

Measurement equivalence of the Big Five:

Shedding further light on potential causes of the educational bias

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Abstract

Rammstedt, Goldberg, and Borg (2010) demonstrated that the Big Five factor structure is sensitive to educational bias and that this bias seems to be due to a more pronounced tendency for acquiescent responding among less well-educated respondents. The present follow-up study investigated whether using an interview assessment mode in which the item presentation is standardized and thus differences in reading ability are controlled for, reduces the bias in the factorial structures. Results based on a large and heterogeneous sample clearly contradict this assumption: The findings unambiguously replicate those reported by Rammstedt et al. in that lower educated respondents have a higher and more varied tendency for acquiescent responding which directly affects the factor structure of the Big Five measure.

Keywords: Big Five, measurement equivalence, acquiescence response bias, factor structure, personal interview

Personality research is primarily based on rather homogeneous samples, mainly samples consisting of college students. These samples differ from the general population in some important aspects: college students are younger, more highly educated, and in general more intelligent. These differences have been shown to have a substantial impact on response behavior in personality questionnaires. Previous research clearly showed that less educated respondents have a higher tendency for acquiescent response bias than higher educated respondents (e.g. Meisenberg & Williams, 2008). These differences in response behavior may in turn affect the psychometric properties of personality questionnaires. In lower educated samples the psychometric quality seems to be lower than in higher educated samples (Rammstedt, Goldberg, & Borg, 2010). In particular, the factor structure seems to be affected by the systematic variance in trait ratings introduced by differential use of the response options (e.g. Ziegler & Bühner, 2009). This in turn raises the question whether the questionnaires used in personality research and validated for student populations are measurement equivalent for groups differing in education.

In a recent study Rammstedt et al. (2010) demonstrated that the Big Five factor structure is sensitive to educational biases and that these biases seem to be due to a more pronounced tendency for acquiescent responding among less well-educated respondents. Acquiescence or “Yeah-saying” refers to the tendency of an individual to consistently agree to questionnaire items regardless of the item content (Jackson & Messick, 1958). Particularly, individuals with lower education seem to be prone to this kind of response bias (e.g. Meisenberg & Williams, 2008; Winkler, Kanouse, & Ware, 1982). Rammstedt et al. (2010) used two large samples representative of the German adult population and found substantial differences in acquiescent responding between groups of low, intermediate, and high education. Acquiescent responding was highest in the low education group and lowest in the high education group. Whereas the Big Five factor structure did not emerge in the group with

low and intermediate education, it clearly emerged in the highly educated group. After controlling for acquiescent responding, the Big Five model held at all educational levels.

Results of this study thus suggest that the tendency for acquiescent responding may blur the factor structure of Big Five scales and that especially lower educated respondents tend to be more prone to such a tendency. But where in the process of responding to questionnaire items does this tendency for acquiescent responding and thus the resulting educational bias come into play? Adapting the model proposed by Tourangeau, Rips, and Rasinski (2000) this cognitive process can be divided into five steps: First, the respondent needs to read the item and response options. Second, he needs to understand its content or meaning. Then he needs to retrieve the relevant information from memory and then make a judgment based on the retrieved information. Finally, this judgment needs to be fitted onto the response options given.

Previous studies indicate that the found educational bias seems to be moderated primarily by differences in cognitive ability, especially in verbal abilities (Messick & Frederikson, 1958). These verbal abilities include – especially at the low literate level – reading ability. Thus, for less intelligent respondents the effort associated with the first step in the described cognitive process, namely the careful reading of the stimulus items can be assumed to be much higher than for respondents with high cognitive ability. Therefore, differences in reading ability might be regarded as one possible explanation for individual differences in acquiescent response tendencies between high and low educated groups found by Rammstedt et al. (2010). Controlling for differences in reading the items and response options should therefore eliminate the found differences between high and low educated in acquiescent responding and thus in turn in the resulting factor structure.

The study by Rammstedt et al. (2010) used a paper-pencil assessment mode. In this mode the whole cognitive process described above is left to the respondent and is thus not controlled. No conclusion can be drawn as to whether the acquiescence is caused by

differences in reading the item, by a failure to retrieve relevant information or by a superficial judgment process.

In order to shed some light on the issue of cognitive processing, a research design is necessary which increases control over this process. As described above, it can be assumed that the educational bias already comes into play during the first step of the process, namely caused by differences in reading abilities between higher and lower educated. In order to control for differences in reading we used an interview assessment mode in which all items and response categories were read to the respondents. Thus, for all respondents the given information was standardized and no reading was necessary by the respondents so that it can be assumed that differences in reading abilities should have no influence on the response to the items. Thus, if our hypothesis holds and indeed differences in education are reflected in differences in the reading of the items and have in turn an effect on acquiescence response tendencies, then acquiescence should be markedly reduced in the present research setting, using interviews compared to self-administered written questionnaires.

