Factorial structure of the indicators in Big Five Plus Inventory

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Author Note

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The data in this paper comes form the Romanian version of BigFive Plus inventory(Constantin et al., 2019), being collected online through the PsihoProfile site

The authors made the following contributions. Cristian Opariuc-Dan: Conceptualization, Writing - Original Draft Preparation, Writing - Data analysis; Gabriela Nicuță: Writing - Systematic review, Writing - Data analysis, Proofreading; Ticu Constantin: Data provider, Writing - Review & Editing.

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Abstract

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Methods

In this paper we aimed to conduct an exploratory study on the **analysis of how the theoretical Big Five model is supported by data**. The volume of the data collected, even if it is very large and gives power to the study, does not constitute a representative sample because no sampling technique was used, but represents the results of tests performed with the Big Five Plus Personality Inventory (Constantin et al., 2019) during 2015-2020 on the population of Romania. The answers resulted either from an online administration using the PsihoProfile site, or from the classic administration, pencil-paper, followed by the introduction of the answers in the platform in order to automatically rate and generate assessment's protocols.

Basically, the manifest variables represent the 240 dichotomous items of the **BigFive Plus Personality Inventory**, the analysis falling into the domain of confirmatory factor analysis using categorical indicators, more precisely dichotomous, and implies a specific approach.

The model does not provide for the existence of indicators loaded in more than one latent trait, each latent factor loading 8 indicators, therefore they will also represent categorical latent variables, because an amplitude of 8 points cannot qualify them as continuous variables.

The latent factors that load the 8 indicators are, in turn, loaded by one of the five Big Five dimensions, resulting in a *second-order factor analysis model* (Byrne, 2013) with uncorrelated second-order factors, which are represented as follows:

- **Extraversion**, exogenous latent variable that loads a number of 6 endogenous latent variables: *Friendliness*, *Gregariousness*, *Assertiveness*, *Activity level*, *Excitement seeking* and *Cheerfulness*.

- **Agreeableness**, exogenous latent variable that loads a number of 6 endogenous latent variables: *Trust*, *Morality*, *Altruism*, *Cooperation*, *Modesty* and *Sympathy*.

- **Neuroticism**, exogenous latent variable that loads a number of 6 endogenous latent variables: *Anxiety*, *Anger*, *Depression*, *Timidity*, *Immoderation* and *Vulnerability*.

- **Conscientiousness**, exogenous latent variable that loads a number of 6 endogenous latent variables: *Self-efficacy*, *Orderliness*, *Dutifulness*, *Achievement-striving*, *Self-discipline* și *Cautiousness*.

- **Openness to experience**, exogenous latent variable that loads a number of 6 endogenous latent variables: *Imagination*, *Artistic interests*, *Emotionality*, *Adventurousness*, *Intellect* and *Liberalism*.

Participants

A total of *14706* protocols were collected, administered to a number of *7907 males (53.80%)* and *6799 females (46.20%)* (see Table 1), most of them being *university graduates (n=4014, representing 27.30%)*, followed by *high school graduated (n=3388, representing 23%)* and the persons with *master's degrees (n=1764, representing 12%)*. The research group also contains graduates of *post-secondary schools (n=1402, representing 9.50%)* and graduates of *arts and crafts schools (n=653, representing 4.40%)*, the other categories being much less represented. (see Table 2)

We note, however, that a large number of people did not specify the level of education *(n=2813, reprezentând 19.10%)*, which will be removed from the analysis that involves the use of this variabile (see Table 2).

Regarding the data gathering method, a number of *7907 protocols* were administered in *paper-pencil form (53.80%), 6799 protocols* being collected directly *online (46.20%)* (see Table 3)

Respondents ranged in age from *min=35.7* and *max=84* years, with a *median age of 35* years *(m=35.7, sd=11.89)* (see Table 4)

Material

The test used is Big Five Plus Personality Inventory (Constantin et al., 2019), being developed and validated on Romanian population (**NEEDS CITATION**) and allows the assessment of five meta-factors of personality (**Extraversion, Agreeableness, Neuroticism, Conscientiousness** and **Openness to experience**), but also 30 facets subordinated to them.

