

# The Hierarchical Structures of the NEO PI-R and the 16 PF 5\*

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**Summary:** The present study compares the higher-level dimensions and the hierarchical structures of the fifth edition of the 16 Personality Factors (16 PF 5) with those of the NEO Personality Inventory Revised (NEO PI-R). Both inventories measure personality according to five higher-level dimensions. These inventories were, however, constructed according to different methods (bottom-up vs. top-down). Both questionnaires were filled out by 386 participants. Correlations, regressions, and canonical correlations made it possible to compare the inventories. As expected, they roughly measure the same aspects of personality. There is a coherent association among four of the five dimensions measured in the tests. However, Agreeableness, the remaining dimension in the NEO PI-R, is not represented in the 16 PF 5. Our analyses confirmed the hierarchical structures of both instruments, but this confirmation was more complete in the case of the NEO PI-R. Indeed, a parallel analysis indicated that a four-factor solution should be considered in the case of the 16 PF 5. On the other hand, the five-factor solution of the NEO PI-R was confirmed. The top-down construction of this instrument seems to make for a more legible structure. Of the two five-dimension constructs, the NEO PI-R, thus, seems the more reliable. This confirms the relevance of the Five-Factor Model of personality.

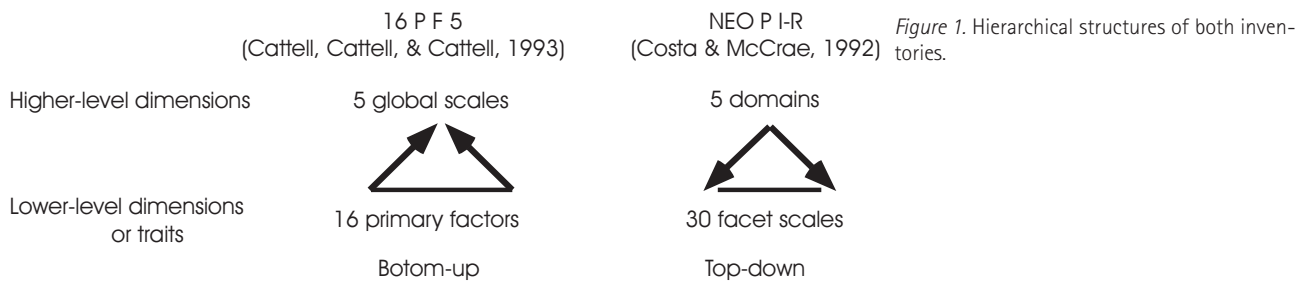
## Introduction

The Five-Factor Model (FFM) of personality is currently the most common dimensional approach to personality. The 16 Personality Factors (16 PF 5) and NEO Personality Inventory Revised (NEO PI-R) are two widely used personality inventories measuring personality according to five higher-level dimensions. The higher-level dimensions measured by each inventory are similar (Cattell, 1995, 1996; Conn & Rieke, 1994). Both tests are implementations of hierarchical models of personality based on the lexical hypothesis. However, these hierarchical structures differ in that they were constructed according to different methods (bottom-up vs. top-down). The purpose of this study is to compare the five higher-level dimensions and the hierarchical structures of both questionnaires.

In the forties, Cattell (1943) used the lexical method to develop his instrument. The lexical hypothesis postu-

lates that language supplies a valuable sample of behavior descriptions and that the analysis of language makes it possible to identify personality traits and their organization (Allport & Odbert, 1936; John, Angleitner, & Ostendorf, 1988). Cattell (1945) started with a list of adjectives (the “35 markers”) administered in the peer-rating domain (life-record data, L-data). From the data he obtained, Cattell extracted 12 factors. Cattell’s following studies (Cattell, 1947) were concerned with the replication of these findings. Cattell (1950a) then tried to measure these 12 factors with a personality questionnaire (self-report-data, Q-data). Cattell (1950a) selected marker items for factors from personality scales, which he sampled in his standard list. But Cattell also developed new items, which were supposed to cover the factors detected in the L-data domain (peer-rating domain). A factor analysis of the item pool (80 items) yielded 19 to 20 extracted factors; according to Cattell, 12 of these factors showed similarities to the factors from the L-data. Cattell detected four additional factors with the Q-data

\* The original data upon which this paper is based are available at <http://www.hhpub.com/journals/ejpa>



medium (self-report domain) labeled Q1, Q2, Q3, and Q4 (Cattell, 1956b). Later, Cattell (1957) proposed to group the 16 primary dimensions into global scales (also called second-order personality factors by Cattell before the fifth edition of the 16 PF) allowing for the description of personality structure at a higher level (Cattell, 1996). At first, Cattell's model included eight global scales. Four of them were largely accepted as being major dimensions of personality (Argentero, 1989; Cattell, Eber, & Tatsuoka, 1970; Krug & Jones, 1986). In the fifth and last edition of the 16 PF (16 PF 5), five global scales are proposed (Cattell & Cattell, 1995).

The 16 PF 5 has a good factorial validity (Saville & Blinkhorn, 1981; Rolland & Mogenet, 1996). The first-order structure seems globally confirmed even if there are some discrepancies in the literature (Eysenck, 1991). In a recent study, Chernyshenko, Stark, and Chan (2001) were able to confirm the hierarchical structure of the fifth edition of the 16 PF. The five-factor structure of the 16 PF (six factors if one includes reasoning) has already been clearly confirmed by Hofer, Horn, and Eber (1997) and Ormerod, McKenzie, and Woods (1995) on large samples. The internal consistency of the 16 PF's scales is satisfying. It ranges from .57 to .81 (Rolland & Mogenet, 1996). The global scales of the last edition are similar to the five higher-level dimensions of the FFM of personality (Cattell, 1996; Chernyshenko, Stark, & Chan, 2001). The only exception is the Independence scale, which is not equivalent to Agreeableness (Cattell, 1996).

