item fit was based on all fit indicators.

Our aim was to construct an English reading competence test that measured the same construct in all participants. If any items favored a certain subgroup (e.g., items that were easier for males than for females), measurement invariance would be violated, and a comparison of competence scores between the subgroups (e.g., males and females) would be biased and thus unfair.³ We addressed the issue of measurement invariance by investigating test fairness for the variables gender, immigration background, books at home (as a proxy for socioeconomic status), and wave (i.e., to which of the three waves do subjects belong?); see Pohl and Carstensen (2012) for a description of these variables. Differential item functioning (DIF) was estimated by applying a multifaceted IRT model in ConQuest in which the main effects of the subgroups and the differential effects of the subgroups on item difficulty were modeled. Differences in the estimated item difficulties between the subgroups were evaluated. On the basis of our experiences with the preliminary data (e.g., Pohl & Carstensen, 2012), we judged absolute differences in estimated difficulties that were greater than 1 logit as having very strong DIF, absolute differences between 0.6 and 1 as worthy of further investigation, differences between 0.4 and 0.6 as considerable but not significant, and differences smaller than 0.4 as not having any considerable DIF. In addition to computing DIF analyses at the item level, we investigated test fairness by comparing a model that included differential item functioning with a model that estimated only main effects but no DIF.

The English reading competence data were scaled with the Rasch model, which assumes Rasch homogeneity. Nonetheless, Rasch homogeneity is an assumption that might not hold for empirical data. We therefore checked for deviations from uniform discrimination. We estimated item discrimination by applying the Birnbaum model (2PL) (Birnbaum, 1986) with the TAM package in R (Kiefer, Robitzsch, & Wu, 2015; R Core Team, 2015).

³ It should be noted that differential item functioning may also reflect valid differences between subgroups – that is, item impact (Zumbo, 1999).

5. Results

In this section, the key scaling results of the three waves of the additional study Baden-Wuerttemberg are presented. Some results in which each wave was scaled separately can be found in Appendices C1–C3.

5.1 Missing Responses

In this subsection, we first report the number of missing responses that can be categorized into the different types of missing responses as described in Chapter 4.1 per person and the total number of missing responses per person. Afterwards, we describe the missing responses per item.

5.1.1 Missing responses per person

Figure 1 shows the number of *invalid responses* per person. As can be seen, almost none of the participants—only 2.9%—produced any invalid responses. The maximum number of invalid responses was 6.

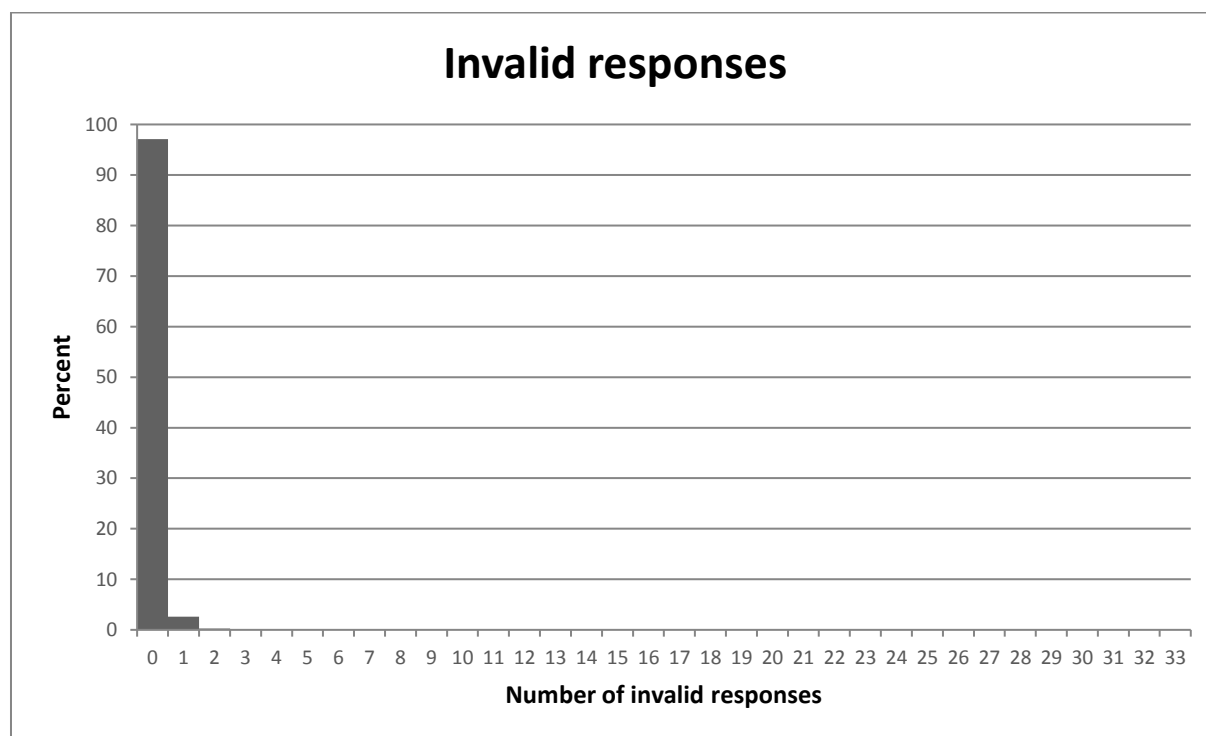


Figure 1. Number of invalid responses per person.

The largest source of missing responses on this test was the *omission of items*. As can be seen in Figure 2, only 11.7% of the participants skipped at least one item. Overall, 1.2% of the participants omitted five or more items.

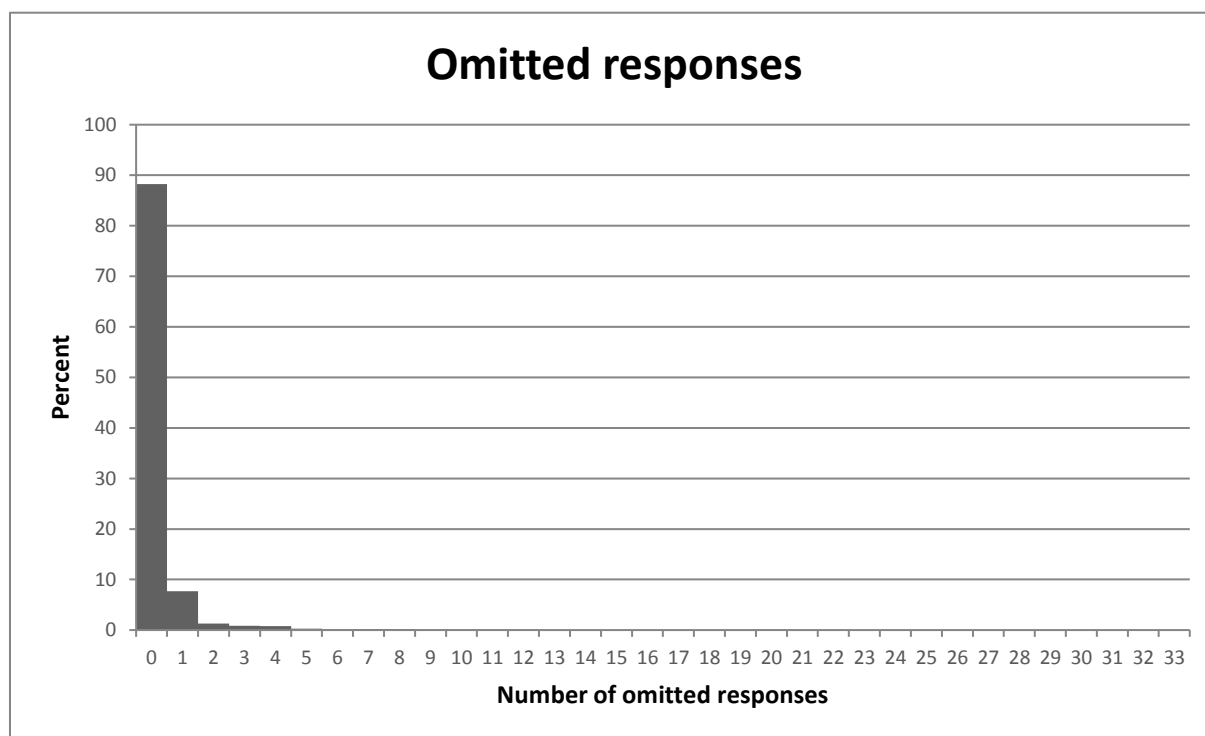


Figure 2. Number of omitted responses per person.

By definition, every item after the last item that was completed is labeled *not reached*. As Figure 3 shows, most participants (97.2%) reached the end of the test.