The inventory contains a number of 240 dichotomous items, 48 for the assessment of each of the five dimensions (meta-factors) and eight for each of the 30 facets. The examinee is instructed to choose between two assertions the one that best describes him/her. (e.g. **When I am at a party:** *(a) I am in the middle of the action, surrounded by others; (b) I prefer to stand aside and observe.*).

The two answer options represents extremes of the target psychological dimension and are indented to be similar in terms of social desirability. The average time to complete the questionnaire is 35 minutes.

A research conducted by the authors of the inventory on a number of **1340 Romanian people** (Constantin et al., 2019) led to acceptable internal consistencies, both on the entire national normative sample and by the gender (see Table 5 & 6)

It can be noted that, from the authors' research, the minimum value of the Cronbach α coefficient was 0.572, and the maximum value was 0.917, both values being obtained on the normative sample.The factors with low values of internal consistency and which pose problems regarding the reliability of the measurement are: *Cooperation (0.641), Timidity (0.649), Dutifulness (0.648), Achievement-striving (0.646), Intellect (0.572), Liberalism (0.607), .*

Procedure

The analysis will involve the initial study of the internal consistency, for each scale, using the α Cronbach (Cronbach, 1951) in order to calculate the internal consistency coefficient α (Guttman λ_3), then comparing the coefficients with the values reported by authors (Constantin et al., 2019).

We will then test the model in which the latent trait loads the 8 indicators, for each of the 6 facets of a dimension, and the existence of the common dimension for all 6 latent factors. After interpreting the parameters and diagnosing the models, they will be re-specified, identifying, if necessary, better explanatory models.

In the first phase we will present the comparative analysis of the authors regarding the internal consistency using the **alpha Cronbach method of τ-equivalent reliability** (Cronbach, 1951), including both global indicators and those broken down by *gender* and *method of data gathering (pencil-paper or online)*. The analysis eas performed using the **psych** package (Revelle, 2021), starting from the condition of the cumulative items, the total score resulting from summing the score of the 8 items (8 point of theoretical range), with identifying the items' negative variance and automatically recording. A non-parametric re-sampling was also used, simulating 100 samples in order to verify the stability of the parameters.

In the second phase, the Big Five Plus Inventory analysis will be performed according to a classical model of confirmatory factor analysis with uncorrelated second order factors, which will be analyzed using the **lavaan** package.(Rosseel, 2012). Since the indicators are dichotomous, we will use the *method of estimating the thresholds of the response categories* in which each indicator becomes loaded in the latent trait and determines an active response (1-Yes) if it exceeds its threshold value, established by the item's position on the latent continuum. As an estimator, we will compute one from the categories of methods based on the least squares, namely **WLSM"**, which uses only the diagonal of the weighted matrix "W" (**DWLS**) and, for statistical tests, adjusted means. The "Satorra Bentler" version of

the χ^2 test was used to test the overall fit, adjusting the means. (Skrondal & Rabe-Hesketh, 2005).

Data analysis

All analyzes were performed using: R (Version 4.1.2; R Core Team, 2021) and the R-packages *dplyr* (Version 1.0.7; Wickham et al., 2021), *epiDisplay* (Version 3.5.0.1; Chongsuvivatwong, 2018), *foreign* (Version 0.8.81; R Core Team, 2020), *kableExtra* (Version 1.3.4; Zhu, 2021), *knitr* (Version 1.36; Xie, 2015), *lavaan* (Version 0.6.9; Rosseel, 2012), *MASS* (Version 7.3.54; Venables & Ripley, 2002a), *nnet* (Version 7.3.16; Venables & Ripley, 2002b), *nortest* (Version 1.0.4; Gross & Ligges, 2015), *papaja* (Version 0.1.0.9997; Aust & Barth, 2020), *psych* (Version 2.1.9; Revelle, 2021), *purrr* (Version 0.3.4; Henry & Wickham, 2020), *rbbt* (Version 0.0.0.9000; Dunnington & Wiernik, 2021), *stargazer* (Version 5.2.2; Hlavac, 2018), *survival* (Version 3.2.13; Terry M. Therneau & Patricia M. Grambsch, 2000), and *tinylabels* (Version 0.2.1; Barth, 2021)