Following the publication of the FFM (Digman, 1990; Peabody & Goldberg, 1989; De Raad, 2000), the interest in personality psychology and the number of studies about the structure of personality have considerably increased (Meyer de Stadelhofen, Rossier, Rigozzi, Zimmermann, & Berthoud, submitted; Rossier, Rigozzi, & Berthoud, 2002; Trull & Geary, 1997). Five main dimensions are supposed to underlie the structure of traits. A large consensus exists about the FFM, even if some disagreement persists about the exact content of some of the five dimensions. In particular, there is still some controversy about the Openness dimension (Goldberg, 1992).

The NEO Personality Inventory Revised (NEO PI-R) (Costa & McCrae, 1992) was specifically designed to assess the five main dimensions of personality (termed

domains). Costa and McCrae (1985) started the development of their NEO measure, which included the domains Neuroticism (N), Extraversion (E) and Openness (O), based on a cluster analytic approach of personality as measured by the 16 PF (Costa & McCrae, 1976). These dimensions were derived from the clusters observed in data obtained by administering the 16 PF to a sample divided into three age groups. Later, the domains of Agreeableness (A) and Conscientiousness (C) were added to the NEO (Costa & McCrae, 1992). The internal consistencies of these five domains are good and vary between .87 and .91 (Rossier, Wenger, & Berthoud, 2001). Test-retest reliability is satisfying and varies between .63 and .83. A great number of studies have confirmed the factorial validity of the NEO PI-R (Rolland, Parker, & Stumpf, 1998).

Byravan and Ramanaiah (1995) investigated the factorial structure underlying the 16 PF 5, the NEO PI, and the Goldberg "Markers." Using a global principal axis factor analysis with varimax rotation on the five factor scales of the NEO PI, the five Goldberg factor scales and the 15 primary scales of the 16 PF 5 (excluding the primary factor Reasoning), they were able to extract five factors corresponding to the FFM. Each factor correlated with a specific domain of the NEO PI and with one or several specific primary factors of the 16 PF. The authors concluded by saying that the FFM seems to be a comprehensive framework for describing personality and for interpreting different personality systems. Moreover, the factor loadings presented in this study do not completely confirm the structure of the global scales of the 16 PF 5. Indeed, for the factor identified as Extraversion, the loadings were above .40 for the primary scales Social boldness (H), Warmth (A), Liveliness (F), Dominance (E), Openness to change (Q1), and Abstractedness (M) when the global scale Extraversion as measured by the 16 PF 5 is actually a linear combination of Warmth (A), Liveliness (F), Social boldness (H), Privativeness (N), and Self-reliance (Q2). It should be noted that the number of subjects ( $n = 188$ ) was quite small in regard of the number of variables taken into account.

Hierarchical models like the FFM allow an all-encompassing view of personality. This type of structure, in which higher-level dimensions are made up of lower-

level dimensions, makes for an easier to interpret and more legible profile (Cattell, 1956a). The lower-level dimensions are numerous and can be directly observed; they represent personality traits. The higher-level dimensions are less explicit; they represent the structure of personality (Figure 1). The 16 PF 5 has a bottom-up hierarchy in which the five higher-level dimensions are obtained by combining the 16 primary factors into five theoretically independent global scales. The fact that some traits (primary factors) contribute to more than one global scale can make it difficult to identify the higher-level dimensions, which then seem somewhat artificial. Nonetheless, these dimensions are close to the five domains around which the NEO PI-R is constructed (Cattell, 1996). In contrast to the 16 PF 5, the NEO PI-R has a top-down hierarchy. Costa and McCrae (1985) first identified five orthogonal higher-level dimensions. Then, in each domain they defined six lower-level dimensions or facets. Thus, in the NEO PI-R, each trait belongs to only one higher-level dimension.

As previously stated, the purpose of this study is to compare the five higher-level dimensions and the hierarchical structures of the two instruments which are both based mainly on the psycholexical approach. Our hypothesis is that the higher-level dimensions of the two instruments are similar but that the top-down method will lead to a more reliable inventory. More precisely, a top-down method based on the results of prior bottom-up approaches, as is the case for the NEO PI-R, will favor the development of reliable instruments. For example, a top-down approach allows the creation of dimensions that have the same weight. In order to compare the higher-level dimensions of the 16 PF 5 and of the NEO PI-R, we used three different methods. We first analyzed correlations and then used both linear regression and canonical correlation to determine to what degree the higher-level dimensions of one instrument could explain the higher-level dimensions of the other. Finally, in order to reveal and compare the hierarchical structures, we conducted principal axis factor analyses on both instruments.

## Method

### Sample

386 subjects from the general population, 230 woman and 156 men, participated voluntarily and anonymously in a study comparing two self-administered personality inventories. The mean age of this sample was 32.5 with a standard deviation of 13.4 (minimum 18 and maximum 78). The diversity of our sample was assessed according

to Holland's vocational theory (Frew & Shaw, 1999; Holland, 1973) with 14.8% having a realistic profession (R), 17.9% an investigative one (I), 4.4% an artistic one (A), 36.5% a social one (S), 8.5% an enterprising one (E) and 10.1% a conventional one (C). Our study is in compliance with the ethical code of the Swiss Association of Psychology (FSP).

