

Comparing the ESEM and CFA approaches to analyze the Big Five factors

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ABSTRACT

Marsh (2007) asserts that no self-reported questionnaire of the Big Five factors shows an acceptable degree of adjustment in confirmatory factor analyses (CFA). Based on CFA results, it can usually be inferred that exploratory factor analysis (EFA) solutions are incorrect, as well as concluded that the instruments evaluated by EFAs do not measure what they intend to measure. The present study investigates this assertion, evaluating the structural validity of the Personality Characteristics Inventory (PCI), a self-reported instrument of the Big Five factors. Only one EFA investigated the validity of PCI (Gomes, 2012). We re-analyzed the data of this study (716 elementary and middle school students from a Brazilian school). The solution of eight correlated factors was investigated through CFA and ESEM (exploratory structural equation modeling). The model was found to be unacceptable through CFA, showing good fit through ESEM. Marsh's assertion correctly predicted the results. Structural validity of PCI could only be concluded through ESEM. *Keywords:* validity; confirmatory factor analysis; structural equation modeling; personality.

RESUMO – Comparando as Abordagens ESEM e CFA para Analisar os Grandes Cinco Fatores

Marsh (2007) afirma que nenhum questionário de autorrelato dos Grandes Cinco Fatores mostra grau de ajuste aceitável em análises fatoriais confirmatórias (AFC). Tomando como referência resultados de AFCs, pode-se usualmente inferir que soluções de análises fatoriais exploratórias (AFE) são incorretas, assim como concluir que os instrumentos avaliados pelas AFEs não mensuram o que pretendem. O presente estudo investiga essa afirmação, avaliando a validade estrutural do Inventário de Características de Personalidade (ICP), um instrumento de autorrelato dos Grandes Cinco Fatores. Somente uma AFE investigou a validade do ICP (Gomes, 2012). Os dados desse estudo foram reanalisados (716 estudantes do ensino fundamental e médio de uma escola brasileira). A solução de oito fatores correlacionados foi investigada via AFC e MEEE (modelamento por equação estrutural exploratório). O modelo mostrou-se inaceitável via AFC, apresentando bom ajuste via MEEE. A afirmação de Marsh corretamente predisse os resultados. Somente o MEEE permitiu concluir a validade estrutural do ICP.

Palavras-chave: validade, análise fatorial confirmatória, modelamento por equação estrutural, personalidade.

RESUMEN – Comparando los enfoques ESEM y CFA para analizar los grandes cinco factores

Marsh (2007) afirma que ningún cuestionario de autoinforme de los grandes cinco factores presenta un grado de ajuste aceptable en análisis factorial confirmatorio (AFC). Tomando como referencia resultados de AFCs, se puede deducir que soluciones de Análisis Factorial Exploratorio (AFE) son incorrectas, así como concluir que los instrumentos evaluados por los AFEs no miden lo que pretenden. Este estudio investiga esta afirmación, evaluando la validez estructural del Inventario de Características de Personalidad (ICP), un instrumento de autoinforme de los grandes cinco factores. Sólo un AFE investigó la validez del ICP (Gomes, 2012). Se volvieron a analizar los datos de este estudio (716 estudiantes de Enseñanza Primaria y Secundaria de una escuela brasileña). El modelo de los ocho factores correlacionados fue investigado vía AFC y por el Modelo Exploratorio de Ecuaciones Estructurales (MEEE). El modelo se mostró inaceptable vía AFC, pero presenta buen ajuste vía MEEE. La afirmación de Marsh predice correctamente los resultados. Sólo el MEEE ha permitido concluir la validez estructural del ICP.

Palabras clave: Validez; análisis factorial confirmatorio, modelado por ecuación estructural; personalidad.

