Comparison of ICCs using IRT and CTT parameters

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Author Note

Add complete departmental affiliations for each author here. Each new line herein must be indented, like this line.

Enter author note here.

The authors made the following contributions. Diego Figueiras: Conceptualization, Writing - Original Draft Preparation, Writing - Review & Editing; John T. Kulas: Writing - Review & Editing.

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Abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words "**here we show**" or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

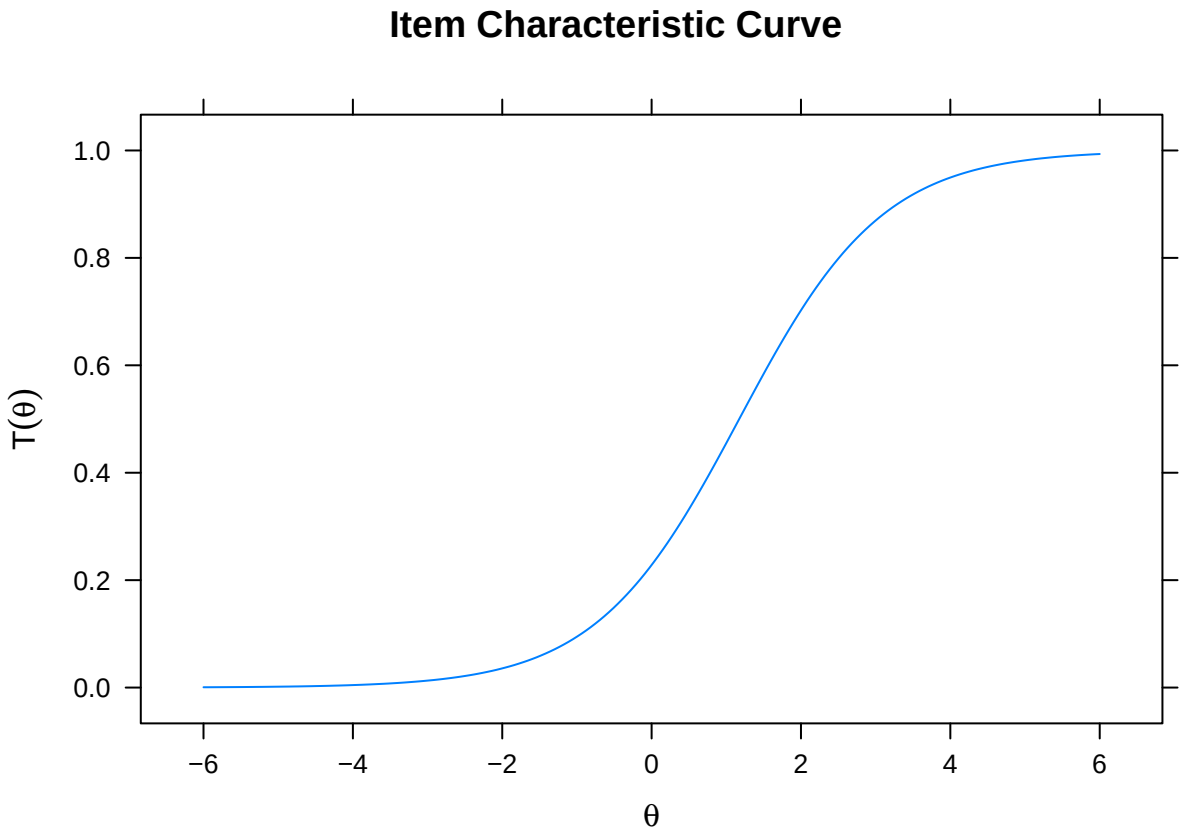
Keywords: keywords

Word count: X

Comparison of ICCs using IRT and CTT parameters

Introduction

Item characteristic curves are very often used by psychometricians to showcase and analyze the attributes of the item on a test or assessment. The x-axis shows a wide range of trait levels (ranging from high to low on the trait), while the y-axis displays probabilities of getting the item correct that range from 0 to 1. Each item has a curve. By looking at it, we can know the likelihood with which respondents of any trait level would answer any item correctly.If the curve is leaning towards the lower end of the trait level, this indicates that it is easy to answer the item correctly. On the contrary, if the curve is leaning towards the higher end of the trait level, this indicates that the item is difficult. If the curve is steep, this indicates high discrimination among respondents; if it is flat, it indicates no discrimination.



Psychometricians who examine ICCs usually do it while using Item Response Theory and Rasch models. From a Classical Test Theory (CTT) frame of thinking, the difficulty of an item is determined by looking at the p-values of the items, while discrimination is determined by checking the Cronbach alpha and the corrected item total correlations. Psychometricians who look at these CTT parameters don't typically use them to plot ICCs.There is no reason for this to happen, since ICCs based on CTT parameters could provide information as valuable as those based on IRT or Rasch without the need of being familiar with these models. Fan states in summary that IRT and CTT "... framework produce very similar item and person statistics" (p.379).