### Instruments

*Sixteen Personality Factors 5th Edition (16 PF 5, Cattell, Cattell, & Cattell, 1993; Mogenet & Rolland, 1995)*

The 16 PF 5 is a self-rating questionnaire of 170 items. For each question, participants had to choose between three answers, generally "yes," "no" and "?". The 16 PF 5 measures 16 primary factors: Warmth (A), Reasoning (B), Emotional stability (C), Dominance (E), Liveliness (F), Rule-consciousness (G), Social boldness (H), Sensitivity (I), Vigilance (L), Abstractedness (M), Privatness (N), Apprehension (O), Openness to change (Q1), Self-reliance (Q2), Perfectionism (Q3), and Tension (Q4). These 16 primary factors can be combined into five global scales: Extraversion (Ex), Anxiety (An), Tough-mindedness (Tm), Independence (In), and Self-control (Sc). The Extraversion score (Ex) is a linear combination of the standardized scores for Warmth (A), Liveliness (F), Social boldness (H), Privatness (N) and Self-reliance (Q2) ( $Ex = 4.4 + .3A + .3F + .2H - .3N - .3Q2$ ). Anxiety (An) is a linear combination of the standardized scores for Emotional stability (C), Vigilance (L), Apprehension (O), and Tension (Q4) ( $An = 1.6 - .4C + .3L + .4O + .4Q4$ ). Tough-mindedness (Tm) is a linear combination of the standardized scores for Warmth (A), Sensitivity (I), Abstractedness (M), and Openness to change (Q1) ( $Tm = 13.8 - .2A - .5I - .3M - .5Q1$ ). Independence (In) is a linear combination of the standardized scores for Dominance (E), Social boldness (H), Vigilance (L), and Openness to change (Q1) ( $In = -2.2 + .6E + .3H + .2L + .3Q1$ ). Self-control (Sc) is a linear combination of the standardized scores for Liveliness (F), Rule-consciousness (G), Abstractedness (M), and Perfectionism (Q3) ( $Sc = 3.8 - .2F + .4G - .3M + .4Q3$ ). One should note that a primary factor can contribute to more than one global scale.

*NEO PI-R (Costa & McCrae, 1992; Rolland & Petot, 1998)*

The NEO PI-R is a self-rating questionnaire of 240 items. Responses are made on a five-point Likert-type scale, ranging from "strongly agree" to "strongly disagree." The NEO PI-R measures 30 subscales termed facets by Costa and McCrae (1985): Anxiety (N1), Hos-

Table 1. Cronbach's alpha coefficients and number of items of all scales for both inventories in our sample ( $n = 386$ ).

Scale	No. items	Cronbach's $\alpha$	Scale	No. items	Cronbach's $\alpha$
16 PF 5			Vulnerability (N6)	8	.81
Warmth (A)	11	.56	Extraversion (E) 4	8	.84
Reasoning (B)	15	.58	Warmth (E1)	8	.71
Emotional stability (C)	10	.74	Gregariousness (E2)	8	.72
Dominance (E)	10	.66	Assertiveness (E3)	8	.75
Liveliness (F)	10	.65	Activity (E4)	8	.61
Rule-consciousness (G)	11	.73	Excitement seeking (E5)	8	.63
Social boldness (H)	10	.84	Positive emotions (E6)	8	.72
Sensitivity (I)	11	.72	Openness (O)	48	.87
Vigilance (L)	10	.74	Fantasy (O1)	8	.76
Abstractedness (M)	11	.77	Aesthetics (O2)	8	.73
Privateness (N)	10	.81	Feelings (O3)	8	.65
Apprehension (O)	10	.73	Actions (O4)	8	.57
Openness to change (Q1)	14	.65	Ideas (O5)	8	.78
Self-reliance (Q2)	10	.68	Values (O6)	8	.55
Perfectionism (Q3)	10	.79	Agreeableness (A)	48	.88
Tension (Q4)	10	.71	Trust (A1)	8	.83
Extraversion (Ex)	51	.86	Straightforwardness (A2)	8	.79
Anxiety (An)	40	.85	Altruism (A3)	8	.61
Tough-mindedness (Tm)	47	.74	Compliance (A4)	8	.62
Independence (In)	44	.78	Modesty (A5)	8	.75
Self-control (Sc)	42	.85	Tender-mindedness (A6)	8	.54
NEO PI-R			Conscientiousness (C)	48	.90
Neuroticism (N)	48	.92	Competence (C1)	8	.57
Anxiety (N1)	8	.83	Order (C2)	8	.76
Hostility (N2)	8	.76	Dutifulness (C3)	8	.64
Depression (N3)	8	.81	Achievement (C4)	8	.63
Self-consciousness (N4)	8	.63	Self-discipline (C5)	8	.80
Impulsiveness (N5)	8	.64	Deliberation (C6)	8	.75

tility (N2), Depression (N3), Self-consciousness (N4), Impulsiveness (N5), Vulnerability (N6), Warmth (E1), Gregariousness (E2), Assertiveness (E3), Activity (E4), Excitement seeking (E5), Positive emotions (E6), Fantasy (O1), Aesthetics (O2), Feelings (O3), Actions (O4), Ideas (O5), Values (O6), Trust (A1), Straightforwardness (A2), Altruism (A3), Compliance (A4), Modesty (A5), Tender-mindedness (A6), Competence (C1), Order (C2), Dutifulness (C3), Achievement (C4), Self-discipline (C5), and Deliberation (C6). These 30 facets are combined into five higher-level personality dimensions termed domains: Neuroticism (N), Extraversion (E), Openness to experience (O), Agreeableness (A), and Conscientiousness (C). Each dimension is made up of six facets.

## Procedure

The anonymous participants were instructed to respond to both questionnaires successively during the same session (the order of presentation was balanced). After data capture, participants could ask for a brief summary of their personality profile. The subjects who didn't com-

pletely answer the two inventories were removed from the sample (this concerned very few people as we had tried to make sure that the subjects were motivated before testing). Therefore there is no missing data in our sample.

## Results

For the 16 PF 5 primary factors, Cronbach's  $\alpha$  coefficients ranged from .56 to .85 with a median of .72 (Table 1) and for the 16 PF 5 global scales, Cronbach  $\alpha$  coefficients ranged from .74 to .86 with a median of .85. For the NEO PI-R facet scales, Cronbach  $\alpha$  coefficients ranged from .54 to .83 with a median of .72 and for the NEO PI-R domains, Cronbach  $\alpha$  coefficients ranged from .84 to .92 with a median of .88. These results were similar to those reported by the authors of these scales and to those found in other studies (Byravan & Ramanaiah, 1995; Rolland, Parker, & Stumpf, 1998; Rossier, Wenger, & Berthoud, 2001).