Method

Analyses were based on a heterogeneous sample of $N = 888$ German adults (age $M = 40.4$, $SD = 14$, range 18 - 81, 46.8% male). Data was collected as part of a nation-wide telephone omnibus survey conducted by a commercial vendor. Telephone numbers were sampled at random based on the Random Digit Dialing Technique. The BFI-10 items and response options were read out by the interviewer while the respondent indicated the chosen response option. As respondents and interviewers were matched randomly the results reported cannot be due to systematic effects of different reading styles of interviewers.

As part of this omnibus survey a short-scale measure assessing the Big Five, the BFI-10 (Rammstedt & John, 2007) was used. The BFI-10 is an abbreviated 10-item version of the well-established Big Five Inventory (BFI; John, Donahue & Kentle, 1991; German version: Rammstedt, 1997). It assesses the Big Five with two balanced-keyed items per dimension

covering the two poles of each dimension (e.g., *I see myself as someone who is reserved* vs. *I see myself as someone who is outgoing, sociable*). The initial item selection for the BFI-10 was guided by (a) the psychometric quality of the items and (b) the comprehensibility for the general population, especially for lower educated respondents as assessed by cognitive interviewing techniques. The BFI-10 possesses sufficient reliability for research settings with retest-reliability coefficients between $r_{tt} = .68$ (Agreeableness) and $r_{tt} = .83$ (Extraversion). The psychometric quality of the BFI-10 was proven in several studies making it an accepted and frequently used short-measure for the assessment of the Big Five (Rammstedt, 2007a, 2007b; Rammstedt & John, 2007).

Results

In a first step, exploratory principal component analyses – the most commonly used procedure in Big Five research – was conducted on the correlations matrix of the BFI-10 variables.¹ The Eigenvalues > 1 criterion suggested to extract five factors which were subsequently rotated to simple structure using the Varimax criterion. Total variance explained was 71%. Besides item means and standard deviations (columns 1 and 2), Table 1 shows the rotated factor structure for the ten BFI-10 items, the explained variance per factor and the factor congruence with an idealized Big Five pattern (consisting of +1, -1, and 0 loadings only) (columns 3 to 7). The resulting structure was hardly interpretable in terms of the Big Five. Only the two Extraversion and the two Conscientiousness items formed discrete factors. For the other three dimensions the two corresponding items did not load on the same factor. The overall congruence of the factor solution with the idealized Big Five pattern was only .74 indicating a poor fit.

In a second step, we investigated whether this lack of replicability of the Big Five structure might be due to individual differences in acquiescent responding possibly stemming from differences in educational level as suggested by Rammstedt et al. (2010). Therefore, we split the sample with regard to the respondent's educational background into three distinct

groups, (1) lower secondary education (up to ten years of schooling; $N = 260$; age $M = 44.1$, $SD = 14.6$; 49.2% males), (2) intermediate secondary education (11 to 12 years of schooling; $N = 321$; age $M = 40.1$, $SD = 13.3$; 38.3% males), and (3) higher secondary education or tertiary education, i.e. those with an entrance qualification for universities or with a university degree (minimum 13 years of schooling; $N = 307$; age $M = 37.9$, $SD = 13.6$; 53.4% males). The latter group consisted of respondents usually investigated in personality research. Thus, this group was used as a reference group for effect size calculations of acquiescence scores (see below).

We then investigated the factor structure of the BFI-10 separately within each of the three subsamples. The Eigenvalues > 1 criterion suggested the extraction of four factors in the lowest and the highest educated subsample, and a five factor solution in the sample with intermediate secondary education. The Scree test criterion, however suggested the extraction of five factors in the highest educated group and less factors for both lower educated subsamples. To keep our analyses aligned with the Big Five model, we chose to extract five factors in all three subsamples. Total variance explained ranged between 66% and 67%. Table 2 shows the rotated factor loading matrices separately for the three subsamples. As suggested by prior research (Rammstedt et al., 2010) factor structures for the two subsamples with lower education were hardly interpretable in terms of the Big Five (mean congruence with the idealized factor structure of .65 and .75, respectively). In contrast, for the highly educated sample the Big Five could unambiguously be replicated (mean congruence of .90).