Results

Scales' reliability

Data screening and descriptive statistics

Confirmatory Factor Analisys

Extraversion

Varianța celor 48 de itemi dihotomici explicată de cei 6 factori latenți a căror variață, mai apoi, va fi explicată de un factor de ordin doi, mai exact de **dimensiunea Extraversiune**, în urma analizei a generat o soluție stabilă după 29 de iterații, estimându-se un număr 61 parametri liberi, pentru o estimare validă fiind necesare minimum 610 observații, ideal 1220 observații, condiția volumului lotului de cercetare fiind îndeplinită.

Modelul global cu un singur factor latent de ordin doi nu este însă susținut în mod corespunzător de date *(Robust $\chi^2_{(1115)}$=55,751.85, p=0)*, testul de potrivire a modelului eșuând și respingându-se ipoteza nulă **H_0:** *Nu există nicio discrepanță statistic semnificativă între covariațele stipulate la nivelul populației și covariațele estimate de model.* Erorile de aproximare sunt însă acceptabile *(RMSEA=0.06, p=0, $CI_{90\%}$=0.06 - 0.06)*, chiar dacă ipoteza nulă de potrivire **H_0:** *Reziduurile standardizate dintre covariațele rezultate din date și matricea ipotetică de covariațe sunt nule* este respinsă, valoarea arătând eșecul testul de nepotrivire (ϵ>.10) și reziduuri standardizate statistic semnificative între covariațele rezultate din date și matricea ipotetică de covariațe.

Indicele Tucker-Lewis de comparare cu modelul de bază *(Robust TLI=0.92, SRMR=0.08)* arată că modelul se îmbunătățește cu 92.07% în comparație cu modelul nul, în condițiile în care indicatorul standardizat al reziduurilor are o valoare ușor ridicată.

Din cauza unei probleme de identificare empirică și care a generat o matrice neinversabilă, erorile standard ale estimării parametrilor nu au putut fi calculate, prin urmare nici testele statistice, așadar parametrii vor fi apreciați pe baza valorilor nestandardizate și standardizate.

Extraversiunea, ca factor latent de ordin doi, încarcă cel mai puternic factorul latent *Sociabilitate* (B=0.78, β=0.95, R^2=0.90) și cel mai slab factorul latent *Excitabilitate* (B=0.49, β=0.55, R^2=0.30), valorile variației explicate și ale coeficientului de încărcare sugerând, de fapt, că *Excitabilitatea* nu reprezintă o fațetă a extraversiunii, cu atât mai mult cu cât cei 8 itemi sunt încărcați foarte bine de aceasta.

În privința itemilor problematici, remarcăm itemul **I7** încărcat foarte slab de factorul **Asertivitate** (B=0.25, β=0.19, R^2=0.04), itemii **I28, I31 și I37** încărcați foarte slab de factorul **Activitate** (Itemul 28: B=0.33, β=0.26, R^2=0.07, Itemul 31: B=0.46, β=0.36, R^2=0.13 și Itemul 37: B=0.48, β=0.37, R^2=0.14), precum și itemul **I30** încărcat foarte slab de factorul **Veselie** (B=0.49, β=0.40, R^2=0.16)

Respecificând modelul prin eliminarea itemilor problematici și a factorului latent *Excitabilitate*, obținem o îmbunătățire a modelului în ce privește potrivirea globală ($\chi^2_{(584)}$=30,643.11, p=0, RMSEA=0.06, p=0, $CI_{90\%}$=0.06 - 0.06 față de $\chi^2_{(1115)}$=55,751.85, p=0, RMSEA=0.06, p=0, $CI_{90\%}$=0.06 - 0.06), însă noul model tot nu este susținut în mod corespunzător de datele observate.

Singurul aspect remarcabil îl reprezintă creșterea capacității explicative față de modelul nul la 94.15% (TLI=0.94, SRMR=0.08) față de modelul inițial cu 92.07% (TLI=0.92, SRMR=0.08).