Correlations between the higher-level dimensions of the 16 PF 5 (global scales) and those of the NEO PI-R

Table 2. Correlations between the global scales of the 16 PF 5 and the domains of the NEO PI-R.

NEO PI-R	16 PF 5				
	Ex	An	Tm	In	Sc
Neuroticism (N)	-.10	.80***	-.21***	-.19***	-.12*
Extraversion (E)	.63***	-.23***	-.13**	.49***	-.20***
Openness to experience (O)	.30***	-.01	-.62***	.26***	-.50***
Agreeableness (A)	.14**	-.25***	-.11*	-.34***	.07
Conscientiousness (C)	-.14**	-.24***	.32***	.13**	.66***

Note. Ex = Extraversion; An = Anxiety; Tm = Tough-mindedness; In = Independence; Sc = Self-control. Significance levels: \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

Table 3. Regressions with the stepwise method predicting each higher-level dimension of both inventories.

16 PF 5	$\beta$	$p$	NEO PI-R	$\beta$	$p$
Extraversion (Ex)			Neuroticism (N)		
Extraversion (E)	.63	.0001	Anxiety (An)	.76	.0001
Openness (O)	.09	.0199	Tough-mindedness (Tm)	-.19	.0001
Agreeableness (A)	.16	.0001	Independence (In)	-.21	.0001
Conscientiousness (C)	-.18	.0001	$R^2$	.69	.0001
$R^2$	.47	.0001			
Anxiety (An)			Extraversion (E)		
Neuroticism (N)	.79	.0001	Extraversion (Ex)	.57	.0001
Openness (O)	-.09	.0026	Anxiety (An)	-.10	.0051
Agreeableness (A)	-.08	.0120	Tough-mindedness (Tm)	.24	.0001
$R^2$	.65	.0001	Independence (In)	.30	.0001
			Self-control (Sc)	-.10	.0096
			$R^2$	.52	.0001
Tough-mindedness (Tm)			Openness (O)		
Neuroticism (N)	-.10	.0150	Tough-mindedness (Tm)	-.50	.0001
Openness (O)	-.57	.0001	Self-control (Sc)	-.27	.0001
Agreeableness (A)	-.09	.0228	$R^2$	.44	.0001
Conscientiousness (C)	.16	.0003			
$R^2$	.43	.0001			
Independence (In)			Agreeableness (A)		
Neuroticism (N)	-.15	.0008	Extraversion (Ex)	.23	.0001
Extraversion (E)	.37	.0001	Anxiety (An)	-.26	.0001
Openness (O)	.24	.0001	Tough-mindedness (Tm)	-.25	.0001
Agreeableness (A)	-.39	.0001	Independence (In)	-.49	.0001
Conscientiousness (C)	.11	.0088	Self-control (Sc)	.16	.0014
$R^2$	.42	.0001	$R^2$	.30	.0001
Self-control (Sc)			Conscientiousness (C)		
Neuroticism (N)	.16	.0001	Extraversion (Ex)	-.10	.0112
Extraversion (E)	-.12	.0004	Anxiety (An)	-.22	.0001
Openness (O)	-.35	.0001	Independence (In)	.28	.0001
Agreeableness (A)	.10	.0033	Self-control (Sc)	.67	.0001
Conscientiousness (C)	.65	.0001	$R^2$	.55	.0001
$R^2$	.61	.0001			

(domains) show a marked similarity between the global scale Anxiety and the domain Neuroticism ( $r = .80$ ). A correspondence can also be observed between the global scale Extraversion and the domain Extraversion ( $r =$

.63), as well as between the global scale Self-control and the domain Conscientiousness ( $r = .66$ ). There is also a negative correlation between the global scale Tough-mindedness and the domain Openness to experience ( $r =$

Table 4. Canonical correlations between the global scales of the 16 PF 5 and the domains of the NEO PI-R.

	Canonical variables									
	1	<i>r</i>	2	<i>r</i>	3	<i>r</i>	4	<i>r</i>	5	<i>r</i>
16 PF 5										
Extraversion (Ex)	-.06	-.19	-.30	-.61	-.75	-.55	.89	.42	.06	.34
Anxiety (An)	.83	.89	.14	.15	-.58	-.37	-.09	-.21	-.10	-.03
Tough-mindedness (Tm)	-.28	-.28	.17	.64	-.61	-.15	.16	.12	-1.00	-.70
Independence (In)	-.37	-.37	-.01	-.31	-.48	-.56	-.90	-.62	.10	.29
Self-control (Sc)	-.18	-.18	.75	.91	-.15	-.13	.19	.17	.80	.30
NEO PI-R										
Neuroticism (N)	.90	.97	.25	.02	-.57	-.23	.19	-.08	.35	.04
Extraversion (E)	-.18	-.43	-.37	-.49	-.94	-.72	.38	.16	.05	.19
Openness (O)	.03	.12	-.48	-.70	.38	.17	-.53	-.29	.72	.62
Agreeableness (A)	.12	-.06	.00	-.05	.24	.40	.94	.83	.35	.38
Conscientiousness (C)	-.12	-.48	.70	.68	-.24	-.18	-.21	-.09	.79	.51
Canonical correlation	.84		.82		.65		.54		.45	
% of variance	41.7		34.5		12.6		6.9		4.3	

-.62). No correspondence, however, can be observed between the global scale Independence and the domain Agreeableness (Table 2).