The Personality Characteristics Inventory (PCI) has a property that makes it a singular instrument to measure the domains of the Big Five model. Its items were created in order to avoid words or terms that possess intrinsic negative values, for example the words “lazy” or “unreliable” (Gomes, 2012). The motive is

simple and straightforward. The majority of the traditional questionnaires of the Big Five model possess an unbalanced quantity of items that have negative values and this condition should provoke an imbalance among the 10 polarities of the five broad factors from the Big Five model. For example, there are more negative words

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for introversion than for extroversion (the two polarities of extroversion), and neuroticism possesses more negative words or terms than its opposite polarity, which is stability (Gomes, 2012). Furthermore, the presence of "negative" items tend to bring undesirable consequences, as the increment of error in the measurement of the domains, since these items tend to elicit respondent' answers with stronger social desirability (Bäckström, Björklund & Larsson, 2009; Bäckström & Björklund, 2013; Bäckström & Björklund, 2014).

A detailed commentary about the occurrence of unbalanced negative items in the 10 polarities of the five broad factors from the Big Five model is presented in Gomes (2012). He shows that this condition occurs in the Revised NEO Personality Inventory (Costa, McCrae & Jónsson, 2002), as well as, in the Five-Factor Personality Inventory (Hendriks, Hofstee & Raad, 2002), in the Big Five Questionnaire (Barbaranelli & Caprara, 2002), in the Hierarchical Personality Inventory for Children (Mervielde & Fruyt, 2002), in the Five-Factor Nonverbal Personality Questionnaire (Paunonen & Ashton, 2002), in the Global Personality Inventory (Schmit, Kihm & Robie, 2002), in the Traits Personality Questionnaire (Tsaousis, 2002), in the Big Five Marker Scales (Perugini & Di Blas, 2002), and in others as well.

Until now, the Personality Characteristics Inventory (PCI) structural validity has been evaluated by Gomes (2012) through an item exploratory factor analysis. Because his motivation was to achieve the best solution that could measure the biggest number of polarities of the Big Five broad factors, with good loadings, he deleted 23 items from the questionnaire, selecting the 27 remained items and found an eight correlated factors solution. This solution showed a good data fit (CFI=0.99; RMSEA=.04), explaining 65.30% of the common variance of the items. Despite being an item exploratory factor analysis, the analysis has been done through the software Mplus 5.2 (Muthén & Muthén, 1998-2014), which informs, even for exploratory analysis, the comparative fit index (CFI) and the root mean square error of approximation (RMSEA), both data fit indexes.

The factors identified measure eight of the 10 polarities of the Big Five broad factors. Gomes (2012) avoided giving names that could implicitly or explicitly assume a negative value both for the items, as well as for the polarities. He named the eight polarities as: Open to New Experiences, Extraversion, Introversion, Mutability, Stability, Focus on Human Relations, Focus on Objects, and Objective. Open to New Experiences is a polarity of Openness factor of the Big Five model. Extraversion and Introversion are polarities of Extraversion factor. Mutability and Stability are polarities of Neuroticism, as well as, Focus on Human Relations and Focus on Objects are polarities of Agreeableness, and Objective is

a polarity of Conscientiousness. These factors showed a Cronbach' alpha between .59 and .80.

Despite the fact that the eight correlated factor model has showed a good data fit, Gomes applied an item exploratory factor analysis, and the present study intends to evaluate this model through confirmatory approaches, analyzing the same data of Gomes (2012) study. Two approaches are used to investigate the exploratory solution found by Gomes (2012): an item confirmatory factor analysis (CFA) and an item exploratory structural equation modeling (ESEM).

The CFA approach presupposes that the Personality Characteristics Inventory (PCI) possesses eight correlated factors which load only on its target items, possessing zero loadings on the non-target items. So, Stability factor only loads on item 4, item 27, item 40 and item 42 – the number of the items follows the original number when the questionnaire had 50 items, despite the present study investigates the solution of Gomes (2012), which maintained only 27 items. Mutability factor loads on item 2, item 10, item 34 and item 46. Extraversion factor loads on item 6, item 9, item 29 and item 37. Introversion factor loads on item 7, item 49 and item 50. Open to New Experiences factor loads on item 8 and item 21, as well as, Focus on Human Relations factor loads on item 17, item 25, item 30 and item 32, Focus on Objects loads on item 18, item 24 and item 32, and Objective factor loads on item 16, item 39, item 41, and item 47.