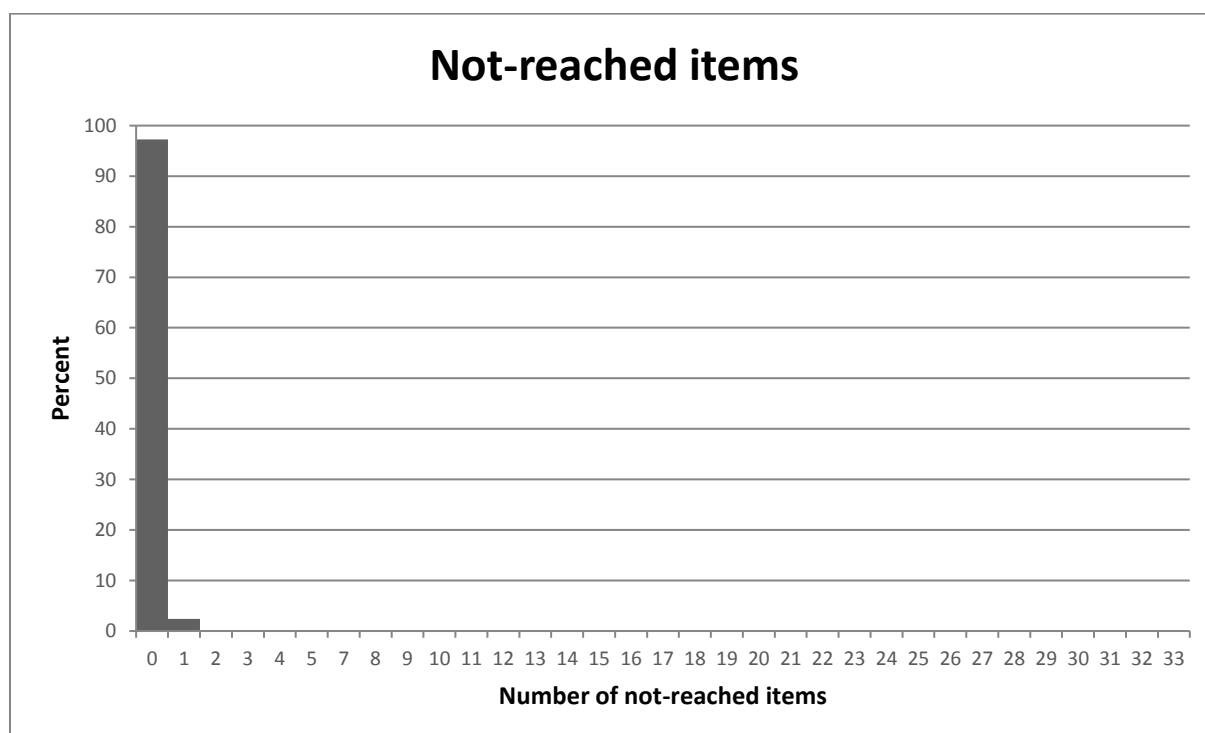


Figure 3. Number of not-reached items per person.

Overall, 99.8% of the participants had no items that were missing by *non-participation*. Only 0.2% (eight) of the students did not take the English reading test but did take at least one of the other tests.

The total number of missing responses (excluding those missing by non-participation and missing by design) aggregated across the invalid, omitted, and not-reached missing responses per person is illustrated in Figure 4. On average, the participants produced 0.33 (SD = 1.20) missing responses. Moreover, 84.2% of the participants had no missing responses at all. Only 1.6% of the participants had five or more missing responses.

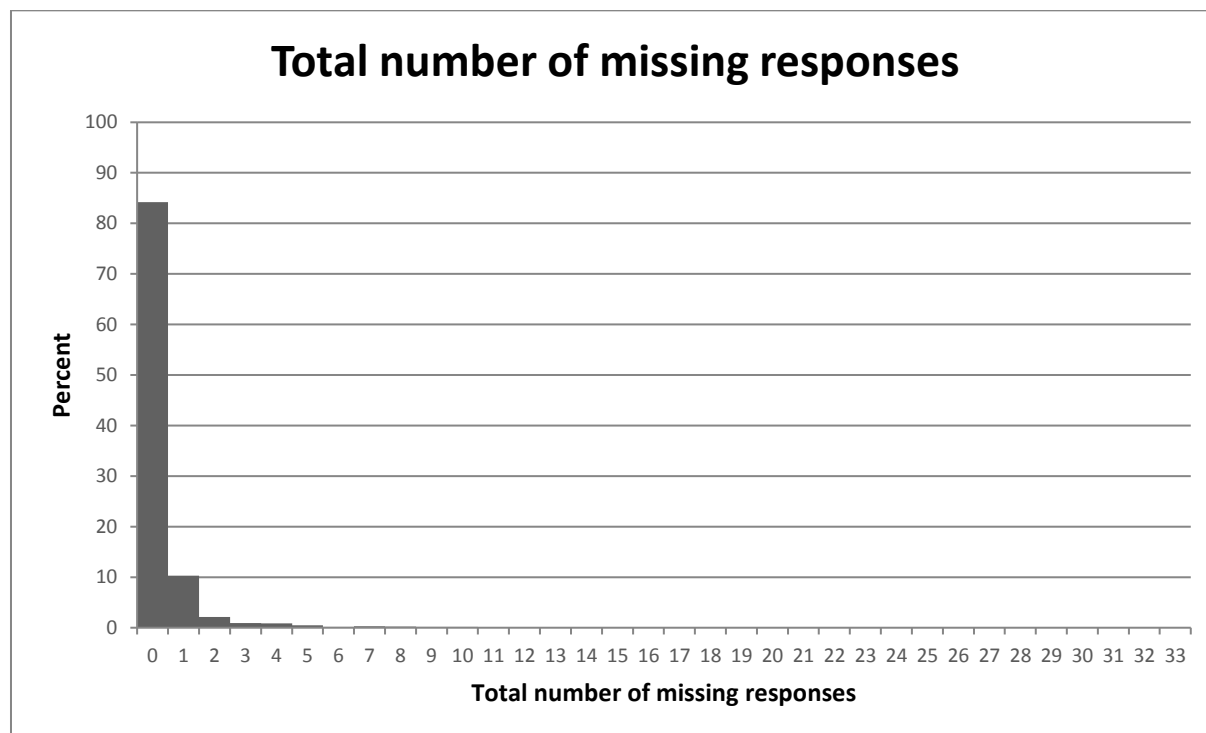


Figure 4. Total number of missing responses.

5.1.2 Missing responses per item

Table 3 provides information about the occurrence of the different kinds of responses that were missing per item. A maximum of 2.8% of the participants failed to reach items (column 5). No item had an omission rate that exceeded 5% (column 6). Item e022d_c (omitted by 2.3% of the participants) and item e008e_c (2.0%) were the most noticeable. Overall, the percentage of invalid responses per item (column 7) was very low (the maximum was 0.9% for item e057a_c). The percentage of items that were missing by non-participation (column 8) was very low (the maximum was 0.2%). All students who took the test had 12 items that were missing by design (column 9).

5.2 Parameter Estimates

5.2.1 Item parameters

The second column in Table 4 shows the percentage of correct responses relative to all valid responses for each item. Please note that, because there is a nonnegligible number of missing responses, this probability cannot be interpreted as an index of item difficulty. The percentage of correct responses varied from 57.9% to 96.3% with an average of 80.2% (SD = 9.8%) correct responses.

For reasons of model identification, in the Rasch model, the mean of the ability distribution was constrained to be zero. The estimated item difficulties (for dichotomous variables) are given in the third column of Table 4. The item difficulties ranged from -3.775 (item e108a_c) to -0.380 (item e022b_c) logits with an average difficulty of -1.88 logits (SD = 0.83). Altogether, the item difficulties were somewhat low. Owing to the large sample size, the corresponding standard errors of the estimated item difficulties (column 4) were small ($SE(\beta) \leq 0.117$).

Table 3

Item Parameters of the English Test

| | Item | Booklet | Position in the test | Number of valid responses | Percentage of not-reached responses | Percentage of omitted responses | Percentage of invalid responses | Percentage of missing by non-participation | Percentage of missing by design |
|----|---------|---------|----------------------|---------------------------|-------------------------------------|---------------------------------|---------------------------------|--|---------------------------------|
| 1 | e108a_c | 1 | 9 | 2450 | - | 0.3 | 0.1 | 0.1 | 49.5 |
| 2 | e108b_c | 1 | 10 | 2454 | - | 0.3 | 0.0 | 0.1 | 49.5 |
| 3 | e108c_c | 1 | 11 | 2389 | - | 1.5 | 0.1 | 0.1 | 49.5 |
| 4 | e108d_c | 1 | 12 | 2451 | - | 0.3 | 0.0 | 0.1 | 49.5 |
| 5 | e022b_c | 1 | 13 | 2432 | 0.0 | 0.6 | 0.0 | 0.2 | 49.5 |
| 6 | e022c_c | 1 | 14 | 2450 | 0.0 | 0.3 | - | 0.2 | 49.5 |
| 7 | e022d_c | 1 | 15 | 2350 | 0.1 | 2.3 | 0.0 | 0.2 | 49.5 |
| 8 | e022e_c | 1 | 16 | 2451 | 0.1 | 0.2 | - | 0.2 | 49.5 |
| 9 | e022f_c | 1 | 17 | 2434 | 0.1 | 0.6 | - | 0.2 | 49.5 |
| 10 | e022g_c | 1 | 18 | 2416 | 0.1 | 0.9 | - | 0.2 | 49.5 |
| 11 | e022h_c | 1 | 19 | 2437 | 0.2 | 0.4 | - | 0.2 | 49.5 |
| 12 | e022i_c | 1 | 20 | 2431 | 0.2 | 0.5 | - | 0.2 | 49.5 |
| 13 | e008a_c | 1,2 | 1 / 5 | 4847 | - | 0.7 | 0.1 | 0.1 | - |
| 14 | e008b_c | 1,2 | 2 / 6 | 4856 | - | 0.6 | 0.0 | 0.1 | - |