The findings of Rammstedt et al. (2010) suggest that the lack of measurement equivalence found in their study and replicated here is due to differences in response bias, namely in acquiescent responding and that this bias is mediated by education. To test whether this bias caused the inequivalence of the Big Five factor structure in the present study as well, an acquiescence index was computed for each respondent (cf. Soto, John, Gosling, & Potter, 2008; Rammstedt et al., 2010). The five pairs of balanced-keyed BFI-10 items each

representing opposite aspects of a Big Five dimension were averaged yielding within-person response means for each respondent. If an individual is responding consistently to the content, responses to items should be symmetrical concerning the response scale's midpoint.

Then, we used this index to test whether less educated respondents demonstrated a higher tendency for acquiescent responding and higher variation than persons with higher education. Indeed, in the lower educated subsample mean acquiescent index was 3.27 ($SD = .41$), in the intermediate group 3.20 ($SD = .40$), and in the higher educated group – thus, those usually investigated in personality research (reference group) - 3.16 ($SD = .34$). This difference was significant ($F_{[2,885]} = 6.12, p < .01$). Respondents with low secondary education had significantly higher scores in acquiescent responding than respondents with high secondary education ($p < .01$, Hedges $g = .29$) and slightly higher scores than respondents with intermediate secondary education ($p = .06$). Furthermore, the variance of this index significantly differed among the three groups ($F_{[2,885]} = 4.15, p < .05$), indicating a greater variation in the tendency for acquiescent responding in the lower and intermediate group compared to the high education group.

To test whether the found differences among the educational groups in the tendency for acquiescent responding were responsible for the lack of measurement equivalence shown in the blurred factor structures, we corrected each respondent's item responses for acquiescence. A common technique to remove variance due to acquiescence from personality questionnaires is ipsatizing (Ten Berge, 1999) referring to an individual standardization of the responses. As ipsatization not only controls for the individual mean (reflecting the individual tendency for acquiescent responding) but also for the individual standard deviation it has often been criticized for extracting too much variance, which in turn does not allow clear inferences to the biasing factor. A more conservative approach is to use mean-corrected data, thus only controlling for the individual mean by leaving individual differences in variance existent. In the present study we followed this latter approach and subtracted each

respondent's acquiescence score (individual mean) from his response to each BFI-10 item. Using these individual mean-corrected scores we repeated the factor analyses for the total sample and the three subsamples.

The Eigenvalues > 1 criterion suggested five-factor solutions for the total as well as for all three subsamples accounting for 71 to 73% of the variance. The resulting factor loading matrix for the total sample is depicted in Table 1, loading matrices for the three educational groups in Table 3. For both the total sample and the three subsamples, the rotated factor loading matrices were clearly interpretable in terms of the Big Five. In the total sample as well as in the groups with highest and with intermediate education all items loaded highest and substantially on their corresponding factors. Also in the lowest educated group the factorial structure became much clearer after the correction of the data. Even though all items loaded substantially on their corresponding factors one Openness item loaded slightly higher on Extraversion (.39) than on Openness (.36). Also the mean factor congruence increased for the overall (.94) and for all three subsamples (.87, .93, .93, respectively). Results thus indicate that the Big Five factor structure could unambiguously be identified in the present data after controlling for acquiescent response bias. However, in the lowest educated group the fit of the resulting factor structure was still somewhat lower than for the two higher educated groups.

The positive effect of correcting for acquiescence on the psychometric quality of the data is also reflected in the mean correlation of the corresponding items and thus in the within domain coherence (cf. Soto et al., 2008). Based on the total sample this mean correlation of the corresponding items is $r = -.21$ for the raw data and $r = -.37$ for the individual mean-corrected data. Results thus indicate an increase in within-domain coherence when controlling for acquiescence. Thus, by partialling out acquiescence, coherence within Big Five domains is increased thereby contributing to a clearer factor structure.

Discussion

The aim of the present study was to investigate whether standardizing the presentation of items and thus controlling for the variation due to the mere reading of the items and response options markedly reduces the educational bias in acquiescence response tendencies which in turn blurs the five-factor structure in lower educated groups. Results of this study clearly contradict this assumption. The findings unambiguously replicate those reported by Rammstedt et al. (2010). Despite controlling for differences in reading ability which were assumed to be reflected in differences in the reading of the items, lower educated respondents had a higher tendency for acquiescent responding and a higher variation in that tendency which in turn directly affected the factor structure of a Big Five questionnaire. Controlling for this acquiescence tendency the Big Five model held at all educational levels.