The ESEM model presupposes the same eight correlated factors present in CFA model, but defines that beyond its target items, the factors load on all the other items, as close as possible to zero. So, for example, Stability factor loads on its target items (4, 27, 40 and 42), as well loads on all the others 23 items, as close as possible to zero.

There are some motives to use the ESEM approach beyond the CFA approach. The Big Five is probably the main scientific field where ESEM approach is applied. Maybe this occurs because of the Marsh's claim (2007) that "it is almost impossible to get an acceptable fit (e.g., CFI, TLI>0.9/ RMSEA<0.05) for even 'good' multifactor rating instruments when analyses are done at the item level and there are multiple factors (e.g., 5-10) [...]", when the researcher applies exclusively the CFA approach (Marsh, 2007, p. 785).

ESEM is a relatively new technique, mainly applied since 2010, and overcomes the central limitation of CFA approach, which it demands that any factor loads exclusively on its target items, unless the researcher specifies what non-target items should be loaded by this factor. Asparouhov and Muthén (2009) presented that approach, as well as its rationale, estimation, and others technical aspects. But substantively, the most important thing to say about the ESEM approach is that it permits cross-loadings, or in other words, apart from the fact that it permits any factor loads on target items, it also loads on

all non-target items, as close as to zero. ESEM has been proved superior to CFA approach to investigate solutions from item exploratory factor analysis, where the cross-loadings are not the exception, but the rule (Marsh, Morin, Parker, & Kaur, 2014). Besides that, as a consequence of the impediment of cross-loadings, Marsh et al. (2014) shows that the CFA approach tends to inflate the factor correlations, because all the loadings of the non-target items are carried by the factor correlations, producing an incorrect estimation of them.

Marsh et al. (2012) states that usually CFA does not support evidences from the Big Five model which come from item exploratory factor analysis, in part because of the restrictive assumption of this approach, which prohibits cross-loadings. Therefore, the present study aims at studying the structural validity of the Personality Characteristics Inventory (PCI), in addition to investigate if the CFA approach is inappropriate to apprehend the PCI factor structure. According to Marsh et al. (2012), it is the biggest possibility, in which case, the ESEM approach should be a reasonable solution for that. Beyond that, the present study investigates if the factors correlations become inflated through the CFA approach in comparison to the ESEM approach.

Method

Participants

The sample possesses 716 students of a private school in Belo Horizonte, Minas Gerais State, Brazil, which has almost in total students from middle class socio-economic status. Part of the sample pertains to elementary school II (59% of the sample), composed by the sixth to ninth grades, and part comes from high school (41% of the sample), composed by the tenth to twelfth grades. The age mean of the sample is equal to 13.75 years and a standard deviation of 2.11 years. The majority is female (53%) and there is an equilibrium among the grades (sixth grade=13.1%; seventh grade=15.3%; eighth grade=13.8%; ninth grade=16.2%; tenth grade=13.5%; eleventh grade=13.9%; twelfth grade=13.5%).

Instrument

The Personality Characteristics Inventory (PCI) includes 27 items, which measure eight polarities from the 10 polarities of the Big Five broad factors (Gomes, 2012). PCI is a self-reported instrument. The instrument is originally written in the Portuguese language of Brazil. There is not a time limit to its application, which can be applied collectively or individually. Each item is composed by a word or phrase that correspond to characteristics of personality. So, the respondent has to choose a Likert-Type scale of 5 points, indicating if the item says nothing about her (point 1 of the scale), or if the item says little about her (point 2), or if the item says somewhat about

her (point 3), or if the item says much about her (point 4), or if the item says entirely about her (point 5).

Procedures

The data comes from the Gomes' study of 2012, which is available after a contact with professor Gomes. The Personality Characteristics Inventory was applied in 2008 in the students' classes after an informed consent of the school managers, teachers, students and their parents or legal guardians. The research followed the Ethics commitments, with the approval of the Ethics Committee of the Federal University of Minas Gerais, Brazil, protocol number 456/07. All students and their parents assigned a free consent term before the CPQ application.