| | Item | Booklet | Position in the test | Number of valid responses | Percentage of not-reached responses | Percentage of omitted responses | Percentage of invalid responses | Percentage of missing by non-participation | Percentage of missing by design |
|----|---------|---------|----------------------|---------------------------|-------------------------------------|---------------------------------|---------------------------------|--|---------------------------------|
| 15 | e008c_c | 1,2 | 3 / 7 | 4818 | - | 1.2 | 0.2 | 0.1 | - |
| 16 | e008e_c | 1,2 | 4 / 8 | 4781 | - | 2.0 | 0.2 | 0.1 | - |
| 17 | e075a_c | 1,2 | 8 / 20 | 4830 | 0.1 | 0.9 | 0.2 | 0.1 | - |
| 18 | e075b_c | 1,2 | 7 / 19 | 4820 | 0.1 | 1.1 | 0.1 | 0.1 | - |
| 19 | e075c_c | 1,2 | 6 / 18 | 4819 | 0.2 | 1.2 | 0.1 | 0.1 | - |
| 20 | e075d_c | 1,2 | 5 / 17 | 4815 | 0.2 | 1.3 | 0.0 | 0.1 | - |
| 21 | e057a_c | 1,2 | 21 / 21 | 4708 | 2.8 | - | 0.9 | 0.2 | - |
| 22 | e065a_c | 2 | 1 | 2411 | - | 0.2 | 0.0 | 0.2 | 50.4 |
| 23 | e065b_c | 2 | 2 | 2410 | - | 0.1 | 0.1 | 0.2 | 50.4 |
| 24 | e065c_c | 2 | 3 | 2401 | - | 0.2 | 0.1 | 0.2 | 50.4 |
| 25 | e065d_c | 2 | 4 | 2398 | - | 0.2 | 0.3 | 0.2 | 50.4 |
| 26 | e059a_c | 2 | 9 | 2365 | - | 1.1 | 0.1 | 0.1 | 50.4 |
| 27 | e059b_c | 2 | 10 | 2344 | - | 1.5 | 0.1 | 0.1 | 50.4 |
| 28 | e059c_c | 2 | 11 | 2393 | - | 0.6 | 0.0 | 0.1 | 50.4 |
| 29 | e059d_c | 2 | 12 | 2397 | - | 0.5 | - | 0.1 | 50.4 |
| 30 | e059e_c | 2 | 13 | 2348 | - | 1.4 | 0.1 | 0.1 | 50.4 |

| | Item | Booklet | Position in the test | Number of valid responses | Percentage of not-reached responses | Percentage of omitted responses | Percentage of invalid responses | Percentage of missing by non-participation | Percentage of missing by design |
|----|---------|---------|----------------------|---------------------------|-------------------------------------|---------------------------------|---------------------------------|--|---------------------------------|
| 31 | e059f_c | 2 | 14 | 2383 | - | 0.7 | 0.2 | 0.1 | 50.4 |
| 32 | e059g_c | 2 | 15 | 2347 | 0.0 | 1.5 | 0.1 | 0.0 | 50.4 |
| 33 | e059i_c | 2 | 16 | 2382 | 0.0 | 0.7 | 0.1 | 0.1 | 50.4 |

Table 4

Item Parameters of the English Test

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score | Discrimination-2 PL |
|----|---------|--------------------|--------------------------------|--|-------|---------------|--|---------------------|
| 1 | e108a_c | 96.3 | -3.775 | 0.112 | 1.01 | 0.1 | 0.21 | 0.82 |
| 2 | e108b_c | 88.0 | -2.392 | 0.070 | 1.09 | 2.1 | 0.27 | 0.58 |
| 3 | e108c_c | 66.6 | -0.834 | 0.052 | 1.01 | 0.7 | 0.49 | 0.85 |
| 4 | e108d_c | 89.8 | -2.604 | 0.074 | 0.99 | -0.1 | 0.37 | 0.96 |
| 5 | e022b_c | 57.9 | -0.380 | 0.050 | 1.16 | 8.1 | 0.35 | 0.48 |
| 6 | e022c_c | 92.9 | -3.048 | 0.085 | 1.01 | 0.3 | 0.29 | 0.77 |
| 7 | e022d_c | 87.7 | -2.364 | 0.071 | 0.97 | -0.6 | 0.41 | 0.97 |
| 8 | e022e_c | 82.6 | -1.896 | 0.061 | 1.12 | 3.5 | 0.29 | 0.46 |
| 9 | e022f_c | 67.1 | -0.875 | 0.052 | 1.20 | 8.7 | 0.30 | 0.38 |
| 10 | e022g_c | 66.2 | -0.820 | 0.052 | 1.08 | 3.5 | 0.43 | 0.66 |
| 11 | e022h_c | 94.8 | -3.397 | 0.097 | 0.96 | -0.5 | 0.34 | 1.18 |
| 12 | e022i_c | 80.7 | -1.740 | 0.060 | 1.13 | 4.0 | 0.30 | 0.51 |
| 13 | e008a_c | 79.6 | -1.686 | 0.043 | 0.97 | -1.5 | 0.49 | 1.13 |
| 14 | e008b_c | 86.0 | -2.230 | 0.048 | 0.96 | -1.4 | 0.46 | 1.21 |

| | | | | <i>SE</i> (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score | Discrimination-2 PL |
|------|---------|--------------------|--------------------------------|---|-------|---------------|--|---------------------|
| Item | | Percentage correct | Difficulty/ location parameter | | | | | |
| 15 | e008c_c | 76.5 | -1.470 | 0.041 | 0.94 | -3.1 | 0.54 | 1.33 |
| 16 | e008e_c | 71.6 | -1.156 | 0.040 | 0.91 | -5.5 | 0.59 | 1.44 |
| 17 | e075a_c | 75.1 | -1.357 | 0.041 | 0.86 | -8.0 | 0.62 | 4.33 |
| 18 | e075b_c | 73.5 | -1.765 | 0.040 | 0.89 | -6.6 | 0.60 | 3.97 |
| 19 | e075c_c | 80.6 | -1.276 | 0.044 | 0.87 | -5.9 | 0.59 | 3.62 |
| 20 | e075d_c | 74.8 | -1.379 | 0.041 | 0.86 | -7.8 | 0.62 | 3.96 |
| 21 | e057a_c | 90.2 | -2.686 | 0.055 | 1.07 | 2.0 | 0.26 | 0.59 |
| 22 | e065a_c | 83.7 | -2.058 | 0.064 | 1.06 | 1.7 | 0.37 | 0.80 |
| 23 | e065b_c | 90.2 | -2.733 | 0.076 | 1.02 | 0.3 | 0.34 | 0.86 |
| 24 | e065c_c | 70.3 | -1.118 | 0.054 | 1.47 | 17.3 | 0.05 | -0.20 |
| 25 | e065d_c | 70.1 | -1.109 | 0.054 | 1.14 | 5.5 | 0.37 | 0.61 |
| 26 | e059a_c | 85.8 | -2.229 | 0.067 | 0.93 | -1.9 | 0.51 | 1.43 |
| 27 | e059b_c | 87.2 | -2.371 | 0.070 | 0.93 | -1.8 | 0.50 | 1.37 |
| 28 | e059c_c | 84.9 | -2.162 | 0.066 | 1.03 | 0.7 | 0.40 | 0.98 |
| 29 | e059d_c | 94.0 | -3.321 | 0.093 | 0.92 | -1.2 | 0.44 | 1.70 |
| 30 | e059e_c | 70.7 | -1.125 | 0.055 | 0.96 | -1.5 | 0.54 | 1.17 |

| Item | | Percentage correct | Difficulty/ location parameter | <i>SE</i> (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score | Discrimination-2 PL |
|------|---------|--------------------|--------------------------------|---|-------|---------------|--|---------------------|
| 31 | e059f_c | 66.2 | -0.867 | 0.053 | 1.13 | 5.8 | 0.38 | 0.56 |
| 32 | e059g_c | 83.9 | -2.052 | 0.065 | 0.93 | -1.9 | 0.51 | 1.30 |
| 33 | e059i_c | 80.9 | -1.823 | 0.061 | 1.10 | 2.9 | 0.35 | 0.61 |

5.2.2 Person parameters

The person parameters were estimated as WLEs (Pohl & Carstensen, 2012). WLEs will be provided in the next release of the SUF. A description of the data in the SUF can be found in Section 7. An overview of how to work with competence data is presented by Pohl and Carstensen (2012).

5.2.3 Test targeting and reliability

Test targeting focuses on how well item difficulties and person abilities are matched; this is an important criterion for evaluating the appropriateness of the test for the target group. In Figure 5, the item difficulties and person abilities are plotted on the same scale. The items covered the lower part of the ability distribution very well but, in general, they were somewhat too easy. Hence, the test can measure person abilities in the low-ability regions relatively precisely, whereas high person abilities are measured with larger standard errors of measurement.