Neuroticism

În cazul dimensiunii Nevrozism, analiza a generat o soluție stabilă în 48 de iterații. Au fost estimați un număr de 61 parametri liberi. Pentru o estimare validă, ar fi necesar un număr minim de 610 cazuri și ideal un număr de 1220 cazuri, astfel că putem considera îndeplinită această condiție. Ca și în cazul dimensiunii Extraversiune, modelul nu este susținut în mod corespunzător de date,*Robust $\chi^2_{(1115)}$=46,791.93, p=0.* Cu toate acestea, erorile de aproximare sunt acceptabile *RMSEA=0.05, p=0, $CI_{90\%}$=0.05 - 0.05*, iar indicele Tucker-Lewis de comparare cu modelul de bază *Robust TLI=0.96* arată că modelul se îmbunătățește cu 96.46% în comparație cu modelul nul. Indicatorul standardizat al reziduurilor are o valoare acceptabilă, SRMR = 0.08.

Factorul latent cel mai puternic încărcat de Nevrozism este **Anxietatea** (B=0.75, β=1.02, R^2=NA), în timp ce factorul cel mai slab încărcat este **Exagerarea** (B=0.30, β=0.49, R^2=0.24), analizele indicând că aceasta nu reprezintă o fațetă reprezentativă a Nevrozismului.

În privința itemilor problematici, remarcăm itemul **I109** încărcat slab de factorul **Timiditate** (B=0.40, β=0.25, R^2=0.06), itemul **I110** încărcat slab de factorul **Exagerare** (B=0.27, β=0.16, R^2=0.03), precum și itemul **I111** încărcat slab de factorul **Vulnerabilitate** (B=0.42, β=0.31, R^2=0.10)

Agreabilitate

Pentru meta-factorul Agreabilitate, analiza a generat o soluție stabilă în 29 de iterații.

Rezultatele arată că modelul nu este susținut în mod corespunzător de date, *Robust* $\chi^2_{(1115)}$*=99,240.45, p=0, RMSEA=0.08, p=0, CI*$_{90\%}$*=0.08 - 0.08, Robust TLI=0.72.* Modelul se îmbunătățește cu doar 71.59% în comparație cu modelul nul. Indicatorul standardizat al reziduurilor are o valoare pest pragul acceptabil, SRMR = 0.12.

Factorul latent cel mai puternic încărcat de Agreabilitate este **Altruismul** (B=0.94, β=0.92, R^2=0.85), în timp ce factorul cel mai slab încărcat este **Modestia** (B=0.31, β=0.26, R^2=0.07).

În privința itemilor problematici, observăm faptul că itemul **I89** este încărcat slab de factorul **Moralitate** (B=0.39, β=0.29, R^2=0.09), iar itemul **I79** este încărcat slab de factorul **Modestie** (B=0.32, β=0.22, R^2=0.05).

Constiinciozitate

Pentru meta-factorul Conștiinciozitate, analiza a generat o soluție stabilă în 29 de iterații.

Rezultatele arată că modelul nu este susținut în mod corespunzător de date, *Robust* $\chi^2_{(1115)}$*=78,505.51, p=0, RMSEA=0.07, p=0, CI*$_{90\%}$*=0.07 - 0.07, Robust TLI=0.85.* Modelul se îmbunătățește cu 84.98% în comparație cu modelul nul. Indicatorul standardizat al reziduurilor are o valoare pest pragul acceptabil, SRMR = 0.11.

Factorul latent cel mai puternic încărcat de Conștiinciozitate este **Perseverența** (B=1.03, β=0.89, R^2=0.80), în timp ce factorul cel mai slab încărcat este **Prudența** (B=0.51, β=0.51, R^2=).

În privința itemilor problematici, observăm faptul că itemul **I147** este încărcat slab de factorul **Datorie** (B=-0.20, β=-0.14, R^2=0.02), itemul **I172** este încărcat slab de factorul **Ambiție** (B=0.32, β=0.22, R^2=0.05), iar itemul **I174** încărcat slab de factorul **Prudență** (B=0.30, β=0.21, R^2=0.05).