Methods

We used the formulas presented by Kulas, Smith, and Xu (2017).

Study 2 simulates a bunch of test data and then we generate ICCs based on the IRT model and then we compare that to our CTT estimates. ## Participants

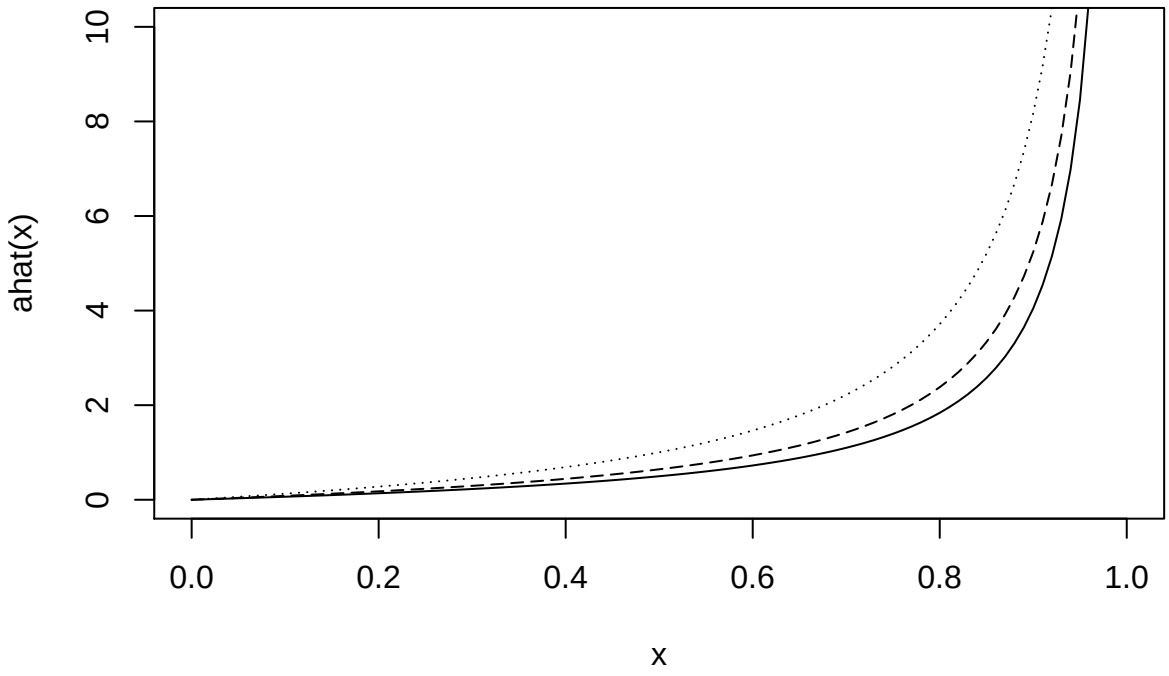
Material

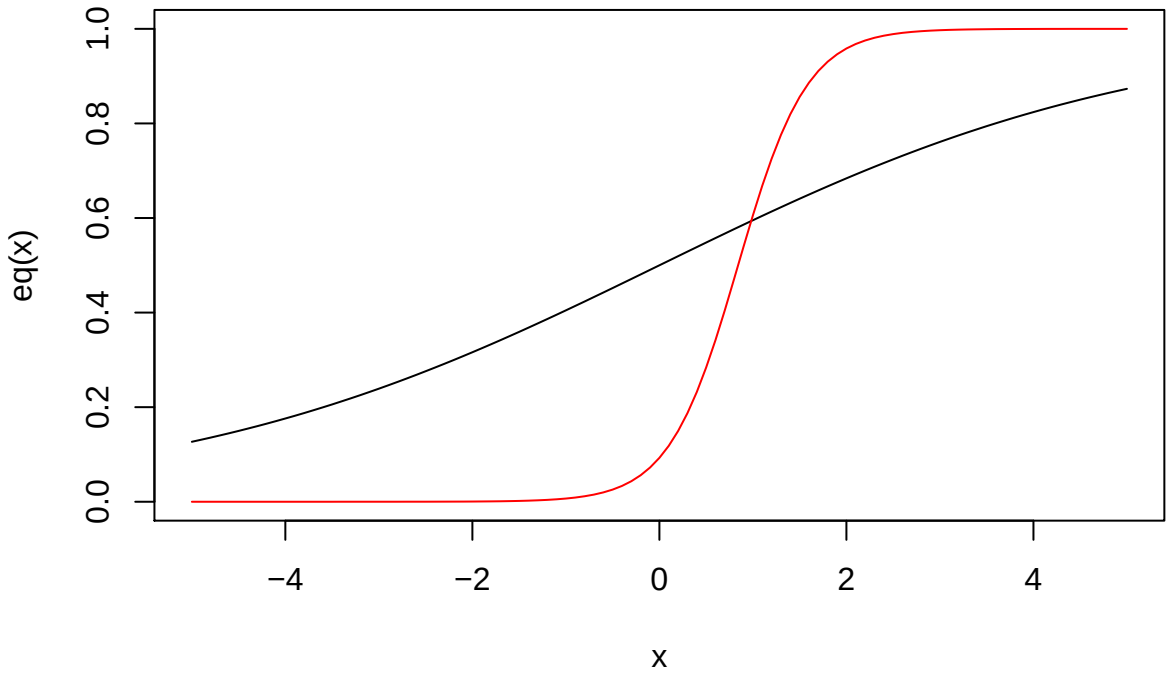
Procedure

Data analysis

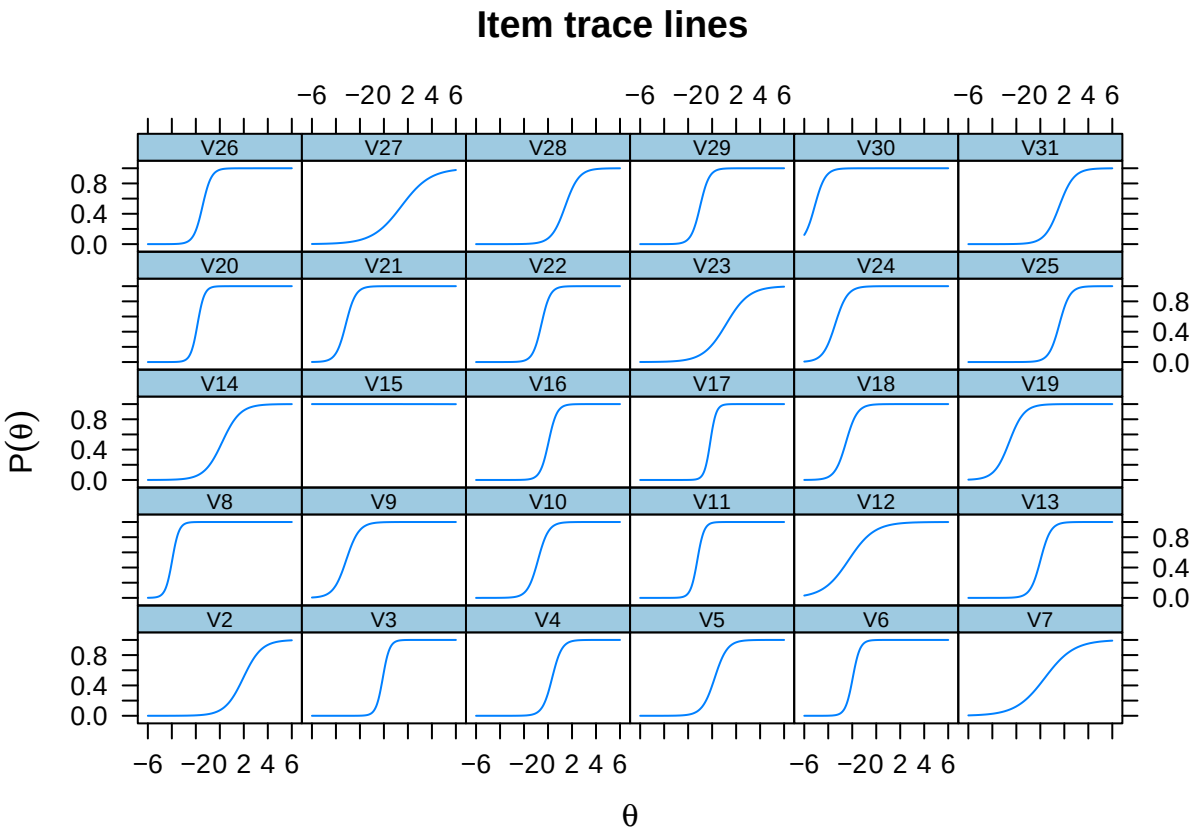
We used R (Version 4.0.3; R Core Team, 2020) and the R-packages *dplyr* (Version 1.0.7; Wickham et al., 2021), *DT* (Version 0.19; Xie, Cheng, & Tan, 2021), *forcats* (Version 0.5.1; Wickham, 2021a), *formattable* (Version 0.2.1; Ren & Russell, 2021), *ggplot2* (Version 3.3.5; Wickham, 2016), *jpeg* (Version 0.1.9; Urbanek, 2021), *knitr* (Version 1.33; Xie, 2015), *markdown* (Version 1.1; Allaire, Horner, Xie, Marti, & Porte, 2019; Xie, Allaire, & Grolemund, 2018; Xie, Dervieux, & Riederer, 2020), *officer* (Version 0.3.19; Gohel, 2021), *papaja* (Version 0.1.0.9997; Aust & Barth, 2020), *pdftools* (Version 3.0.1; Ooms, 2021),