The mean of the ability distribution was constrained to be zero, and its variance was estimated to be 1.33, indicating a reasonable differentiation between the subjects. The reliability of the test (EAP/PV reliability = .74, WLE reliability = .60) was acceptable but not good. This should be related to the suboptimal test targeting described above.

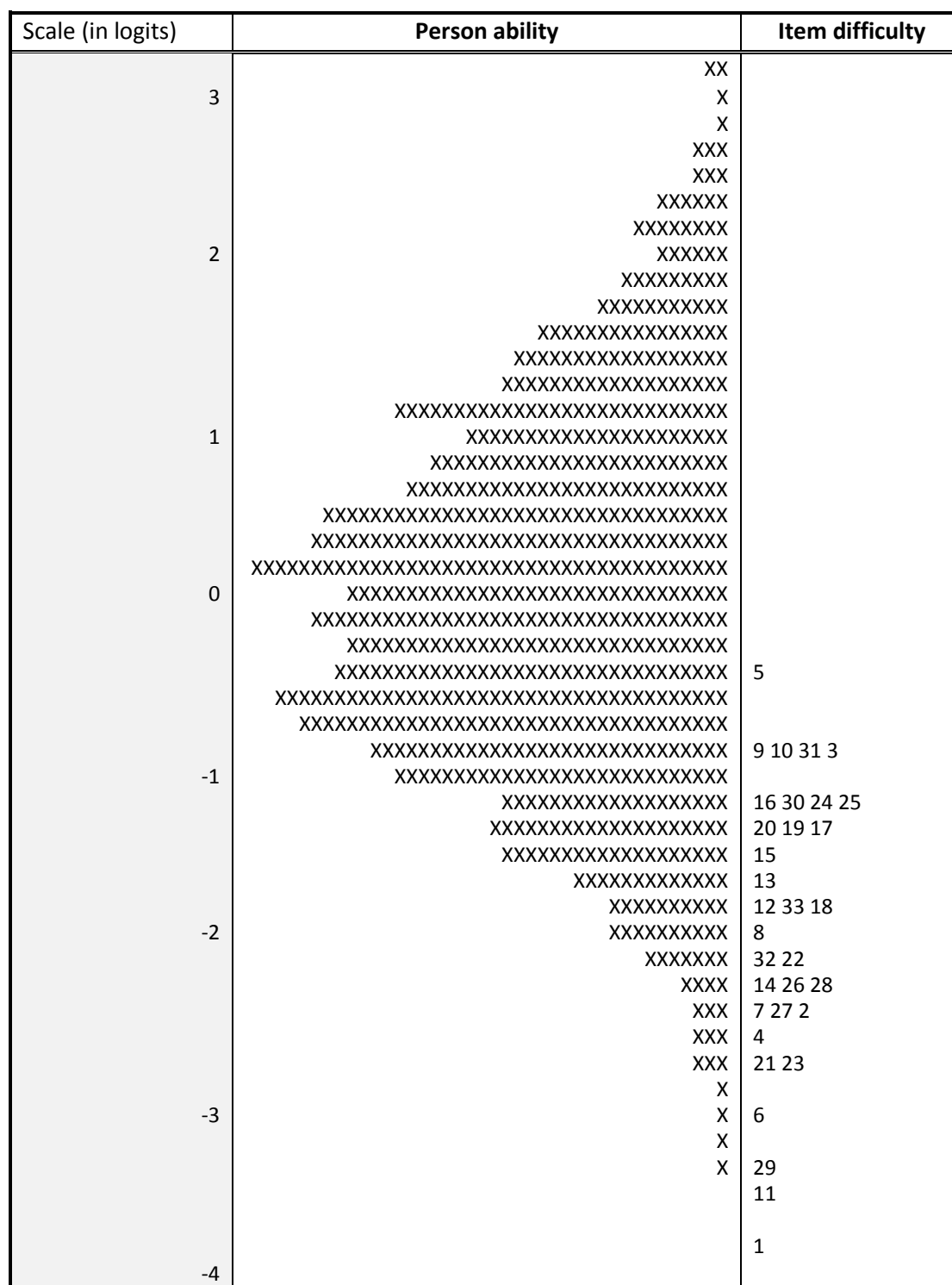


Figure 5. Test targeting. The distribution of person abilities in the sample is depicted on the left-hand side, with each 'X' representing 7.1 cases. The item difficulties (or location parameters) are depicted on the right-hand side. Each number represents one item with a corresponding position in the test, cf. Table 3.

5.3 Quality of the Test

5.3.1 Item fit

Altogether, the item fit could be considered moderate, with values of the WMNSQ ranging from 0.86 (items e075a_c and e075d_c) to 1.47 (item e065c_c), cf. column 5 of Table 4. This latter item also had the largest absolute WMNSQ t-value (17.3). It might be viewed as under-fitting. Point-biserial correlations between the item scores and the total scores ranged from 0.05 (item e065c_c) to 0.62 (items e075a_c and e075d_c). Discriminations estimated in the 2PL-model with the TAM package in R ranged from -0.20 (item e065c_c) to 4.33 (item e075a_c), cf. Table 4, column 8. In conclusion, only item e065c_c showed considerably bad fit and was therefore excluded from further analyses.

5.3.2 Differential item functioning

Differential item functioning (DIF) was used to evaluate test fairness for several subgroups (i. e., measurement invariance with regard to item difficulties). For this purpose, DIF was examined for the variables gender, immigration background, books, and wave (see Pohl & Carstensen, 2012, for a description of these variables). Table 5 provides a summary of the results of the DIF analyses. According to Pohl and Carstensen (2012), absolute difficulty differences greater than 1 logit can be considered to show very strong DIF. For the current test, no item exceeded this threshold.

The table depicts the differences in the estimated item difficulties between the respective groups. “Male vs. female,” for example, indicates the difference in difficulty $\beta_{\text{male}} - \beta_{\text{female}}$. A positive value indicates a higher difficulty for males, whereas a negative value indicates a lower difficulty for males as opposed to females.

Gender: On average, female participants had a higher English reading competence (main effect = 0.112 logits, Cohen’s $d = 0.091$).⁴ One item (e065d_c) showed a DIF greater than 0.6 logits.

Immigration background: On average, participants with and without an immigration background did not differ in their English reading competence (main effect = -0.010 logits, Cohen’s $d = -0.008$). No item showed a DIF greater than 0.6 logits.

Wave: On average, participants in the three waves differed in their English reading competence (1 vs 2: main effect = -0.143, Cohen’s $d = -0.116$; 1 vs 3: main effect = -0.224, Cohen’s $d = -0.182$; 2 vs 3: main effect = -0.081, Cohen’s $d = -0.066$). One item (e108a_c) showed a DIF greater than 0.6 logits.

Books: On average, participants with many books at home performed better on the English reading competence test (0-200 vs 201-500: main effect = 0.325, Cohen’s $d = 0.263$; 0-200 vs > 500: main effect = 0.608, Cohen’s $d = 0.493$; 201-500 vs > 500: main effect = 0.283, Cohen’s $d = 0.229$). No item showed a DIF greater than 0.6 logits.

⁴ The variance of the Rasch model was used to estimate the effect size.

Table 5

Differential Item Functioning

| | | Gender | Immigration background | Wave | | | Books | | |
|------|---------|-------------------|---------------------------|--------|--------|--------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 1 vs 2 | 1 vs 3 | 2 vs 3 | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 1 | e108a_c | 0.232 | -0.110 | -0.202 | -0.644 | -0.442 | -0.378 | -0.117 | 0.261 |
| 2 | e108b_c | -0.114 | 0.048 | 0.198 | 0.168 | -0.030 | -0.023 | -0.346 | -0.323 |
| 3 | e108c_c | 0.018 | 0.392 | 0.054 | 0.024 | -0.030 | -0.111 | -0.090 | 0.021 |
| 4 | e108d_c | -0.062 | 0.308 | -0.219 | -0.215 | 0.004 | 0.026 | -0.102 | -0.128 |
| 5 | e022b_c | -0.188 | 0.202 | 0.270 | 0.393 | 0.123 | 0.010 | -0.100 | -0.110 |
| 6 | e022c_c | 0.142 | 0.068 | 0.190 | 0.074 | -0.116 | -0.097 | -0.224 | -0.127 |
| 7 | e022d_c | -0.172 | 0.240 | -0.231 | -0.234 | -0.003 | -0.186 | 0.162 | 0.348 |
| 8 | e022e_c | 0.066 | 0.102 | -0.043 | -0.008 | 0.035 | 0.105 | -0.264 | -0.369 |
| 9 | e022f_c | 0.084 | 0.054 | -0.077 | -0.022 | 0.055 | -0.313 | -0.302 | 0.011 |
| 10 | e022g_c | 0.056 | -0.116 | -0.157 | -0.119 | 0.038 | -0.080 | -0.304 | -0.224 |
| 11 | e022h_c | -0.068 | -0.292 | -0.230 | -0.307 | -0.077 | 0.277 | 0.014 | -0.263 |
| 12 | e022i_c | 0.136 | -0.006 | 0.405 | 0.270 | -0.135 | -0.162 | -0.014 | 0.148 |
| 13 | e008a_c | 0.124 | -0.122 | -0.121 | -0.185 | -0.064 | 0.099 | 0.096 | -0.003 |
| 14 | e008b_c | 0.298 | -0.038 | 0.102 | 0.057 | -0.045 | 0.142 | 0.121 | -0.021 |