Regarding the correlations between the global scales of the 16 PF 5 and the facets of the NEO PI-R, we find that the global scale Extraversion correlates with the facets Warmth ( $r = .60$ ) and Gregariousness ( $r = .61$ ). The global scale Anxiety correlates positively with the facets Anxiety ( $r = .67$ ), Hostility ( $r = .68$ ), Depression ( $r = .70$ ), Self-consciousness ( $r = .59$ ), and Vulnerability ( $r = .62$ ) as well as negatively with the facet Trust ( $r = -.42$ ). The global scale Tough-mindedness correlates negatively with the facets Fantasy ( $r = -.49$ ), Aesthetics ( $r = -.50$ ) and Feelings ( $r = -.47$ ). The global scale Independence correlates positively with the facet Assertiveness ( $r = .65$ ) and negatively with the facets Compliance ( $r = -.44$ ) and Modesty ( $r = -.41$ ). The global scale Self-control correlates negatively with the facet Fantasy ( $r = -.56$ ) and positively with the facets Order ( $r = .67$ ), Dutifulness ( $r = .53$ ), Self-discipline ( $r = .46$ ) and Deliberation ( $r = .54$ ).

Regarding correlations between the domains of the NEO PI-R and the primary factors of the 16 PF 5, we find that the domain Neuroticism correlates negatively with the primary factor Emotional stability ( $r = -.75$ ) as well as positively with the primary factors Apprehension ( $r = .61$ ) and Tension ( $r = .49$ ). The domain Extraversion correlates with Liveliness ( $r = .60$ ) and Social boldness ( $r = .57$ ). The domain Openness to experience correlates with Abstractedness ( $r = .44$ ) and Openness to change ( $r = .59$ ). The domain Agreeableness correlates negatively with Vigilance ( $r = -.45$ ), and the domain Conscientiousness correlates negatively with Abstractedness ( $r = -.48$ ) and positively with Perfectionism ( $r = .69$ ). Correlations below .40 are not reported. These results confirm that the

correlations between the global scales of the 16 PF 5 and the facets of the NEO PI-R, as well as the correlations between the domains of the NEO PI-R and the primary factors of the 16 PF 5, form a coherent pattern.

In order to more precisely compare the higher-level dimensions measured by the two personality inventories we conducted a series of linear regressions with the stepwise method in order to predict the global scales of the 16 PF 5 from the domains of the NEO PI-R and vice versa (Table 3). That analysis confirmed the association between the Extraversion scales of both instruments, as well as between the global scale Anxiety and the Neuroticism domain, between the global scale Tough-mindedness and the Openness to experience domain, and, finally, between the global scale Self-control and the Conscientiousness domain. We found no single correspondence for the global scale Independence. Nevertheless, the  $R^2$  for this scale is also above .40. Doing the regressions the other way around confirmed all the above relations. The only domain that was not predicted with an  $R^2$  above .40 was the Agreeableness scale. This shows that this last dimension is not well measured by the 16 PF 5. Regressions with the enter method provided very similar  $R^2$ .

Regressions were confirmed by a canonical analysis on the global scales of the 16 PF 5 and on the domains of the NEO PI-R. The standardized canonical coefficients and correlations of the higher-level dimension with each variate are displayed in Table 4. The first canonical variable explains 41.7% of the common variance and is associated positively with the global scale Anxiety and with the domain Neuroticism. The second canonical variable explains 34.5% of the common variance and is mainly associated with the global scale Self-control and the domain Conscientiousness. The third canonical variable explains 12.6% of the common variance and is

Table 5. Rotated factor matrix, communalities and correlations between the extracted factors and the five higher-level dimensions after principal axis analysis of the primary factors of the 16 PF 5 for the four-factor and the five-factor solutions.

16 PF 5	Four-factor solution					Five-factor solution					
	$h^2$	I	II	III	IV	$h^2$	I	II	III	IV	V
Warmth (A)	.43	.65	.09	-.04	.02	.41	.09	.58	.06	.06	.24
Emotional stability (C)	.67	.07	-.79	-.16	.13	.66	-.78	.05	.17	.12	.05
Dominance (E)	.58	.15	.02	.03	.75	.60	.00	.11	-.03	.77	.01
Liveliness (F)	.38	.44	-.11	.40	.12	.72	-.09	.23	-.34	.10	.73
Rule-consciousness (G)	.41	-.01	.01	-.63	-.11	.42	.01	.02	.63	-.12	-.07
Social boldness (H)	.55	.49	-.28	.15	.45	.54	-.28	.38	-.11	.47	.29
Sensitivity (I)	.30	.27	.33	.05	-.35	.30	.34	.28	-.06	-.31	.04
Vigilance (L)	.38	-.42	.39	-.04	.24	.58	.43	-.56	.11	.24	.12
Abstractedness (M)	.52	-.06	.27	.67	.02	.51	.27	-.09	-.65	.03	.08
Privateness (N)	.47	-.67	-.06	-.03	-.13	.50	-.06	-.66	.04	-.19	-.13
Apprehension (O)	.42	-.01	.59	-.10	-.24	.42	.60	.02	.09	-.23	-.05
Openness to change (Q1)	.31	.34	-.06	.38	.20	.34	-.07	.34	-.41	.24	.06
Self-reliance (Q2)	.22	-.45	.11	-.07	.04	.26	.10	-.35	.01	.04	-.36
Perfectionism (Q3)	.38	-.09	.09	-.57	.20	.37	.08	-.09	.57	.18	-.07
Tension (Q4)	.31	-.04	.54	-.01	.15	.31	.52	-.01	.00	.16	-.07
Correlations		I	II	III	IV		I	II	III	IV	V
Extraversion (Ex)		.93	-.07	.19	.21		-.06	.79	-.15	.24	.62
Anxiety (An)		-.18	.94	.03	-.03		.95	-.19	-.01	-.02	-.03
Tough-mindedness (Tm)		-.53	-.26	-.52	.06		-.27	-.51	.53	-.01	-.18
Independence (In)		.31	-.02	.20	.91		-.04	.21	-.18	.93	.18
Self-control (Sc)		-.14	-.02	-.96	.00		-.03	-.06	.94	-.02	-.29

mainly associated negatively with the global scale Extraversion and with the domain Extraversion. The fourth canonical variable explains 6.9% of the common variance and is associated negatively with the global scale Independence and positively with the domain Agreeableness. The last canonical variable explains 4.3% of the common variance and is associated negatively with the global scale Tough-mindedness and positively with the domain Openness. Together the five canonical variates extract 71% of the variance of the five 16 PF 5's global scales and 69% of the variance of the five NEO PI-R's domains.