psych (Version 2.1.6; Revelle, 2021), *purrr* (Version 0.3.4; Henry & Wickham, 2020), *readr* (Version 2.0.1; Wickham & Hester, 2021), *readxl* (Version 1.3.1; Wickham & Bryan, 2019), *reticulate* (Version 1.20; Ushey, Allaire, & Tang, 2021), *rmarkdown* (Version 2.10; Xie et al., 2018, 2020), *shiny* (Version 1.6.0; Chang et al., 2021), *stringr* (Version 1.4.0; Wickham, 2019), *tibble* (Version 3.1.4; Müller & Wickham, 2021), *tidyr* (Version 1.1.3; Wickham, 2021b), *tidyverse* (Version 1.3.1; Wickham, Averick, et al., 2019), and *tinytex* (Version 0.33; Xie, 2019) for all our analyses.



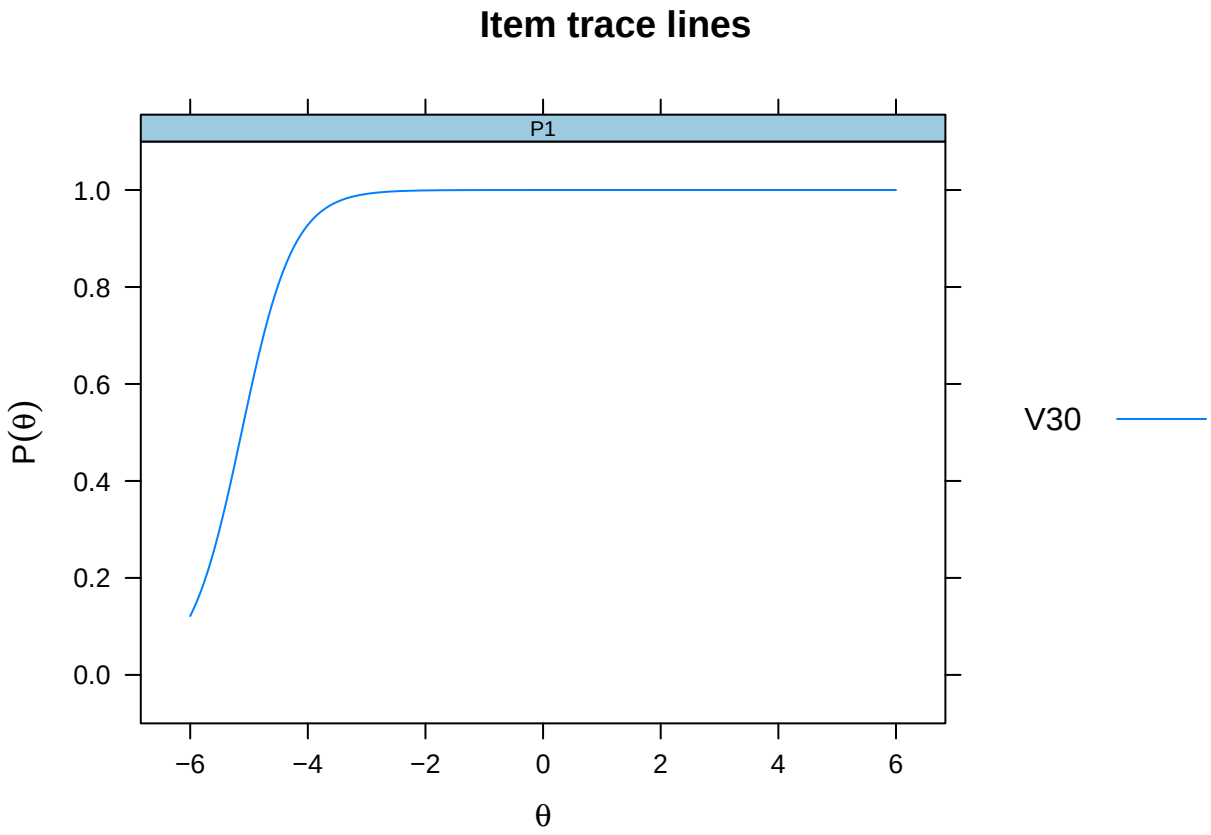



```
## Iteration: 1, Log-Lik: -98116.710, Max-Change: 4.09843Iteration: 2, Log-Lik: -93555.3
##
## Calculating information matrix...
```



78

79 ## Iteration: 1, Log-Lik: -98116.710, Max-Change: 4.09843Iteration: 2, Log-Lik: -93555.3




```
## Warning in mean.default(data$v10): argument is not numeric or logical: returning
## NA

## Warning in alpha(data): Some items were negatively correlated with the total scale an
## should be reversed.
## To do this, run the function again with the 'check.keys=TRUE' option

## Some items ( V15 ) were negatively correlated with the total scale and
## probably should be reversed.
## To do this, run the function again with the 'check.keys=TRUE' option

##
## Reliability analysis
```