| | | Gender | Immigration background | Wave | | | Books | | |
|------|---------|-------------------|---------------------------|--------|--------|--------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 1 vs 2 | 1 vs 3 | 2 vs 3 | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 15 | e008c_c | -0.176 | -0.116 | -0.019 | 0.004 | 0.023 | 0.122 | 0.256 | 0.134 |
| 16 | e008e_c | -0.374 | -0.100 | -0.084 | 0.048 | 0.132 | 0.219 | 0.390 | 0.171 |
| 17 | e075a_c | -0.282 | 0.038 | -0.110 | -0.172 | -0.062 | -0.078 | 0.221 | 0.299 |
| 18 | e075b_c | -0.014 | 0.014 | -0.189 | -0.234 | -0.045 | -0.105 | 0.086 | 0.191 |
| 19 | e075c_c | -0.150 | 0.050 | -0.059 | -0.136 | -0.077 | -0.061 | 0.046 | 0.107 |
| 20 | e075d_c | -0.090 | -0.016 | -0.063 | -0.162 | -0.099 | -0.047 | 0.047 | 0.094 |
| 21 | e057a_c | 0.186 | 0.198 | -0.246 | 0.058 | 0.304 | 0.292 | 0.185 | -0.107 |
| 22 | e065a_c | 0.508 | 0.080 | 0.279 | 0.111 | -0.168 | -0.089 | -0.047 | 0.042 |
| 23 | e065b_c | 0.580 | 0.030 | 0.549 | 0.576 | 0.027 | 0.013 | -0.018 | -0.031 |
| 25 | e065d_c | 0.632 | -0.334 | -0.157 | -0.092 | 0.065 | -0.081 | -0.063 | 0.018 |
| 26 | e059a_c | -0.198 | 0.034 | -0.222 | -0.267 | -0.045 | 0.196 | -0.013 | -0.209 |
| 27 | e059b_c | 0.252 | -0.096 | -0.143 | 0.052 | 0.195 | 0.100 | 0.005 | -0.095 |
| 28 | e059c_c | -0.194 | 0.050 | 0.096 | 0.426 | 0.330 | 0.288 | -0.015 | -0.303 |
| 29 | e059d_c | -0.068 | -0.102 | 0.323 | -0.032 | -0.355 | -0.133 | -0.266 | -0.133 |
| 30 | e059e_c | 0.142 | -0.164 | -0.223 | -0.144 | 0.079 | 0.321 | 0.009 | -0.312 |
| 31 | e059f_c | 0.088 | -0.054 | 0.309 | 0.344 | 0.035 | -0.122 | -0.295 | -0.173 |

| | | Gender | Immigration background | Wave | | | Books | | |
|-------------|---------|-------------------|---------------------------|--------|--------|--------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 1 vs 2 | 1 vs 3 | 2 vs 3 | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 32 | e059g_c | 0.066 | -0.042 | 0.124 | 0.080 | -0.044 | 0.174 | 0.072 | -0.102 |
| 33 | e059i_c | -0.076 | -0.046 | 0.082 | -0.232 | -0.314 | -0.325 | -0.455 | -0.130 |
| main effect | | 0.112 | -0.010 | -0.143 | -0.224 | -0.081 | 0.325 | 0.608 | 0.283 |

In Table 6, the models with DIF are compared with those that included only the main effect of the respective variable. Regarding Akaike's (1974) information criterion (AIC), the more parsimonious models including only main effects were preferred over the ones containing the variables immigration background and wave. The Bayesian information criterion (BIC; Schwarz, 1978) takes into account the number of estimated parameters and thus prevents the overparameterization of models. Using BIC, the more complex model including DIF was preferred only for the variable gender.

Table 6

Comparison of Models With and Without DIF

| DIF variable | Model | Number of parameters | AIC | BIC |
|------------------------|-------------|----------------------|-----------|-----------|
| Gender | main effect | 35 | 83,890.82 | 83,948.24 |
| | DIF | 68 | 83,798.31 | 83,909.78 |
| Immigration background | main effect | 35 | 83,294.25 | 83,351.67 |
| | DIF | 68 | 83,319.74 | 83,431.20 |
| Wave | main effect | 36 | 84,198.51 | 84,257.62 |
| | DIF | 102 | 84,220.07 | 84,387.27 |
| Books | main effect | 36 | 83,673.29 | 83,732.40 |
| | DIF | 102 | 83,672.45 | 83,839.64 |

5.3.3 Rasch homogeneity

One essential assumption of the Rasch (1960) model is Rasch homogeneity. Rasch homogeneity implies that all item-discrimination parameters are equal. In order to test this assumption, a Birnbaum model (2PL; Birnbaum, 1986) was specified. In this model, discrimination parameters are freely estimated and not fixed to 1. The estimated discriminations differed across the items (see Table 4), ranging from 0.38 (item e022f_c) to 4.33 (item e075a_c). Item e065c_c had a negative discrimination, paradoxically indicating that students with lower ability had a higher probability of solving the item. Therefore, after we rechecked the coding procedure, this item was excluded from further analyses. Despite the empirical preference for the 2PL (AIC = 81759.24, BIC = 82174.85, number of parameters = 64) model, the Rasch model (AIC = 84,212.74, BIC = 84,268.47, number of parameters = 33) more adequately matched the theoretical conceptions underlying the construction of the test (see Pohl & Carstensen, 2012, 2013 for a discussion of this issue). For this reason, the 1PL model was chosen as the scaling model.

5.3.4 Unidimensionality and local item independence

The unidimensionality and assumption of local item independency of the test was further investigated by comparing the unidimensional model with a testlet model (Wang, & Wilson, 2005; see Figure 6) in which the factor loadings were constrained to 1. The testlet model, which was based on the seven texts, was estimated with the Monte Carlo estimation algorithm implemented in ConQuest. Covariances between the testlet-specific factors and be-

tween the testlet-specific factors and the general factor were fixed to zero in this model. Comparing the model fit indices of the unidimensional model (see section 5.3.3) with the testlet model (AIC: 82,658.28, BIC: 82,724.14, number of parameters = 39) suggested that the testlet model fit the data better. However, for theoretical reasons, we used the unidimensional Rasch model for estimating the WLEs. We encourage the reader to further investigate the potential use of such models over the course of running their analyses. The variance of the testlet factors ranged from 0.52 to 1.32. The variance of the common factor was 1.37.

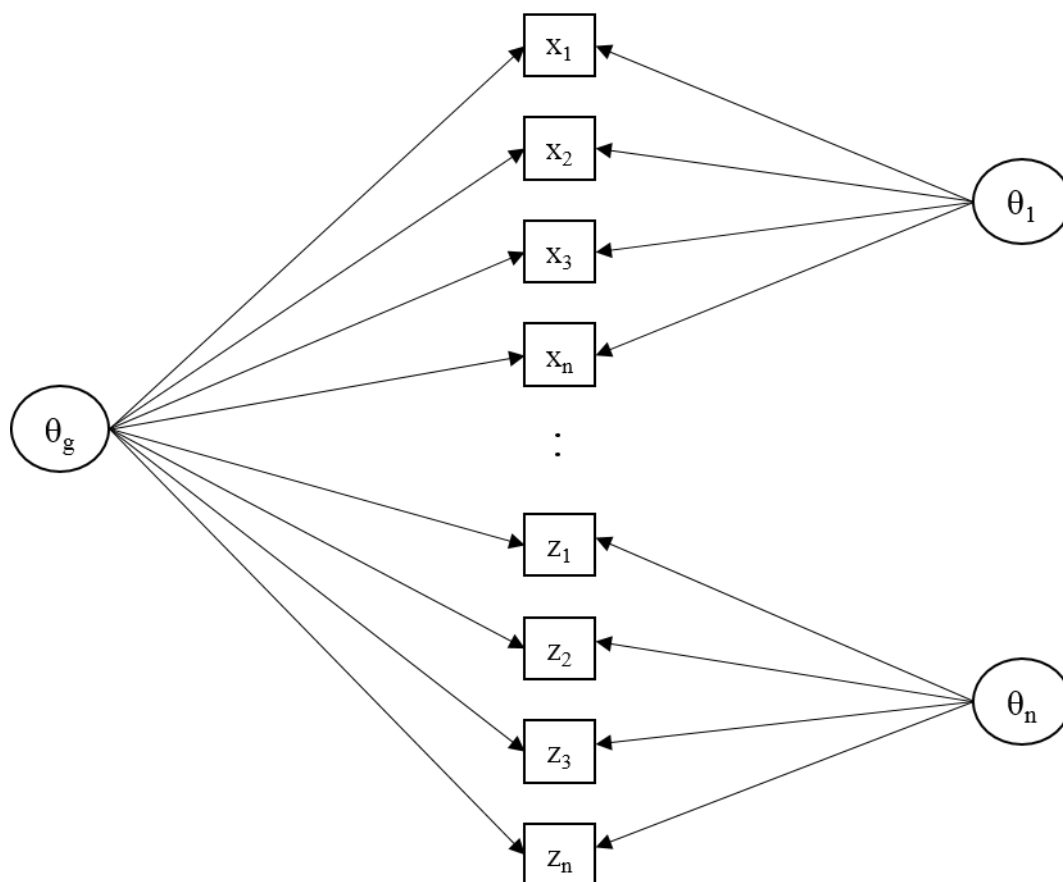


Figure 6. The testlet model that was specified and tested against the unidimensional model. The testlet model consisted of one general latent variable θ_g and testlet-specific latent variables ($\theta_1 - \theta_n$) as well as testlet-specific indicators (X_1-X_n, Z_1-Z_n).