Deschidere

În ceea ce privește meta-factorul Deschidere, analiza a ajuns la o soluție validă în 29 de iterații.

Din nou, rezultatele arată că modelul nu este susținut în mod corespunzător de date,*Robust* $\chi^{2}_{(1115)}$*=70,909.88, p=0, RMSEA=0.07, p=0, CI*$_{90\%}$*=0.06 - 0.07, Robust TLI=0.80, SRMR = 0.10.*

Factorul latent cel mai puternic încărcat de Deschidere este **Imaginația** (B=0.96, β=0.93, R^2=0.86), în timp ce factorul cel mai slab încărcat este **Emoționalitatea** (B=0.57, β=0.42, R^2=).

În privința itemilor problematici, observăm faptul că itemul **I195** este încărcat slab de factorul **Emoționalitate** (B=-0.20, β=-0.14, R^2=0.02). În cazul factorului **Liberalism**, mai mulți itemi sunt problematici: itemul **I207** (B=0.08, β=0.05, R^2=0.00),itemul **I216** (B=0.04, β=0.03, R^2=0.00), itemul **I238** (B=1.31, β=0.83, R^2=0.68), precum și itemul **I240** (B=0.37, β=0.24, R^2=0.06). Itemul **I221** (B=0.03, β=0.02, R^2=0.00), precum și itemul **I230** (B=-0.22, β=-0.13, R^2=0.06) sunt încărcați slab de factorul Intelect.

Discussion

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Table 1

Participants' gender

	Frequency	Percent	Cum. percent
Male	7907	53.8	53.8
Female	6799	46.2	100.0
Total	14706	100.0	100.0

Table 2

Participants' educational level

	Frequency	%(NA+)	%(NA-)
Illiterate	11	0.1	0.1
Primary (4 years)	284	1.9	2.4
Gymnasium (8 years)	240	1.6	2.0
Arts and crafts school	653	4.4	5.5
Highschool (12 years)	3388	23.0	28.5
Post graduated school	1402	9.5	11.8
University (Bachelor level)	4014	27.3	33.8
University (Master level)	1764	12.0	14.8
Doctoral school	137	0.9	1.2
NA's	2813	19.1	0.0
Total	14706	100.0	100.0

Table 3

Type of data gathering

	Frequency	Percent	Cum. percent
Paper-Pencil	7907	53.8	53.8
Online	6799	46.2	100.0
Total	14706	100.0	100.0

Table 4

Participants' age

n	mean	sd	median	min	max	range	skewness	kurtosis
14706	35.7	11.89	35	16	84	68	0.31	-0.71

Table 5

Alpha Cronbach - Authors' research on normative sample (n=1340)

Dimension/Facet	Male	Female	Normative sample
EXTRAVERSION	0.92	0.914	0.917
- Friendliness	0.742	0.748	0.744
- Gregariousness	0.781	0.767	0.775
- Assertiveness	0.712	0.692	0.702
- Activity level	0.727	0.669	0.696
- Excitement seeking	0.802	0.762	0.786
- Cheerfulness	0.716	0.75	0.735
AGREEABLENESS	0.844	0.826	0.838
- Trust	0.647	0.672	0.66
- Morality	0.711	0.703	0.708
- Altruism	0.655	0.65	0.653
- Cooperation	0.645	0.635	0.641
- Modesty	0.65	0.666	0.66
- Sympathy	0.717	0.653	0.705
NEUROTICISM	0.875	0.877	0.879
- Anxiety	0.7	0.7	0.708
- Anger	0.834	0.839	0.839
- Depression	0.737	0.717	0.73
- Timidity	0.623	0.665	0.649
- Immoderation	0.779	0.738	0.761
- Vulnerability	0.741	0.742	0.746

Table 6

Alpha Cronbach - Authors' research on normative sample (n=1340)