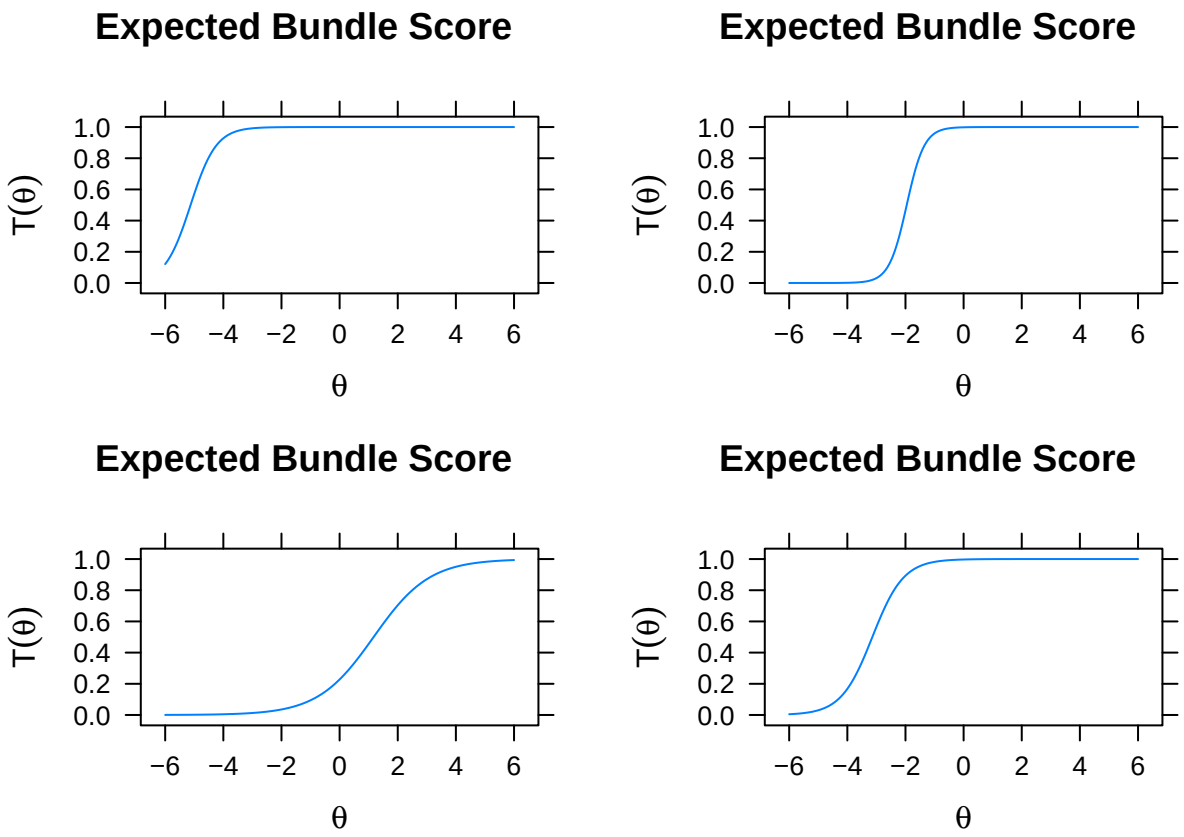
```
## Call: alpha(x = data)
##
##   raw_alpha std.alpha G6(smc) average_r S/N    ase mean   sd median_r
##       0.88      0.86    0.87      0.17 6.2 0.0015 0.65 0.17     0.15
##
##  lower alpha upper     95% confidence boundaries
## 0.88 0.88 0.89
##
##  Reliability if an item is dropped:
##     raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## V2       0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
## V3       0.87      0.85    0.86      0.16 5.7   0.0016 0.017  0.15
## V4       0.87      0.85    0.86      0.17 5.8   0.0016 0.018  0.15
## V5       0.88      0.85    0.87      0.17 5.8   0.0015 0.018  0.15
## V6       0.88      0.86    0.87      0.17 6.0   0.0015 0.019  0.15
## V7       0.88      0.86    0.87      0.17 6.1   0.0014 0.020  0.16
## V8       0.88      0.87    0.88      0.18 6.4   0.0015 0.018  0.17
## V9       0.88      0.86    0.87      0.18 6.2   0.0015 0.020  0.16
## V10      0.88      0.85    0.86      0.17 5.8   0.0015 0.018  0.15
## V11      0.88      0.85    0.86      0.17 5.8   0.0015 0.018  0.15
## V12      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
## V13      0.87      0.85    0.86      0.17 5.8   0.0016 0.018  0.15
## V14      0.88      0.86    0.87      0.17 5.9   0.0015 0.019  0.15
## V15      0.88      0.87    0.88      0.18 6.5   0.0015 0.018  0.17
## V16      0.87      0.85    0.86      0.16 5.7   0.0016 0.017  0.15
## V17      0.87      0.85    0.86      0.16 5.6   0.0016 0.017  0.15
## V18      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
```

```
## V19      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
## V20      0.88      0.86    0.87      0.17 5.9   0.0015 0.019  0.15
## V21      0.88      0.86    0.87      0.18 6.3   0.0015 0.019  0.16
## V22      0.87      0.85    0.86      0.16 5.7   0.0016 0.018  0.15
## V23      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.15
## V24      0.88      0.86    0.87      0.18 6.3   0.0015 0.019  0.16
## V25      0.88      0.86    0.87      0.17 6.1   0.0015 0.019  0.15
## V26      0.88      0.85    0.87      0.17 5.8   0.0015 0.019  0.15
## V27      0.88      0.86    0.87      0.17 6.1   0.0014 0.020  0.16
## V28      0.88      0.86    0.87      0.17 6.0   0.0015 0.019  0.15
## V29      0.88      0.85    0.86      0.17 5.8   0.0015 0.018  0.15
## V30      0.88      0.87    0.88      0.18 6.5   0.0015 0.018  0.17
## V31      0.88      0.86    0.87      0.17 6.1   0.0015 0.019  0.15
##