6. Discussion

Descriptions and analyses presented in the previous sections were aimed at documenting the quality of the English reading competence test used in the additional study Baden-Wuerttemberg. The occurrence of different kinds of missing responses was evaluated, and item as well as test quality was examined. Furthermore, measurement invariance with regard to item difficulties was examined for various grouping variables. The item fit statistics provided evidence of items with good fit that were measurement invariant across these subgroups. The test was found to be reasonably reliable. As shown, ability estimates for participants with low performance were found to be precise but less precise for medium- and high-performing participants.

7. Data in the Scientific Use File

The data in the Scientific Use File contain 33 items, all of which are scored as dichotomous variables with 0 indicating an incorrect response and 1 indicating a correct response. MC items are marked with a ‘_c’ at the end of the variable name. Appendix A provides the syntax that was used to generate the person estimates with the ConQuest 4.2 software (Wu, Adams, Wilson, & Haldane, 1997). Appendix B provides an alternative syntax for use with the TAM package (Kiefer, Robitzsch, & Wu, 2015) in the software R (R Core Team, 2015).

Manifest English competence scores are provided in the form of WLEs (e_sc1) along with their corresponding standard errors (e_sc2). As described in Section 5, these person estimates were derived from the joint scaling of all three waves of the study. For persons who did not take the English test, no WLE was estimated. WLEs were estimated for all items delivered in the Scientific Use File. Items with negative discriminations in the 2PL were excluded, therefore the delivered WLE is based on 32 items (item e065c_c was excluded). In order to allow the users to estimate their own WLEs by considering different item selection standards, all test items are delivered in the Scientific Use File. For researchers interested in analyses that require one of the variables that showed $DIF > 0.6$ logits, we emphasize that models should be considered on the basis of partial measurement invariance (e.g. Byrne, Shavelson, & Muthén, 1989).

We recommend the use of plausible values to investigate latent relationships between competence scores and other variables. Users interested in examining latent relationships may either include the measurement model in their analyses or estimate plausible values themselves. A description of these approaches can be found in Pohl and Carstensen (2012).

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This paper used data from the National Educational Panel Study (NEPS): Additional Study Baden-Wuerttemberg, doi:10.5157/NEPS:BW:3.0.0. From 2008 to 2013, NEPS data were collected as part of the Framework Program for the Promotion of Empirical Educational Research funded by the German Federal Ministry of Education and Research (BMBF). As of 2014, NEPS is carried out by the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg in cooperation with a nationwide network.

Appendix

Appendix A: ConQuest Syntax for generating WLE estimates in the Additional Study Baden-Wuerttemberg

title Additional Study Baden-Wuerttemberg, English, Waves 1-3;

datafile filename.dat;

format pid 1-7 responses 12-13;

labels << labels.nam;

codes 0,1;

model item;

set constraints=cases;

estimate ! stderr=empirical;

itanal ! form=long >> filename.itn;

export parameters >> filename.prm;

show cases ! estimates=wle >> filename.wle;

show ! estimates=latent, tables=1:2:3:4:5 >> filename.shw;

Appendix B: TAM Syntax for generating WLE estimates in the Additional Study Baden-Wuerttemberg

```
setwd ("Your/Working/Directory")

data <- # data read

items <- # column positions of the English items in the SUF

library (TAM)

# Compute Rasch

RASCH <- tam(data[,items], irtmodel="Rasch", pid=data$id)

summary (RASCH)

# Compute 2 PL- Modell

TWOPL <- tam.mml.2pl(data[,items], irtmodel="2PL", pid=data$id)

summary (TWOPL)
```

Appendix C1: Item Parameters and Differential Item Functioning for Wave 1 from the Additional Study Baden-Wuerttemberg only

Table 7

Item Parameters of the English Test – Wave 1

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 1 | e108a_c | 97.40 | -4.227 | 0.255 | 0.99 | 0.0 | 0.19 |
| 2 | e108b_c | 87.58 | -2.408 | 0.134 | 1.09 | 1.0 | 0.31 |
| 3 | e108c_c | 67.61 | -0.947 | 0.103 | 0.96 | -1.0 | 0.55 |
| 4 | e108d_c | 91.74 | -2.925 | 0.156 | 0.98 | -0.1 | 0.36 |
| 5 | e022b_c | 55.19 | -0.294 | 0.098 | 1.19 | 5.1 | 0.32 |
| 6 | e022c_c | 92.79 | -3.096 | 0.165 | 1.07 | 0.6 | 0.22 |
| 7 | e022d_c | 90.05 | -2.694 | 0.149 | 1.00 | 0.0 | 0.38 |
| 8 | e022e_c | 83.90 | -2.072 | 0.123 | 1.17 | 2.3 | 0.26 |
| 9 | e022f_c | 69.38 | -1.063 | 0.103 | 1.20 | 4.2 | 0.30 |
| 10 | e022g_c | 69.58 | -1.071 | 0.104 | 1.06 | 1.2 | 0.45 |
| 11 | e022h_c | 95.97 | -3.754 | 0.212 | 0.98 | -0.1 | 0.26 |
| 12 | e022i_c | 78.33 | -1.630 | 0.113 | 1.12 | 2.0 | 0.34 |
| 13 | e008a_c | 82.67 | -1.953 | 0.089 | 0.98 | -0.3 | 0.48 |
| 14 | e008b_c | 86.77 | -2.333 | 0.097 | 0.97 | -0.6 | 0.46 |

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 15 | e008c_c | 78.60 | -1.635 | 0.084 | 1.00 | 0.0 | 0.49 |
| 16 | e008e_c | 74.24 | -1.336 | 0.080 | 0.92 | -2.1 | 0.58 |
| 17 | e075a_c | 78.22 | -1.609 | 0.083 | 0.88 | -3.0 | 0.60 |
| 18 | e075b_c | 84.16 | -2.081 | 0.092 | 0.90 | -2.0 | 0.56 |
| 19 | e075c_c | 76.52 | -1.492 | 0.082 | 0.90 | -2.6 | 0.58 |
| 20 | e075d_c | 78.11 | -1.605 | 0.083 | 0.89 | -2.9 | 0.60 |
| 21 | e057a_c | 92.04 | -2.972 | 0.119 | 1.10 | 1.3 | 0.22 |
| 22 | e065a_c | 84.00 | -2.072 | 0.127 | 1.06 | 0.9 | 0.40 |
| 23 | e065b_c | 88.46 | -2.513 | 0.143 | 1.04 | 0.5 | 0.36 |
| 25 | e065d_c | 74.64 | -1.363 | 0.111 | 1.16 | 2.8 | 0.37 |
| 26 | e059a_c | 89.48 | -2.596 | 0.151 | 0.91 | -0.9 | 0.49 |
| 27 | e059b_c | 89.53 | -2.614 | 0.151 | 0.90 | -1.1 | 0.52 |
| 28 | e059c_c | 85.35 | -2.188 | 0.132 | 1.01 | 0.2 | 0.44 |
| 29 | e059d_c | 94.35 | -3.379 | 0.190 | 0.87 | -0.9 | 0.48 |
| 30 | e059e_c | 76.09 | -1.426 | 0.115 | 1.03 | 0.5 | 0.48 |
| 31 | e059f_c | 65.11 | -0.773 | 0.104 | 1.17 | 3.8 | 0.37 |
| 32 | e059g_c | 85.08 | -2.146 | 0.132 | 0.92 | -1.0 | 0.53 |

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 33 | e059i_c | 83.63 | -2.018 | 0.127 | 1.11 | 1.5 | 0.34 |