Dimension/Facet	Male	Female	Normative sample
CONSCIENTIOUSNESS	0.857	0.82	0.84
- Self-efficacy	0.67	0.675	0.679
- Orderliness	0.653	0.647	0.65
- Dutifulness	0.674	0.608	0.648
- Achievement-striving	0.655	0.639	0.646
- Self-discipline	0.699	0.596	0.655
- Cautiousness	0.748	0.704	0.729
OPENNESS TO EXPERIENCE	0.82	0.809	0.813
- Imagination	0.653	0.665	0.658
- Artistic interests	0.744	0.702	0.732
- Emotionality	0.421	0.51	0.671
- Adventurousness	0.753	0.744	0.75
- Intellect	0.564	0.579	0.572
- Liberalism	0.628	0.587	0.607

Table 7

Loadings for Friendliness' latent trait

Latent trait	Item	B	z	p	Beta
Friendliness	I1	0.85	NA	NA	0.67
Friendliness	I5	0.70	NA	NA	0.55
Friendliness	I10	1.06	NA	NA	0.83
Friendliness	I16	0.97	NA	NA	0.76
Friendliness	I18	0.80	NA	NA	0.63
Friendliness	I25	0.65	NA	NA	0.51
Friendliness	I34	0.65	NA	NA	0.51
Friendliness	I40	0.97	NA	NA	0.76

Table 8

Loadings for Gregariousness' latent trait

Latent trait	Item	B	z	p	Beta
Gregariousness	I2	0.99	NA	NA	0.77
Gregariousness	I6	0.91	NA	NA	0.71
Gregariousness	I11	0.81	NA	NA	0.63
Gregariousness	I17	0.92	NA	NA	0.71
Gregariousness	I19	0.86	NA	NA	0.67
Gregariousness	I26	0.91	NA	NA	0.71
Gregariousness	I35	0.92	NA	NA	0.71
Gregariousness	I41	0.81	NA	NA	0.63

Table 9

Loadings for Assertiveness' latent trait

Latent trait	Item	B	z	p	Beta
Assertiveness	I3	1.04	NA	NA	0.79
Assertiveness	I7	0.25	NA	NA	0.19
Assertiveness	I12	0.97	NA	NA	0.74
Assertiveness	I20	0.59	NA	NA	0.45
Assertiveness	I21	0.52	NA	NA	0.40
Assertiveness	I27	0.99	NA	NA	0.75
Assertiveness	I36	0.74	NA	NA	0.56
Assertiveness	I42	0.78	NA	NA	0.60

Table 10

Loadings for Activity's latent trait

Latent trait	Item	B	z	p	Beta
Activity	I4	1.00	NA	NA	0.78
Activity	I13	0.56	NA	NA	0.43
Activity	I22	0.98	NA	NA	0.76
Activity	I28	0.33	NA	NA	0.26
Activity	I31	0.46	NA	NA	0.36
Activity	I37	0.48	NA	NA	0.37
Activity	I43	0.99	NA	NA	0.77
Activity	I44	0.84	NA	NA	0.65

Table 11

Loadings for Excitement's latent trait

Latent trait	Item	B	z	p	Beta
Excitement	I8	0.62	NA	NA	0.52
Excitement	I14	0.95	NA	NA	0.81
Excitement	I23	0.92	NA	NA	0.78
Excitement	I29	0.80	NA	NA	0.68
Excitement	I32	0.83	NA	NA	0.71
Excitement	I38	0.81	NA	NA	0.69
Excitement	I45	0.69	NA	NA	0.58
Excitement	I47	0.87	NA	NA	0.74

Table 12

Loadings for Cheerfulness' latent trait

Latent trait	Item	B	z	p	Beta
Cheerfulness	I9	0.90	NA	NA	0.73
Cheerfulness	I15	0.66	NA	NA	0.54
Cheerfulness	I24	1.09	NA	NA	0.89
Cheerfulness	I30	0.49	NA	NA	0.40
Cheerfulness	I33	0.75	NA	NA	0.61
Cheerfulness	I39	0.70	NA	NA	0.57
Cheerfulness	I46	0.56	NA	NA	0.46
Cheerfulness	I48	0.69	NA	NA	0.56