##  Item statistics
##         n  raw.r std.r   r.cor  r.drop mean    sd
## V2  10000  0.366  0.36  0.3121  0.3092 0.12 0.325
## V3  10000  0.748  0.70  0.7108  0.6999 0.53 0.499
## V4  10000  0.665  0.62  0.6141  0.6074 0.39 0.488
## V5  10000  0.629  0.58  0.5730  0.5656 0.44 0.496
## V6  10000  0.395  0.47  0.4512  0.3613 0.96 0.203
## V7  10000  0.422  0.39  0.3453  0.3386 0.43 0.495
## V8  10000  0.041  0.13  0.0656  0.0383 1.00 0.014
## V9  10000  0.198  0.28  0.2306  0.1762 0.99 0.115
## V10 10000  0.627  0.61  0.6077  0.5717 0.74 0.436
## V11 10000  0.590  0.62  0.6151  0.5437 0.86 0.343
## V12 10000  0.341  0.35  0.3060  0.2802 0.86 0.343
```

```
## V13 10000  0.681  0.63  0.6307  0.6235 0.49 0.500
## V14 10000  0.545  0.51  0.4800  0.4718 0.45 0.498
## V15 10000 -0.003  0.07 -0.0044 -0.0049 1.00 0.010
## V16 10000  0.716  0.67  0.6708  0.6633 0.48 0.500
## V17 10000  0.763  0.71  0.7286  0.7179 0.56 0.497
## V18 10000  0.291  0.36  0.3174  0.2612 0.97 0.164
## V19 10000  0.303  0.36  0.3100  0.2668 0.96 0.201
## V20 10000  0.419  0.49  0.4751  0.3838 0.95 0.216
## V21 10000  0.160  0.25  0.1894  0.1450 0.99 0.077
## V22 10000  0.691  0.67  0.6672  0.6386 0.68 0.468
## V23 10000  0.434  0.41  0.3677  0.3608 0.27 0.443
## V24 10000  0.154  0.24  0.1777  0.1384 0.99 0.083
## V25 10000  0.431  0.42  0.3818  0.3810 0.10 0.306
## V26 10000  0.529  0.56  0.5525  0.4825 0.89 0.318
## V27 10000  0.375  0.35  0.3054  0.2985 0.26 0.438
## V28 10000  0.457  0.44  0.4022  0.3987 0.16 0.362
## V29 10000  0.622  0.62  0.6200  0.5709 0.80 0.403
## V30 10000  0.024  0.10  0.0314  0.0223 1.00 0.010
## V31 10000  0.430  0.41  0.3762  0.3733 0.14 0.345
##
## Non missing response frequency for each item
##        0    1 miss
## V2  0.88 0.12    0
## V3  0.47 0.53    0
## V4  0.61 0.39    0
## V5  0.56 0.44    0
## V6  0.04 0.96    0
```

```
## V7  0.57 0.43    0
## V8  0.00 1.00    0
## V9  0.01 0.99    0
## V10 0.26 0.74    0
## V11 0.14 0.86    0
## V12 0.14 0.86    0
## V13 0.51 0.49    0
## V14 0.55 0.45    0
## V15 0.00 1.00    0
## V16 0.52 0.48    0
## V17 0.44 0.56    0
## V18 0.03 0.97    0
## V19 0.04 0.96    0
## V20 0.05 0.95    0
## V21 0.01 0.99    0
## V22 0.32 0.68    0
## V23 0.73 0.27    0
## V24 0.01 0.99    0
## V25 0.90 0.10    0
## V26 0.11 0.89    0
## V27 0.74 0.26    0
## V28 0.84 0.16    0
## V29 0.20 0.80    0
## V30 0.00 1.00    0
## V31 0.86 0.14    0
```

```
## Warning: package 'gridExtra' was built under R version 4.0.5
```