Table 8

Differential Item Functioning – Wave 1

| | | Gender | Immigration background | Books | | |
|------|---------|-------------------|---------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 1 | e108a_c | -0.066 | 0.412 | -0.217 | 0.386 | 0.603 |
| 2 | e108b_c | -0.276 | -0.128 | -0.034 | -0.572 | -0.538 |
| 3 | e108c_c | -0.068 | 0.544 | 0.281 | -0.092 | -0.373 |
| 4 | e108d_c | -0.470 | 0.018 | 0.163 | 0.425 | 0.262 |
| 5 | e022b_c | -0.132 | 0.154 | 0.206 | -0.164 | -0.370 |
| 6 | e022c_c | 0.632 | 0.212 | -0.014 | -0.010 | 0.004 |
| 7 | e022d_c | -0.232 | -0.028 | -0.059 | -0.011 | 0.048 |
| 8 | e022e_c | -0.108 | -0.272 | -0.304 | -0.518 | -0.214 |
| 9 | e022f_c | 0.376 | -0.264 | 0.020 | -0.281 | -0.301 |

| | | Gender | Immigration background | Books | | |
|-------------|---------|-------------------|-----------------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 10 | e022g_c | 0.166 | -0.334 | 0.248 | 0.025 | -0.223 |
| 11 | e022h_c | -0.186 | -0.466 | 0.405 | -0.498 | -0.903 |
| 12 | e022i_c | 0.334 | 0.038 | 0.091 | 0.021 | -0.070 |
| 13 | e008a_c | 0.002 | -0.280 | 0.131 | 0.127 | -0.004 |
| 14 | e008b_c | 0.420 | -0.190 | -0.224 | -0.382 | -0.158 |
| 15 | e008c_c | -0.026 | -0.320 | -0.024 | 0.076 | 0.100 |
| 16 | e008e_c | -0.432 | -0.086 | 0.084 | 0.082 | -0.002 |
| 17 | e075a_c | -0.252 | 0.002 | -0.013 | 0.162 | 0.175 |
| 18 | e075b_c | -0.030 | 0.060 | -0.108 | 0.375 | 0.483 |
| 19 | e075c_c | -0.226 | -0.062 | -0.024 | 0.132 | 0.156 |
| 20 | e075d_c | 0.036 | -0.054 | -0.135 | 0.129 | 0.264 |
| 21 | e057a_c | 0.042 | 0.212 | -0.199 | 0.265 | 0.464 |
| 22 | e065a_c | 0.392 | 0.536 | -0.252 | -0.084 | 0.168 |
| 23 | e065b_c | 0.740 | 0.280 | -0.150 | -0.399 | -0.249 |
| 25 | e065d_c | 0.556 | -0.076 | -0.494 | -0.152 | 0.342 |
| 26 | e059a_c | -0.526 | 0.466 | 0.284 | 0.215 | -0.069 |

| | | Gender | Immigration background | Books | | |
|-------------|---------|-------------------|-----------------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 27 | e059b_c | 0.120 | 0.296 | 0.270 | 0.333 | 0.063 |
| 28 | e059c_c | -0.258 | 0.248 | 0.139 | 0.126 | -0.013 |
| 29 | e059d_c | -0.026 | 0.642 | 0.002 | -0.605 | -0.607 |
| 30 | e059e_c | 0.104 | -0.264 | -0.023 | -0.193 | -0.170 |
| 31 | e059f_c | -0.016 | 0.004 | 0.058 | 0.058 | 0.000 |
| 32 | e059g_c | -0.128 | 0.586 | 0.111 | 0.015 | -0.096 |
| 33 | e059i_c | 0.136 | 0.310 | -0.462 | -0.294 | 0.168 |
| main effect | | -0.066 | 0.018 | 0.225 | 0.486 | 0.261 |

Appendix C2: Item Parameters and Differential Item Functioning for Wave 2 from the Additional Study Baden-Wuerttemberg only

Table 9

Item Parameters of the English Test – Wave 2

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 1 | e108a_c | 96.58 | -3.892 | 0.167 | 1.02 | 0.2 | 0.19 |
| 2 | e108b_c | 88.50 | -2.471 | 0.102 | 1.14 | 2.0 | 0.24 |
| 3 | e108c_c | 66.95 | -0.861 | 0.076 | 1.06 | 2.0 | 0.45 |
| 4 | e108d_c | 89.40 | -2.572 | 0.105 | 1.02 | 0.3 | 0.35 |
| 5 | e022b_c | 58.67 | -0.422 | 0.073 | 1.16 | 5.5 | 0.35 |
| 6 | e022c_c | 93.41 | -3.152 | 0.126 | 1.00 | -0.0 | 0.31 |
| 7 | e022d_c | 87.25 | -2.329 | 0.100 | 1.00 | 0.0 | 0.41 |
| 8 | e022e_c | 82.39 | -1.893 | 0.088 | 1.14 | 2.9 | 0.29 |
| 9 | e022f_c | 66.53 | -0.847 | 0.075 | 1.20 | 6.2 | 0.31 |
| 10 | e022g_c | 65.20 | -0.776 | 0.075 | 1.10 | 3.1 | 0.43 |
| 11 | e022h_c | 94.64 | -3.391 | 0.138 | 0.96 | -0.4 | 0.34 |
| 12 | e022i_c | 82.59 | -1.899 | 0.089 | 1.17 | 3.2 | 0.27 |
| 13 | e008a_c | 79.17 | -1.696 | 0.062 | 1.00 | 0.0 | 0.49 |
| 14 | e008b_c | 86.24 | -2.300 | 0.070 | 0.98 | -0.5 | 0.45 |

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 15 | e008c_c | 76.07 | -1.478 | 0.060 | 0.94 | -2.1 | 0.55 |
| 16 | e008e_c | 70.38 | -1.114 | 0.057 | 0.92 | -3.5 | 0.59 |
| 17 | e075a_c | 74.33 | -1.362 | 0.059 | 0.84 | -6.2 | 0.65 |
| 18 | e075b_c | 79.92 | -1.755 | 0.063 | 0.86 | -4.6 | 0.61 |
| 19 | e075c_c | 73.29 | -1.296 | 0.059 | 0.88 | -4.6 | 0.61 |
| 20 | e075d_c | 74.96 | -1.405 | 0.059 | 0.86 | -5.3 | 0.63 |
| 21 | e057a_c | 89.05 | -2.593 | 0.077 | 1.10 | 2.0 | 0.29 |
| 22 | e065a_c | 84.60 | -2.214 | 0.094 | 1.11 | 2.0 | 0.35 |
| 23 | e065b_c | 91.02 | -2.927 | 0.114 | 1.05 | 0.7 | 0.31 |
| 25 | e065d_c | 68.74 | -1.067 | 0.078 | 1.19 | 5.3 | 0.36 |
| 26 | e059a_c | 85.09 | -2.239 | 0.096 | 0.95 | -0.9 | 0.49 |
| 27 | e059b_c | 86.10 | -2.336 | 0.098 | 0.96 | -0.7 | 0.49 |
| 28 | e059c_c | 84.00 | -2.148 | 0.093 | 1.07 | 1.3 | 0.38 |
| 29 | e059d_c | 94.73 | -3.569 | 0.141 | 0.92 | -0.8 | 0.40 |
| 30 | e059e_c | 69.03 | -1.064 | 0.079 | 0.96 | -1.3 | 0.56 |
| 31 | e059f_c | 66.95 | -0.942 | 0.077 | 1.17 | 4.9 | 0.39 |
| 32 | e059g_c | 84.01 | -2.133 | 0.094 | 0.96 | -0.8 | 0.50 |

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 33 | e059i_c | 81.88 | -1.963 | 0.090 | 1.17 | 3.4 | 0.32 |

Table 10

Differential Item Functioning – Wave 2

| | | Gender | Immigration background | Books | | |
|------|---------|-------------------|---------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 1 | e108a_c | 0.440 | -0.180 | -0.579 | -0.345 | 0.234 |
| 2 | e108b_c | 0.026 | 0.044 | -0.132 | -0.375 | -0.243 |
| 3 | e108c_c | -0.024 | 0.152 | -0.170 | -0.085 | 0.085 |
| 4 | e108d_c | 0.142 | 0.144 | 0.322 | -0.130 | -0.452 |
| 5 | e022b_c | -0.172 | -0.004 | -0.084 | -0.141 | -0.057 |
| 6 | e022c_c | -0.110 | -0.032 | -0.023 | -0.295 | -0.272 |
| 7 | e022d_c | -0.188 | 0.160 | -0.419 | 0.114 | 0.533 |
| 8 | e022e_c | 0.008 | 0.094 | -0.003 | -0.508 | -0.505 |
| 9 | e022f_c | -0.004 | 0.208 | -0.462 | -0.382 | 0.080 |

| | | Gender | Immigration background | Books | | |
|-------------|---------|-------------------|-----------------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 10 | e022g_c | -0.024 | -0.344 | -0.348 | -0.600 | -0.252 |
| 11 | e022h_c | -0.006 | -0.356 | -0.108 | -0.072 | 0.036 |
| 12 | e022i_c | -0.104 | -0.090 | -0.164 | -0.061 | 0.103 |
| 13 | e008a_c | 0.228 | -0.022 | 0.058 | -0.010 | -0.068 |
| 14 | e008b_c | 0.306 | 0.060 | 0.229 | 0.257 | 0.028 |
| 15 | e008c_c | -0.230 | -0.032 | -0.007 | 0.229 | 0.236 |
| 16 | e008e_c | -0.360 | -0.120 | 0.125 | 0.448 | 0.323 |
| 17 | e075a_c | -0.378 | -0.016 | -0.015 | 0.357 | 0.372 |
| 18 | e075b_c | -0.092 | -0.034 | -0.069 | 0.066 | 0.135 |
| 19 | e075c_c | -0.148 | 0.146 | 0.034 | 0.089 | 0.055 |
| 20 | e075d_c | -0.154 | 0.006 | 0.086 | 0.007 | -0.079 |
| 21 | e057a_c | 0.278 | 0.260 | 0.481 | 0.205 | -0.276 |
| 22 | e065a_c | 0.664 | 0.182 | 0.012 | 0.006 | -0.006 |
| 23 | e065b_c | 0.464 | -0.120 | 0.086 | 0.064 | -0.022 |
| 25 | e065d_c | 0.672 | -0.318 | 0.029 | -0.017 | -0.046 |
| 26 | e059a_c | -0.222 | -0.006 | 0.080 | -0.047 | -0.127 |

| | | Gender | Immigration background | Books | | |
|-------------|---------|-------------------|-----------------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 27 | e059b_c | 0.302 | -0.096 | 0.060 | -0.018 | -0.078 |
| 28 | e059c_c | -0.152 | 0.290 | 0.333 | -0.001 | -0.334 |
| 29 | e059d_c | -0.228 | -0.170 | -0.248 | 0.068 | 0.316 |
| 30 | e059e_c | 0.168 | -0.042 | 0.495 | 0.255 | -0.240 |
| 31 | e059f_c | 0.388 | 0.096 | -0.162 | -0.346 | -0.184 |
| 32 | e059g_c | 0.058 | -0.312 | 0.373 | 0.278 | -0.095 |
| 33 | e059i_c | 0.086 | 0.108 | -0.448 | -0.577 | -0.129 |
| main effect | | 0.178 | -0.006 | 0.319 | 0.605 | 0.286 |