Data Analysis

In both CFA and ESEM approaches, the estimator applied was the weighted least square of means and variance (WLSMV), which treated the items of CPI as categories with four thresholds, in function of this instrument possesses a Likert-Type scale of 5 points. The statistical software employed was Mplus 7.0 (Muthén & Muthén, 1998-2014). Because ESEM demands a rotated estimation, the present study applied the target rotation, as suggested by Marsh et al. (2014), aiming at maximizing the confirmatory approach in ESEM. The advantage of the target rotation is that it "provides a stronger a priori model, gives the researcher greater control in specifying the model, and facilitates interpretation of the results" (Marsh et al., 2014, p. 90).

As informed in the introductory section, the CFA approach defined a model with eight correlated factors, where each factor only loads on its target items and possesses zero loading on all the non-target items. On the contrary, the ESEM approach defined the same model of CFA, but permitted cross-loadings among the factors and all the non-target items.

The cross-loadings in ESEM were modeled to be as close as possible to zero. One example is the following: Stability BY p4 p27 p40 p42 are part of the model command which informs that the latent variable Stability loads on items 4, 27, 40 and 42. This is equal to CFA approach. However, in the model command there is an additional part, which defines that the non-target items of this factor are loaded by it, as close as possible to zero. So, the entire command is: Stability BY p4 p27 p40 p42 p2~0 p6-p10~0 p16-p18~0 p21~0 p24-p25~0 p29-p30~0 p32~0 p34~0 p37~0 p39~0 p41~0 p46-p47~0 p49-p50~0 (*1); So, p2~0 means that item 2 is loaded by factor Stability as close as possible to zero, and so on. This is possible through the target rotation, which permits that the researcher defines all the relationships among the factors and the items, maximizing the confirmatory analysis in the ESEM approach.

The comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of

approximation (RMSEA) were used to inspect the data fit of the eight correlated factors model in the CFA approach and in the ESEM approach. Models with values equal or above 0.95 in CFI and TLI, as well below .06 in RMSEA possess good data fit, while values below 0.90 in CFI and TLI, as well as equal or above .10 in RMSEA indicate unacceptable models (Schumacker & Lomax, 2004). The reliability of the factors was estimated through Cronbach's alpha (Cronbach & Meehl, 1955).

Results and Discussion

Both CFA and ESEM approaches estimated the same eight correlated factor models. The unique difference is that, the ESEM aggregates the cross-loadings, but the CFA prohibits it. The CFA indicated that the model is unacceptable because CFI and TLI possess values below 0.90 ($\chi^2[295]=1,199.03$; CFI=.888; TLI=.867; RMSEA=.065, 90% CI of RMSEA=.062 and .069). The CFA loadings are showed in Figure 1.