In order to assess the hierarchical structure of the 16 PF 5, we conducted a principal axis factor analysis with varimax rotation on the primary factors. We took all the primary factors of the 16 PF 5 into account except the Reasoning factor (B), which is not usually considered to measure a personality trait. A parallel analysis (Horn, 1965; O'Connor, 2000) with the 95th percentile as the comparison baseline prescribed extracting four factors explaining 56.9% of variance. The first six eigenvalues were: 3.03, 2.25, 1.73, 1.52, 0.97, and 0.87. For the four-factor solution, the loading matrix (Table 5) shows that Factor I correlates positively with the primary factor Warmth and negatively with the primary factor Privateness. This first factor correlates positively with the Extraversion global scale ( $r = .93$ ) and negatively with the Tough-mindedness global scale ( $r = -.53$ ). Factor II cor-

relates positively with the primary factors Apprehension and Tension and negatively with the primary factor Emotional stability. This second factor highly correlates with the global scale Anxiety ( $r = .94$ ). Factor III correlates positively with the primary factor Abstractedness and negatively with the primary factors Rule-consciousness and Perfectionism. This third factor correlates negatively with the global scales Self-control ( $r = -.96$ ) and Tough-mindedness ( $r = -.52$ ). Factor IV correlates positively with the primary factor Dominance. This fourth factor highly correlates with the global scale Independence ( $r = .91$ ). A principal axis factor analysis with oblimin rotation give very similar results. Indeed, the correlations among the oblimin factors range from  $-.20$  to  $.03$  with a mean of  $-.07$ , indicating that factors are essentially orthogonal. A comparison between the two sets of factors obtained with varimax and oblimin rotations shows that there is a one to one correspondence ( $r > |.99|$ ).

In order to compare the factorial structure with the hierarchical structure of the inventory, we chose to extract five factors explaining 63.3% of the variance. The loading matrix (Table 5) shows that Factor I correlates positively with the primary factor Apprehension and negatively with the primary factor Emotional stability. This first factor is highly correlated with the Anxiety global scale ( $r = .95$ ). Factor II correlates positively with the primary factor Warmth and negatively with the primary factor Privateness. This second factor correlates

Table 6. Rotated factor matrix, communalities and correlations between the five extracted factors and the five higher-level dimensions after principal axis analysis of the facets of the NEO PI-R.

NEO PI-R	$h^2$	Five-factor solution				
		I	II	III	IV	V
Anxiety (N1)	.73	.85	.00	.00	.06	-.08
Hostility (N2)	.67	.62	-.08	-.52	.00	-.03
Depression (N3)	.74	.83	-.20	-.04	.09	-.11
Self-consciousness (N4)	.55	.69	-.16	.13	-.08	-.17
Impulsiveness (N5)	.47	.35	-.45	-.27	.14	.24
Vulnerability (N6)	.66	.74	-.31	.03	.00	-.10
Warmth (E1)	.70	-.14	.14	.27	.22	.73
Gregariousness (E2)	.30	-.11	-.15	-.02	-.03	.51
Assertiveness (E3)	.49	-.39	.24	-.44	.12	.27
Activity (E4)	.31	-.08	.36	-.25	-.05	.33
Excitement seeking (E5)	.36	-.02	-.19	-.46	.09	.32
Positive emotions (E6)	.45	-.26	.01	-.01	.22	.58
Fantasy (O1)	.60	.13	-.39	-.09	.64	.10
Aesthetics (O2)	.40	.17	.03	.03	.59	.13
Feelings (O3)	.52	.25	-.07	-.16	.55	.35
Actions (O4)	.30	-.22	-.18	.01	.42	.20
Ideas (O5)	.49	-.15	.10	-.10	.67	-.06
Values (O6)	.31	-.06	-.18	.18	.49	.01
Trust (A1)	.51	-.36	-.02	.52	.16	.28
Straightforwardness (A2)	.46	-.04	.09	.67	-.01	.04
Altruism (A3)	.52	-.03	.18	.48	.21	.46
Compliance (A4)	.57	-.09	.00	.75	.04	.00
Modesty (A5)	.38	.17	-.13	.54	-.19	.04
Tender-mindedness (A6)	.36	.18	-.01	.40	.26	.32
Competence (C1)	.49	-.32	.61	.01	.10	-.03
Order (C2)	.51	.05	.69	-.04	-.18	-.04
Dutifulness (C3)	.59	-.07	.71	.23	-.13	.11
Achievement (C4)	.46	-.09	.61	-.26	.01	.08
Self-discipline (C5)	.66	-.30	.75	.00	-.06	.04
Deliberation (C6)	.49	-.07	.60	.24	-.08	-.25
Correlations		I	II	III	IV	V
Neuroticism (N)		.95	-.27	-.15	.05	-.07
Extraversion (E)		-.29	.10	-.29	.17	.83
Openness (O)		.04	-.17	-.04	.97	.19
Agreeableness (A)		-.07	.02	.92	.11	.29
Conscientiousness (C)		-.18	.96	.05	-.10	-.03

positively with the global scale Extraversion ( $r = .79$ ) and negatively with the global scale Tough-mindedness ( $r = -.51$ ). Factor III correlates positively with the primary factors Rule-consciousness and Perfectionism and negatively with the primary factor Abstractedness. This third factor correlates positively with the Self-control ( $r = .94$ ) and Tough-mindedness global scales ( $r = .53$ ). Factor IV correlates positively with the primary factor Dominance. This fourth factor correlates positively with the global scale Independence ( $r = .93$ ). Factor V correlates positively with the primary factor Liveliness. This fifth factor correlates positively with the global scale Extraversion ( $r = .62$ ). A principal axis factor analysis with oblimin rotation gives quite similar results. The correlations among the oblimin factors range from  $-.45$  to  $.20$  with a mean of  $-.06$ . A comparison between the two sets

of factors obtained with varimax and oblimin rotations shows that there is a one to one correspondence ( $r > |.85|$ ). It is notable that the fifth factor correlates with the first factor ( $r = -.42$ ). These principal axis factor analyses only partially corroborate the hierarchical structure of the French version of the 16 PF 5.