The results of the present study thus indicate that the mere reading of the items by the respondents does not have an effect on their tendency for acquiescent responding. Even though results clearly indicate that differences in education cause this bias in the resulting factor structure, it does not seem to be due to differences in reading ability reflected in higher difficulties reading the items in the lower educated groups. The effect of education on the processing of items apparently comes into play at a later stage in the cognitive process (cf. Tourangeau et al., 2000). Future studies – empirical and qualitative ones based on cognitive interviewing methods – should investigate the remaining steps in this cognitive process in more detail.

In contrast to the former study (Rammstedt et al. 2010) we used a more conservative approach for controlling for acquiescence. The widely used technique - also followed by Rammstedt et al. (2010) - of ipsatizing the raw data by controlling for the individual mean *and* the individual standard deviation does not only eliminate effects due to acquiescence but also due to other response styles, e.g. extreme responding. To reassure that the here found and controlled effects are merely due to acquiescence we controlled in the present study only for

the individual mean, leaving the standard deviations unaffected. The results of the two studies are highly comparable indicating that indeed acquiescence plays the central role in the blurred factor structures found based on the raw data. However, in the present study results based on the corrected data for the group with lowest education did not emerge in the same textbook-like clarity as in the previous study indicating that other response styles, e.g., the tendency for extreme or midpoint responding found in diverse self-report measures (cf. Kemper, 2010), may have affected participant's item responses and the resulting factor structure as well.

The present study contributes to the understanding of the educational bias in acquiescent response tendencies and its possible effects on the psychometric quality of personality questionnaires. Over the past years, the detrimental effect of acquiescence on the factorial validity of personality and attitude questionnaires has been repeatedly demonstrated (Ten Berge, 1999; Winkler, Kanouse, & Ware, 1982). The present study replicated results of a previous one (Rammstedt et al., 2010) indicating a moderating role of education for these detrimental effects. It is of note that the here found differences in acquiescence between the educational groups were rather small ($.11 < \text{Hedges } g < .29$). However, the effect of education on acquiescence seems to be robust as it was already found in two large representative samples before ($.08 < \text{Hedges } g < .42$; Rammstedt et al., 2010). Although differences in acquiescence between groups may be minor in size, their effect on the psychometric quality of a questionnaire seems to be substantial. The present results reveal that the correction for acquiescence by use of individual mean-corrected item scores prior to factor analysis seems a reasonable approach for the validation of personality measures when heterogeneous samples are used instead of student samples.

Even though the present study supports the generalizability of the moderating effect of education on acquiescence which in turn reduces psychometric quality, future studies need to show that the educational biases found here also generalize across different Big Five measures. All studies so far were based on either the full 44-item BFI (cf. Soto et al., 2008) or

on one of its abbreviated scales, the BFI-10. Future studies therefore have to show whether the effects of education on acquiescence and on the factor structure can be corroborated for other Big Five measures, e.g. the NEO-FFI (Costa & McCrae, 1992).

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Footnotes

1) Correlation matrices of BFI-10 items for each sample/subsample x data (raw vs. individual-mean corrected) combination can be obtained as supplemental online material on the JRP website

Table 1

Means and standard deviations as well as the Varimax rotated factor structure of the BFI-10 items for the total sample: raw and individual mean-corrected data

I see myself as someone who ...	Raw data							Mean corrected data						
	M	SD	Factor Loadings					M	SD	Factor Loadings				
... is reserved	2.95	1.27	.86	.07	.05	.06	.06	.16	1.21	-.86	.06	.10	-.03	-.01
... is outgoing, sociable	2.14	1.10	-.61	.28	.14	.06	.41	-.65	1.04	.74	.09	.18	.15	.18
... is generally trusting	3.02	1.27	-.08	-.23	-.02	.70	.17	.22	1.18	.25	-.79	-.04	-.24	.05
... tends to find fault with others	2.98	1.13	-.15	.78	-.09	.03	.17	.19	1.03	.28	.75	-.08	-.20	.03
... does a thorough job	1.58	.77	.16	.14	.73	.10	.33	-1.22	.77	-.08	-.01	.76	.07	.15
... tends to be lazy	3.65	1.24	.17	.19	-.79	.20	.14	.85	1.15	-.14	.02	-.85	-.02	.05
... is relaxed, handles stress well	2.62	1.19	.14	-.07	-.10	-.41	.68	-.17	1.13	-.01	-.10	-.01	.87	.10
... gets nervous easily	3.63	1.14	.18	.20	-.10	.72	-.29	.83	1.08	-.18	-.14	-.11	-.78	-.03
... has an active imagination	2.03	1.01	-.15	.06	.17	.11	.71	-.77	.94	.16	.11	.25	.20	.68
... has few artistic interests	3.35	1.34	.21	.55	.06	-.14	-.38	.55	1.27	-.03	.11	.09	.02	-.92
% explained variance			13.1	11.5	12.3	12.7	15.5			15.1	12.6	14.2	15.3	13.8
Factor congruence			.89	.62	.94	.68	.59			.91	.95	.94	.93	.95

Highest loadings are set in bold.