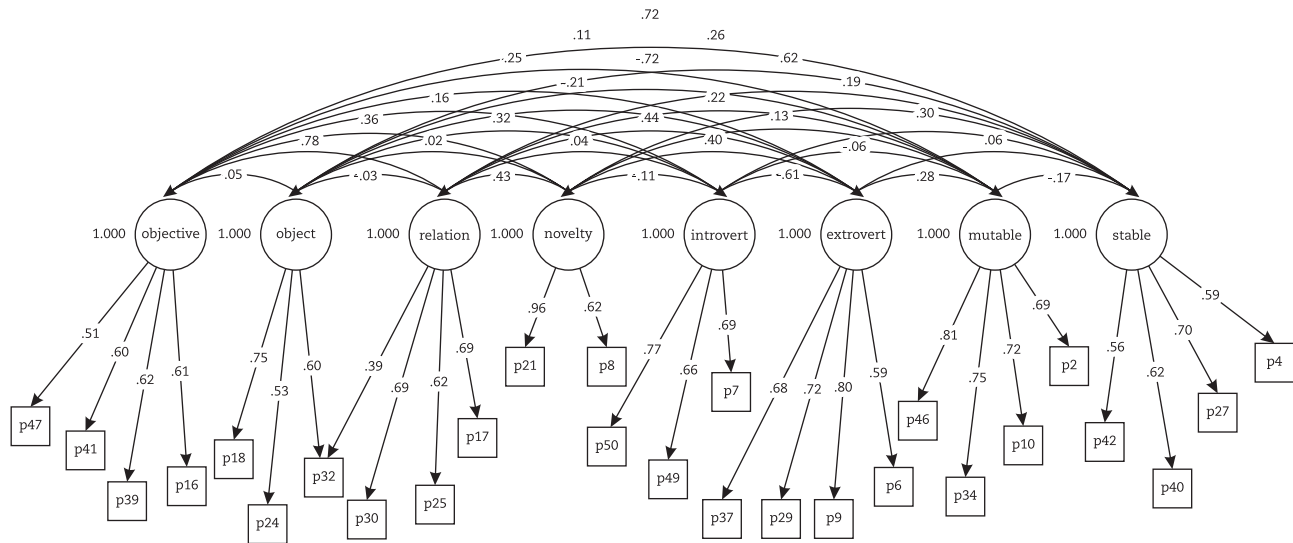


Figure 1. The eight correlated model in CFA approach

Note. object = focus on object; relation = focus on human relations; novelty = open to new experiences; introvert = introversion; extrovert = extraversion; mutable = mutability; stable = stability; p2 = “attuned to a variety of emotions”; p4 = “stable”; p6 = “talkative”; p7 = “reserved”; p8 = “inventive”; p9 = “communicative”; p10 = “influenced by emotions”; p16 = “focused”; p17 = “helpful”; p18 = “unemotional”; p21 = “creative”; p24 = “does not like to show much affection”; p25 = “kind”; p27 = “balanced”; p29 = “extroverted”; p30 = “cooperative”; p32 = “affective”; p34 = “acts with feelings”; p37 = “nice to talk to”; p39 = “self-disciplined”; p40 = “calm”; p41 = “decided”; p42 = “constant”; p46 = “emotional”; p47 = “likes to meet goals”; p49 = “discreet”; p50 = “private”

The circles represent the eight factors, which are polarities of the Big Five broad factors. The bidirectional arrows indicate the correlations among the eight factors, and the unidirectional arrows show the causal relation of each factor in relation of its target items. For example, the Objective factor possesses four unidirectional arrows which come in direction of the items p47, p41, p19 and p16. The item that possesses the lowest load is .39, but it is the only item that is loaded by two factors (Focus on Objects – named as “object” in the Figure 1, and Focus on Human Relations – named as “relation”). All the other loadings are bigger than the value of .50.

Table 1 presents the correlation matrix of the factors, estimated by the CFA approach. There are three correlations above .70: Focus on Human Relations and Objective, Objective and Stability, and Mutability and

Focus on Objects (negative correlation). The mean of the correlations is .29 and the standard deviation is .23.

Differently of the CFA approach, the ESEM approach indicated that the eight correlated factor models possess a good data fit. CFI and TLI showed values above 0.95 and RMSEA value below .06 ($\chi^2[163]=306.50$; CFI=.982; TLI=.962; RMSEA=.035, 90% CI of RMSEA=.029 and .041). As informed, the unique difference in relation to the CFA solution was that ESEM inserted the cross-loadings in the model. That was the cause for the considerable increase in data fit.

Table 2 presents the eight factors from the ESEM approach and its loadings on the items. The target items are marked with a bold grey, while non-target items which possess loadings equal or above .20 are marked with a soft grey. Excepting item 32, which is loaded by two factors, as occurred in the CFA solution, and item

39, all target items are loaded by their target factor with a loading of at least .41. Three factors (Focus on Objects, Open to New Experiences, and Introversion) did not show any non-target items with loadings equal or above .20. The Objective and the Extraversion factors showed only one non-target item with loadings of .20 and -.22, respectively. The Focus on Human Relations showed two non-target items with loadings of .20 and .23. And the Mutability and the Stability factors presented three non-target items with loadings at least .20.