The principal axis factor analyses with varimax rotation and a parallel analysis of the NEO PI-R allowed us to extract five factors explaining 58.1% of variance. The first six eigenvalues were: 5.7, 4.0, 3.5, 2.4, 1.7, and 1.1. The loading matrix (Table 6) shows that Factor I correlates well with most of the facets of the domain Neuroticism, that Factor II correlates well with all the facets of the domain Conscientiousness, that Factor III correlates well with most of the facets of the domain Agreeableness, that Factor IV correlates well with most of the fac-



Table 7. Correlations between the four-factor and five-factor solutions obtained from the 16 PF 5 and the five-factor solution obtained from the NEO PI-R.

NEO PI-R	Four-factor solution				16 PF 5				
	I	II	III	IV	I	II	III	IV	V
I	-.10	.79	-.05	-.25	.79	-.10	.05	-.23	-.01
II	-.06	-.12	-.61	.31	-.13	-.02	.60	.30	-.18
III	.13	-.20	-.19	-.59	-.20	.22	.16	-.58	-.13
IV	.28	.04	.48	.05	.03	.30	-.51	.08	.05
V	.59	-.10	.09	.15	-.09	.46	-.05	.16	.53

Table 8. Inter-correlations between the global scales of the 16 PF 5.

16 PF 5	16 PF 5				
	Ex	An	Tm	In	Sc
Extraversion (Ex)	1.00				
Anxiety (An)	-.16**	1.00			
Tough-mindedness (Tm)	-.44***	-.10*	1.00		
Independence (In)	.40***	-.05	-.29***	1.00	
Self-control (Sc)	-.27***	-.03	.46***	-.17**	1.00

Note. Significance levels: \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

ets of the domain Openness to experience and that Factor V correlates well with most of the facets of the domain Extraversion. The correlations between our factors and the five domains of the French version of the NEO PI-R are very high. Factor I correlates with the domain Neuroticism ( $r = .95$ ), Factor II with the domain Conscientiousness ( $r = .96$ ), Factor III with the domain Agreeableness ( $r = .92$ ), Factor IV with the domain Openness to experience ( $r = .97$ ), and Factor V with the domain Extraversion ( $r = .83$ ). Thus, the hierarchical structure of the inventory is confirmed. A principal axis factor analysis with oblimin rotation gives very similar results. Indeed, the correlations among the oblimin factors range from  $-.10$  to  $.27$  with a mean of  $.06$ , indicating that the factors are essentially orthogonal. A comparison between the two sets of factors obtained with varimax and oblimin rotations shows that there is a one to one correspondence ( $r > |.98|$ ).

The comparison of the two sets of factors obtained from the 16 PF 5 with the set of factors obtained from the NEO PI-R shows that the first factor obtained from the NEO PI-R correlates positively with the second factor of the four-factor solution ( $r = .79$ ) and with the first factor of the five-factor solution ( $r = .79$ ) obtained from the 16 PF 5 (Table 7). The second factor obtained from the NEO PI-R correlates negatively with the third factor of the four-factor solution ( $r = -.61$ ) and positively with the third factor of the five-factor solution ( $r = .60$ ) obtained from the 16 PF 5. The third factor obtained from the NEO PI-R correlates negatively with the fourth factor of

the four-factor solution ( $r = -.59$ ) and with the fourth factor of the five-factor solution ( $r = .58$ ) obtained from the 16 PF 5. The fourth factor obtained from the NEO PI-R correlates negatively with the third factor of the five-factor solution ( $r = -.51$ ) obtained from the 16 PF 5. The fifth factor obtained from the NEO PI-R correlates positively with the first factor of the four-factor solution ( $r = .59$ ) and with the fifth factor of the five-factor solution ( $r = .53$ ) obtained from the 16 PF 5. This comparison corroborates both some similarities and some discrepancies between the two hierarchical structures.

According to Cattell (1950b) the global scales should be orthogonal. In our study, however, we found that some global scales are intercorrelated (Table 8). Indeed, the global scale Tough-mindedness correlates with both the global scales Extraversion and Self-control. Concerning the NEO PI-R, on the other hand, none of the correlations between domains is superior to  $.40$ .

These results clearly show some correspondence between four of the five higher-level dimensions of both personality inventories. Nevertheless, this correspondence is not as strong as we would have expected. In addition, the hierarchical structure of the 16 PF 5 is not entirely validated, whereas the hierarchical structure of NEO PI-R seems very reliable.

## Discussion

Our results confirm the similarity between Cattell's global scales (Cattell et al., 1993) and the FFM as measured by Costa and McCrae's NEO PI-R (1985, 1992). These two tests share four of their five global dimensions. Both inventories are based mainly on a lexical hypothesis and the NEO was primarily created through a cluster analytic approach of the 16 PF. Based on this evidence, the discrepancies between the two tests can be considered important. This can be due either to theoretical differences or to methodological or psychometrical differences. We consider that the different construction methods used for

the two questionnaires (bottom-up versus top-down) might partly explain these results.