Table 2

Varimax rotated factor structure of the BFI-10 items for respondents with low, intermediate, and high education: raw data

I see myself as someone who ...	Low secondary education (N = 260)					Intermediate secondary education (N = 321)					High secondary education (N = 307)				
	... is reserved	-.70	.32	.04	.08	.13	.89	.06	.06	.02	.09	-.76	-.10	.16	.01
... is outgoing, sociable	.63	-.11	-.06	-.14	.33	-.49	.58	.15	.04	.27	.83	.02	-.01	-.05	.16
... is generally trusting	-.07	-.56	.08	.50	.33	-.20	-.12	.08	.76	.19	.21	.83	.19	.04	-.03
... tends to find fault with others	.61	.37	.21	.24	.15	.12	.83	-.04	-.07	-.10	.39	-.49	.43	-.03	-.23
... does a thorough job	-.04	.13	-.17	-.04	.79	.08	.23	.72	.10	.17	.02	-.12	-.66	.11	.07
... tends to be lazy	.01	.02	.95	.06	-.10	.05	.16	-.80	.19	.09	-.17	-.01	.77	.16	.07
... is relaxed, handles stress well	-.09	-.10	.26	-.70	.40	-.14	.16	.03	-.44	.50	-.01	.14	.15	-.82	.09
... gets nervous easily	-.10	.06	.18	.79	-.02	.31	.14	-.26	.68	-.22	-.08	.22	.20	.77	-.08
... has an active imagination	.31	-.15	.06	-.10	.68	.02	.40	.26	-.05	.61	.22	-.19	.09	-.07	.81
... has few artistic interests	-.18	.71	.02	.12	.04	-.07	.22	.06	-.11	-.76	.02	-.19	.11	.10	-.76
% explained variance	14.1	11.2	10.8	14.7	15.2	12.2	13.8	13.5	12.9	14.1	15.5	11.0	13.7	13.1	13.4
Factor congruence	.78	.59	.71	.86	.29	.86	.51	.91	.67	.80	.90	.85	.85	.96	.94

Highest loadings are set in bold.

Table 3

Varimax rotated factor structure of the BFI-10 items for respondents with low, intermediate, and high education: individual mean-corrected data

I see myself as someone who ...	Low secondary education (<i>N</i> = 260)					Intermediate secondary education (<i>N</i> = 321)					High secondary education (<i>N</i> = 307)				
... is reserved	-.75	-.09	.11	.04	-.22	-.89	.11	.10	-.08	.11	-.85	.07	.04	-.01	-.02
... is outgoing, sociable	.81	-.01	.14	.20	-.06	.72	.16	.17	.11	.25	.79	.03	.20	-.06	.21
... is generally trusting	.19	-.71	.01	-.39	.28	.18	-.79	.01	-.27	.04	.24	-.87	-.10	.02	-.07
... tends to find fault with others	.26	.77	-.01	-.30	.16	.20	.80	-.01	-.19	.04	.37	.62	-.21	-.06	-.21
... does a thorough job	-.17	.17	.71	.20	.35	-.01	-.11	.75	.09	.06	-.09	.06	.83	.07	.12
... tends to be lazy	-.15	.14	-.86	.06	.22	-.05	-.10	-.85	-.04	-.04	-.23	.09	-.79	.15	.11
... is relaxed, handles stress well	.00	-.08	-.01	.84	.13	.02	-.08	-.03	.90	.09	-.07	-.13	.03	-.86	.12
... gets nervous easily	-.23	-.06	-.12	-.74	.04	-.18	-.14	-.22	-.75	-.04	-.12	-.19	-.02	.81	-.05
... has an active imagination	.39	-.02	.34	.27	.36	.12	.15	.29	.22	.66	.14	.16	.13	-.10	.83
... has few artistic interests	-.12	.03	.02	-.03	-.90	.01	.11	.09	.03	-.93	-.06	.23	.10	.08	-.81
% explained variance	15.9	11.5	14.1	16.7	12.9	14.2	13.8	14.7	15.5	13.9	16.4	12.8	14.3	14.5	14.9
Factor congruence	.87	.94	.92	.86	.77	.94	.94	.92	.93	.94	.90	.91	.94	.97	.94

Highest loadings are set in bold.