The Mutability factor showed one relevant non-target item with loading of -.31, an item theoretically opposite to mutability (item 18 is “unemotional”). The

Stability factor showed two relevant non-target items (25 and 41), both with loadings of .31. They are “kind” and “decided”, respectively. Interpreting, these should be secondary characteristics of stable persons but it is a speculation. However, it is important to observe that these two items did not show the highest loading in the Stability Factor, but showed its highest loading on its own target factor. Besides, the target items of Stability possess the biggest loadings in this factor (.49 until .60). So, despite the cross-loadings having considerably improved the data fit of the eight correlated factor model, these loadings did not affect the substantive interpretation of the factors and its theoretical properties.

Table 1
Correlation Matrix of the Eight Factors in the CFA Approach and Cronbach's Alpha

	stable	mutable	extrovert	introvert	novelty	relation	object	objective
stable	.70							
mutable	-.17	.80						
extrovert	.06	.28	.75					
introvert	.30	-.06	-.61	.69				
novelty	.19	.13	.40	-.11	.70			
relation	.62	.22	.44	.04	.43	.64		
object	.26	-.72	-.21	.32	.02	-.03	.59	
objective	.73	.11	.25	.16	.36	.78	.05	.62

Note. object = focus on objects; relation = focus on human relations; novelty = open to new experiences; introvert = introversion; extrovert = extraversion; mutable = mutability; stable = stability

Table 2
The Eight Correlated Factors Model in the ESEM Approach

items	stable	mutable	extrovert	introvert	novelty	relation	object	objective
2	.05	.58	.13	.11	.10	-.14	-.15	.07
4	.60	-.11	.05	.07	.01	.00	.00	.02
6	-.04	.06	.68	-.05	.03	-.12	-.05	-.11
7	.09	.11	-.05	.66	.02	.03	.06	-.02
8	-.01	.01	-.05	.04	.95	-.10	.02	-.06
9	-.03	.02	.70	-.10	.04	.12	.02	.11
10	-.13	.76	.12	.08	-.02	-.06	.04	.07
16	.07	.01	.05	.08	.07	.15	-.01	.46
17	-.05	-.10	.17	.09	.09	.61	.00	.13
18	.17	-.31	.13	.12	.00	-.01	.41	-.07
21	-.02	-.03	.07	-.10	.64	.10	.00	.03
24	.00	.14	.03	.12	.06	-.03	.71	.06
25	.31	.21	-.07	-.17	.00	.47	.09	.01
27	.54	-.04	-.08	.01	.08	.20	.02	.02
29	.08	.20	.53	-.15	.03	.15	.04	-.06
30	-.04	-.03	.17	.11	.03	.69	-.13	.01
32	.18	.12	.05	.08	.04	.15	-.67	-.04
34	.02	.73	.03	-.06	-.04	.11	-.02	-.04
37	.03	-.03	.60	-.06	.00	.18	.01	.06
39	.21	.12	-.22	-.04	.09	.23	.07	.36
40	.49	-.02	-.15	.10	-.03	.14	-.01	.10

Table 2 (continuation)
The Eight Correlated Factors Model in the ESEM Approach

items	stable	mutable	extrovert	introvert	novelty	relation	object	objective
41	.31	.00	.19	-.07	.02	-.03	-.01	.43
42	.56	-.05	.18	.05	-.01	-.14	-.05	.20
46	-.09	.68	-.06	.00	.00	.10	-.18	-.03
47	-.06	.00	-.05	.05	.05	.09	-.05	.60
49	-.01	-.07	-.11	.59	.01	.22	-.01	.06
50	.05	.08	-.09	.72	-.06	-.12	.09	-.09