Concerning the comparison between the higher-level dimensions of the NEO PI-R and those of the 16 PF 5, the results show an adequate internal consistency for all global dimensions of both inventories. However, two global scales of the 16 PF 5, Tough-mindedness and Independence, have an internal consistency below .80. Correlations between both inventories show that there is a good correspondence between the Neuroticism domain and the global scale Anxiety; as well as slightly weaker correspondences between the two Extraversion scales, between Openness to experience and Tough-mindedness, and between Conscientiousness and Self-control. Nevertheless, these scales are indeed close from a semantic point of view. However, concerning the last pair of higher-level dimensions, correlations between both inventories show that the domain Agreeableness of the NEO PI-R has no correspondent in Cattell's questionnaire. This domain only slightly negatively correlates with the primary factor Vigilance. The linear regressions as well as the canonical correlations confirm that the Agreeableness domain is not represented in the 16 PF 5. Furthermore, five of the facets of the NEO PI-R do not correlate well with any of the factors of the 16 PF 5 (no correlation above .40). Nevertheless, there is an adequate correspondence between four of the higher-level dimensions of the two inventories. This was confirmed by the canonical correlation analysis that indicated that the overlap between the two sets of global dimensions is important. This shows that both questionnaires have a good convergent and predictive validity. It is interesting to note that our results did not confirm the conclusion that the concept of Openness to experience is not represented in the 16 PF 5 (McKenzie, Tindell, & French, 1997). This is not surprising, considering that the Openness to experience domain correlates well with the Openness to change primary factor that participates in the Tough-mindedness global scale. The correlations we obtained between the NEO PI-R's domains and the 16 PF 5's primary scales do not reproduce the rotated factor loadings obtained by Byravan and Ramanaiah (1995) even though the factors they extracted were closely associated to the five NEO PI-R's domains.

The validity of the hierarchical structure of the 16 PF 5 was confirmed for four of the global scales by our principal axis factor analyses. Indeed, the parallel analysis we conducted indicated extraction of four factors. None of these factors was closely associated to the global scale Tough-mindedness. This was also the case with the five-factor solution. That scale always loaded on two factors. This is certainly due to the relatively high correlations between Tough-mindedness and Extraversion and between Tough-mindedness and Self-control. It

is notable that this state of affairs was not really improved by a principal axis factor analysis with oblimin rotation. Our results do not agree with the observations of Hofer, Horn, and Eber (1997) and Chernyshenko, Stark, and Chan (2001) who were able to identify a stable and solid five-factor structure. The difference might be due to the sample size ( $n > 10,000$ ) or to the translation. On the other hand, the hierarchical structure of the NEO PI-R has been confirmed for all five dimensions. The parallel analysis confirmed this number of dimensions. Thus, the structure of the French version of the 16 PF 5 seems less robust than the structure of the French version of the NEO PI-R. The correlations between the factors obtained from the principal axis analyses of the NEO PI-R and of the 16 PF 5 confirm the correspondence we observed for four of the five global personality dimensions. We also conducted confirmatory factor analyses (CFA) but we decided not to present these results because CFA models with large degrees of freedom may easily lead to a rejection of the model as a result of statistical artifacts stemming from overly high power because of the size of the model (McCrae, Zonderman, Costa, Bond, & Paunonen, 1996; Raykov, 1998).

The higher-level dimensions of the two inventories were constructed very differently. The global scales of the 16 PF 5 are linear combinations of the standardized scores on the primary factors, each made up of several items. Thus, the global scales are made of fractions of traits or primary factors. A particular primary factor can contribute to none, or to one, or more, global scales. The idea was to create a small number of orthogonal higher-level dimensions based on dependent primary factors (Cattell, 1996). Furthermore, the instruction manual for the French version suggests using the coefficients obtained for the English version. This seems inappropriate knowing that translation can sensibly transform the meaning of an item. Our data might contribute to the calculation of more appropriate coefficients for this French version. The fact that coefficients were not recalculated for the French version might account for the high intercorrelation between the global scales of the 16 PF 5. The correlations we obtained correspond to those reported by Mogenet and Rolland (1995). Moreover, to calculate the scores for the global scales on the basis of the standardized scores on the primary factors implies a loss of information that could also account for this intercorrelation. Each domain of the NEO PI-R is made up of 48 items and each item belongs to only one dimension. Each dimension is made up of six subscales. Thus, the 48 items are divided into six groups of eight items each measuring a specific trait or facet. This legible structure lends itself well to a validation based on a factorial approach.

Cattell's theoretical structure in terms of factors and Costa and McCrae's more recent theoretical structure in

terms of domains show how these authors have built their inventories. Cattell (1943) was particularly interested in describing concrete behaviors or traits (the lower part of the hierarchical structure). Only later did he try to combine traits into global scales to describe the structure of personality. For Cattell, the hierarchical structure was an *a posteriori* way of looking at personality. Costa and McCrae (1985, 1992) first tried to define dimensions and were only later able to identify subscales. They followed the top-down method. The hierarchical structure was, for them, an *a priori* way of describing personality (Borkenau & Ostendorf, 1990; Johnson, 2000). This method made it possible to elaborate an instrument that has a particularly legible and solid structure.

## Conclusion

Both inventories roughly measure the same aspects of personality. The structure of the 16 PF 5 seems less reliable than the structure of the NEO PI-R. This might be partly due to the method of construction (bottom-up or top-down). It is interesting to note that the top-down hierarchy of the NEO PI-R is based on the bottom-up hierarchy of the 16 PF. The very legible structure of NEO PI-R makes the interpretation of a profile much easier than does the oblique structure of the 16 PF 5. One advantage of the 16 PF 5 is that the response styles can be easily assessed (social desirability, defensiveness, and acquiescence). To conclude, the NEO PI-R seems particularly reliable in assessing the five global dimensions of personality. Moreover, the top-down method makes it possible to construct inventories that are remarkably legible and reliable.

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