Appendix C3: Item Parameters and Differential Item Functioning for Wave 3 from the Additional Study Baden-Wuerttemberg only

Table 11

Item Parameters of the English Test – Wave 3

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 1 | e108a_c | 94.49 | -3.379 | 0.193 | 1.00 | 0.1 | 0.26 |
| 2 | e108b_c | 87.38 | -2.368 | 0.140 | 1.10 | 1.2 | 0.27 |
| 3 | e108c_c | 64.78 | -0.753 | 0.107 | 1.02 | 0.4 | 0.50 |
| 4 | e108d_c | 88.65 | -2.503 | 0.146 | 0.98 | -0.2 | 0.40 |
| 5 | e022b_c | 59.27 | -0.466 | 0.104 | 1.15 | 3.6 | 0.38 |
| 6 | e022c_c | 92.15 | -2.964 | 0.167 | 1.01 | 0.1 | 0.31 |
| 7 | e022d_c | 86.25 | -2.252 | 0.138 | 0.98 | -0.2 | 0.44 |
| 8 | e022e_c | 81.70 | -1.853 | 0.124 | 1.11 | 1.7 | 0.32 |
| 9 | e022f_c | 65.88 | -0.824 | 0.107 | 1.26 | 5.4 | 0.26 |
| 10 | e022g_c | 64.47 | -0.736 | 0.106 | 1.11 | 2.6 | 0.40 |
| 11 | e022h_c | 93.80 | -3.242 | 0.184 | 0.94 | -0.4 | 0.40 |
| 12 | e022i_c | 79.70 | -1.688 | 0.121 | 1.14 | 2.2 | 0.33 |
| 13 | e008a_c | 77.00 | -1.556 | 0.086 | 0.99 | -0.1 | 0.50 |
| 14 | e008b_c | 84.79 | -2.182 | 0.097 | 0.98 | -0.3 | 0.47 |

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|------------------|--|
| 15 | e008c_c | 75.13 | -1.425 | 0.085 | 0.93 | -1.8 | 0.56 |
| 16 | e008e_c | 71.17 | -1.169 | 0.082 | 0.89 | -3.2 | 0.61 |
| 17 | e075a_c | 71.96 | -1.224 | 0.083 | 0.90 | -2.8 | 0.60 |
| 18 | e075b_c | 78.14 | -1.636 | 0.088 | 0.91 | -2.2 | 0.59 |
| 19 | e075c_c | 70.73 | -1.142 | 0.082 | 0.92 | -2.5 | 0.59 |
| 20 | e075d_c | 72.15 | -1.230 | 0.083 | 0.85 | -4.2 | 0.64 |
| 21 | e057a_c | 90.58 | -2.825 | 0.115 | 1.11 | 1.5 | 0.24 |
| 22 | e065a_c | 81.46 | -1.974 | 0.126 | 1.10 | 1.5 | 0.40 |
| 23 | e065b_c | 90.41 | -2.883 | 0.157 | 1.02 | 0.2 | 0.37 |
| 25 | e065d_c | 68.22 | -1.055 | 0.110 | 1.18 | 3.5 | 0.39 |
| 26 | e059a_c | 83.31 | -2.121 | 0.130 | 0.92 | -1.1 | 0.55 |
| 27 | e059b_c | 86.99 | -2.458 | 0.143 | 0.93 | -0.8 | 0.50 |
| 28 | e059c_c | 86.26 | -2.406 | 0.139 | 1.01 | 0.1 | 0.43 |
| 29 | e059d_c | 92.18 | -3.144 | 0.170 | 0.89 | -0.9 | 0.47 |
| 30 | e059e_c | 68.53 | -1.066 | 0.111 | 0.97 | -0.7 | 0.56 |
| 31 | e059f_c | 65.77 | -0.899 | 0.109 | 1.18 | 3.6 | 0.40 |
| 32 | e059g_c | 82.24 | -2.016 | 0.130 | 0.96 | -0.6 | 0.52 |

| | Item | Percentage correct | Difficulty/ location parameter | SE (difficulty/ location parameter) | WMNSQ | WMNSQ t-value | Correlation of item score with total score |
|----|---------|--------------------|--------------------------------|--|-------|---------------|--|
| 33 | e059i_c | 76.30 | -1.574 | 0.118 | 1.14 | 2.3 | 0.39 |

Table 12

Differential Item Functioning – Wave 3

| | | Gender | Immigration background | Books | | |
|------|---------|----------------|------------------------|------------------|----------------|------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 1 | e108a_c | 0.094 | -0.326 | -0.228 | -0.024 | 0.204 |
| 2 | e108b_c | -0.178 | 0.262 | 0.210 | -0.063 | -0.273 |
| 3 | e108c_c | 0.204 | 0.694 | -0.423 | -0.123 | 0.300 |
| 4 | e108d_c | -0.156 | 0.868 | -0.632 | -0.478 | 0.154 |
| 5 | e022b_c | -0.252 | 0.656 | -0.025 | 0.001 | 0.026 |
| 6 | e022c_c | 0.112 | 0.110 | -0.264 | -0.299 | -0.035 |
| 7 | e022d_c | -0.122 | 0.644 | 0.095 | 0.403 | 0.308 |
| 8 | e022e_c | 0.346 | 0.492 | 0.738 | 0.453 | -0.285 |
| 9 | e022f_c | -0.044 | 0.104 | -0.399 | -0.177 | 0.222 |

| | | Gender | Immigration background | Books | | |
|-------------|---------|-------------------|-----------------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 10 | e022g_c | 0.098 | 0.544 | 0.082 | -0.025 | -0.107 |
| 11 | e022h_c | -0.132 | -0.024 | 0.849 | 0.567 | -0.282 |
| 12 | e022i_c | 0.412 | 0.096 | -0.390 | 0.021 | 0.411 |
| 13 | e008a_c | 0.034 | -0.154 | 0.153 | 0.273 | 0.120 |
| 14 | e008b_c | 0.176 | -0.068 | 0.325 | 0.349 | 0.024 |
| 15 | e008c_c | -0.214 | -0.062 | 0.537 | 0.486 | -0.051 |
| 16 | e008e_c | -0.346 | -0.054 | 0.551 | 0.585 | 0.034 |
| 17 | e075a_c | -0.142 | 0.186 | -0.270 | 0.029 | 0.299 |
| 18 | e075b_c | 0.130 | 0.078 | -0.173 | -0.097 | 0.076 |
| 19 | e075c_c | -0.086 | -0.002 | -0.278 | -0.108 | 0.170 |
| 20 | e075d_c | -0.086 | -0.008 | -0.204 | 0.054 | 0.258 |
| 21 | e057a_c | 0.100 | 0.082 | 0.377 | 0.058 | -0.319 |
| 22 | e065a_c | 0.358 | -0.572 | -0.124 | -0.074 | 0.050 |
| 23 | e065b_c | 0.652 | -0.076 | 0.054 | 0.429 | 0.375 |
| 25 | e065d_c | 0.636 | -0.572 | 0.100 | -0.088 | -0.188 |
| 26 | e059a_c | 0.050 | -0.228 | 0.390 | -0.122 | -0.512 |

| | | Gender | Immigration background | Books | | |
|-------------|---------|-------------------|-----------------------------------|---------------------|-------------------|---------------------|
| Item | | male vs female | without vs with | 0-200 vs 201-500 | 0-200 vs > 500 | 201-500 vs > 500 |
| 27 | e059b_c | 0.266 | -0.426 | 0.086 | -0.227 | -0.313 |
| 28 | e059c_c | -0.190 | -0.632 | 0.438 | -0.162 | -0.600 |
| 29 | e059d_c | 0.108 | -0.820 | -0.049 | -0.347 | -0.298 |
| 30 | e059e_c | 0.132 | -0.272 | 0.307 | -0.286 | -0.593 |
| 31 | e059f_c | -0.386 | -0.382 | -0.229 | -0.546 | -0.317 |
| 32 | e059g_c | 0.266 | -0.250 | -0.153 | -0.234 | -0.081 |
| 33 | e059i_c | -0.540 | -0.650 | -0.017 | -0.400 | -0.383 |
| main effect | | 0.178 | -0.068 | 0.475 | 0.779 | 0.304 |