Note. object = Focus on Object; relation = Focus on Human Relations; novelty = Open to New Experiences; introvert = Introversion; extrovert = Extraversion; mutable = Mutability; stable = Stability; item 2 = "attuned to a variety of emotions"; item 4 = "stable"; item 6 = "talkative"; item 7 = "reserved"; item 8 = "inventive"; item 9 = "communicative"; item 10 = "influenced by emotions"; item 16 = "focused"; item 17 = "helpful"; item 18 = "unemotional"; item 21 = "creative"; item 24 = "does not like to show much affection"; item 25 = "kind"; item 27 = "balanced"; item 29 = "extroverted"; item 30 = "cooperative"; item 32 = "affective"; item 34 = "acts with feelings"; item 37 = "nice to talk to"; item 39 = "self-disciplined"; item 40 = "calm"; item 41 = "decided"; item 42 = "constant"; item 46 = "emotional"; item 47 = "likes to meet goals"; item 49 = "discreet"; item 50 = "private"

Table 3 shows the correlation matrix of the factors from the ESEM. The biggest correlation (-.51) occurred between Mutability and Focus on Objects, followed by Focus on Human Relations and Objective (.45), Introversion and Extraversion (-.45), together with Focus on Objects and Stability (.41). The mean of the correlations is .18 and its standard deviation is .14.

As argued in the introductory section, beyond CFA approach usually does not support exploratory

factor solutions of item factor analysis, CFA inflates the correlations of the factors. The results pointed that CFA increased the factor correlations mean in 61.11% and increased the standard deviation in 56.86% in comparison to ESEM approach. This is an evidence for the claim that usually CFA overestimates factor correlations as a consequence of the constraint which obliges the non-target items to have zero loadings.

Table 3
Matrix Correlation of the Factors in ESEM Approach

	stable	mutable	extrovert	introvert	novelty	relation	object	objective
stable								
mutable	-.09							
extrovert	.04	.12						
introvert	.15	-.04	-.45					
novelty	.18	.12	.31	-.02				
relation	.41	.15	.13	-.01	.32			
object	.12	-.51	-.23	.23	-.04	-.07		
objective	.34	.03	.12	.12	.25	.45	-.07	

Note. object = focus on object; relation = focus on human relations; novelty = open to new experiences; introvert = introversion; extrovert = extraversion; mutable = mutability; stable = stability

About the reliability of the factors, the Cronbach's alpha was calculated employing the target items for each factor, as well the non-target items with a loading of .30 at least. Item 32 was not used to calculate alpha for the Focus on Human Relations factor, being used only to calculate alpha for the Focus on Objects. Table 1 shows the alpha values in the diagonal cells of the factors correlations matrix. The lowest value is present in the Focus on Objects factor (.59) and the lowest value occurs in the Mutability (.80). Results are similar to Gomes (2012).

Concluding, Marsh's claim (2007) was capable of predicting the results of the present study. The CFA approach brought incorrectly the inference that the eight correlated factors model is unacceptable, and, as a consequence, Personality Characteristics Inventory does not measure what it intends to measure. This inference was produced by the constraint present in CFA approach impeding the occurrence of cross-loadings. However, the ESEM approach corrected this distortion, showing that the eight correlated factor model possesses good data fit, as well PCI measures what it intends to do.

Furthermore, the results of the present study reinforce the argument for Marsh et al. (2014) that the CFA approach tends to inflate the factor correlations, because all the loadings of the non-target items are carried to the factor correlations, producing an incorrect estimation of them. The considerable inflation of the factor correlations has important implications, because it diminishes the discriminant validity of the factor scores and its capacity to explain or predict outcomes.

So, the present study reinforces the use of the item ESEM approach for structural validity studies about

self-report questionnaires of the personality field. The CFA approach tends to sub estimate the data fit of the models from item exploratory factor analysis, as well overestimates the factor correlations, which has implications in discriminant validity. Through the ESEM analysis, PCI could be seen as a promising instrument to measure polarities of the Big Five model. Researchers in the personality field should be benefited using the ESEM approach, as well clinicians should demand ESEM analysis to a better estimation of the factors correlations and its implications for discriminant validity.

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