198

```
199 ## Warning in mean.default(data$i28): argument is not numeric or logical: returning
200 ## NA

201 ## Warning in alpha(data): Some items were negatively correlated with the total scale an
202 ## should be reversed.
203 ## To do this, run the function again with the 'check.keys=TRUE' option

204 ## Some items ( V15 ) were negatively correlated with the total scale and
205 ## probably should be reversed.
206 ## To do this, run the function again with the 'check.keys=TRUE' option

207 ##
208 ## Reliability analysis
```

```
## Call: alpha(x = data)
##
##   raw_alpha std.alpha G6(smc) average_r S/N    ase mean   sd median_r
##       0.88      0.86    0.87      0.17 6.2 0.0015 0.65 0.17     0.15
##
##  lower alpha upper     95% confidence boundaries
## 0.88 0.88 0.89
##
##  Reliability if an item is dropped:
##     raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## V2       0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
## V3       0.87      0.85    0.86      0.16 5.7   0.0016 0.017  0.15
## V4       0.87      0.85    0.86      0.17 5.8   0.0016 0.018  0.15
## V5       0.88      0.85    0.87      0.17 5.8   0.0015 0.018  0.15
## V6       0.88      0.86    0.87      0.17 6.0   0.0015 0.019  0.15
## V7       0.88      0.86    0.87      0.17 6.1   0.0014 0.020  0.16
## V8       0.88      0.87    0.88      0.18 6.4   0.0015 0.018  0.17
## V9       0.88      0.86    0.87      0.18 6.2   0.0015 0.020  0.16
## V10      0.88      0.85    0.86      0.17 5.8   0.0015 0.018  0.15
## V11      0.88      0.85    0.86      0.17 5.8   0.0015 0.018  0.15
## V12      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
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## V14      0.88      0.86    0.87      0.17 5.9   0.0015 0.019  0.15
## V15      0.88      0.87    0.88      0.18 6.5   0.0015 0.018  0.17
## V16      0.87      0.85    0.86      0.16 5.7   0.0016 0.017  0.15
## V17      0.87      0.85    0.86      0.16 5.6   0.0016 0.017  0.15
## V18      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
```

```
## V19      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.16
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## V22      0.87      0.85    0.86      0.16 5.7   0.0016 0.018  0.15
## V23      0.88      0.86    0.87      0.17 6.1   0.0015 0.020  0.15
## V24      0.88      0.86    0.87      0.18 6.3   0.0015 0.019  0.16
## V25      0.88      0.86    0.87      0.17 6.1   0.0015 0.019  0.15
## V26      0.88      0.85    0.87      0.17 5.8   0.0015 0.019  0.15
## V27      0.88      0.86    0.87      0.17 6.1   0.0014 0.020  0.16
## V28      0.88      0.86    0.87      0.17 6.0   0.0015 0.019  0.15
## V29      0.88      0.85    0.86      0.17 5.8   0.0015 0.018  0.15
## V30      0.88      0.87    0.88      0.18 6.5   0.0015 0.018  0.17
## V31      0.88      0.86    0.87      0.17 6.1   0.0015 0.019  0.15
##
##  Item statistics
##         n  raw.r std.r   r.cor  r.drop mean    sd
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## V3  10000  0.748  0.70  0.7108  0.6999 0.53 0.499
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## V7  10000  0.422  0.39  0.3453  0.3386 0.43 0.495
## V8  10000  0.041  0.13  0.0656  0.0383 1.00 0.014
## V9  10000  0.198  0.28  0.2306  0.1762 0.99 0.115
## V10 10000  0.627  0.61  0.6077  0.5717 0.74 0.436
## V11 10000  0.590  0.62  0.6151  0.5437 0.86 0.343
## V12 10000  0.341  0.35  0.3060  0.2802 0.86 0.343
```
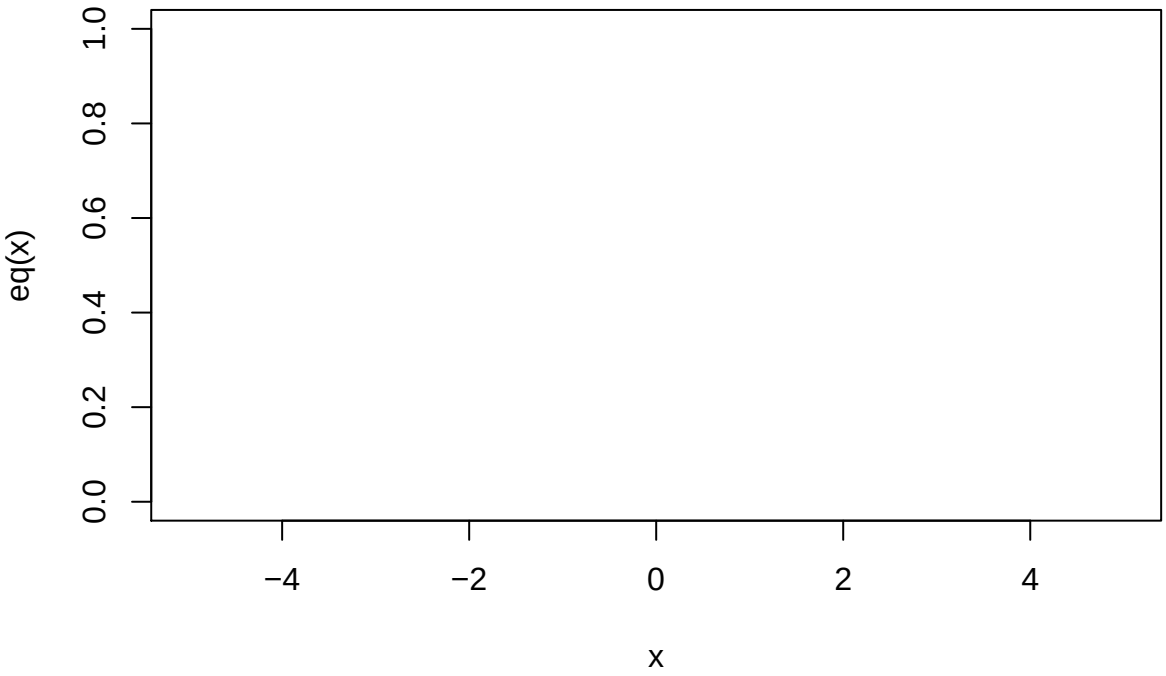

```
## V13 10000  0.681  0.63  0.6307  0.6235 0.49 0.500
## V14 10000  0.545  0.51  0.4800  0.4718 0.45 0.498
## V15 10000 -0.003  0.07 -0.0044 -0.0049 1.00 0.010
## V16 10000  0.716  0.67  0.6708  0.6633 0.48 0.500
## V17 10000  0.763  0.71  0.7286  0.7179 0.56 0.497
## V18 10000  0.291  0.36  0.3174  0.2612 0.97 0.164
## V19 10000  0.303  0.36  0.3100  0.2668 0.96 0.201
## V20 10000  0.419  0.49  0.4751  0.3838 0.95 0.216
## V21 10000  0.160  0.25  0.1894  0.1450 0.99 0.077
## V22 10000  0.691  0.67  0.6672  0.6386 0.68 0.468
## V23 10000  0.434  0.41  0.3677  0.3608 0.27 0.443
## V24 10000  0.154  0.24  0.1777  0.1384 0.99 0.083
## V25 10000  0.431  0.42  0.3818  0.3810 0.10 0.306
## V26 10000  0.529  0.56  0.5525  0.4825 0.89 0.318
## V27 10000  0.375  0.35  0.3054  0.2985 0.26 0.438
## V28 10000  0.457  0.44  0.4022  0.3987 0.16 0.362
## V29 10000  0.622  0.62  0.6200  0.5709 0.80 0.403
## V30 10000  0.024  0.10  0.0314  0.0223 1.00 0.010
## V31 10000  0.430  0.41  0.3762  0.3733 0.14 0.345
##
## Non missing response frequency for each item
##        0    1 miss
## V2  0.88 0.12    0
## V3  0.47 0.53    0
## V4  0.61 0.39    0
## V5  0.56 0.44    0
## V6  0.04 0.96    0
```

```
## V7  0.57 0.43    0
## V8  0.00 1.00    0
## V9  0.01 0.99    0
## V10 0.26 0.74    0
## V11 0.14 0.86    0
## V12 0.14 0.86    0
## V13 0.51 0.49    0
## V14 0.55 0.45    0
## V15 0.00 1.00    0
## V16 0.52 0.48    0
## V17 0.44 0.56    0
## V18 0.03 0.97    0
## V19 0.04 0.96    0
## V20 0.05 0.95    0
## V21 0.01 0.99    0
## V22 0.32 0.68    0
## V23 0.73 0.27    0
## V24 0.01 0.99    0
## V25 0.90 0.10    0
## V26 0.11 0.89    0
## V27 0.74 0.26    0
## V28 0.84 0.16    0
## V29 0.20 0.80    0
## V30 0.00 1.00    0
## V31 0.86 0.14    0
```



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316 **Results**

317 **Discussion**

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