Personality Changes in Dementia
Are They Disease Specific and Universal?

Fernando Torrente, Lic.,†‡ Mariángeles Pose, MD,*† Ezequiel Gleichgerrcht, MD,*†‡ Teresa Torralva, Lic.,*†‡ Pablo López, PhD,*† Marcelo Cetkovich-Bakmas, MD,*† and Facundo Manes, MD*†‡§‖*

Abstract: Previous studies about personality changes in dementia suggest that they may be due to the disruption of the biological basis of personality traits, and hence, that they are disease specific and universal. However, evidence about its specificity is still limited and scarce regarding culturally diverse populations. Accordingly, our aim was to compare personality changes in Argentinean patients with Alzheimer disease, behavioral variant of frontotemporal dementia, and primary progressive aphasia. The closest living relatives of patients diagnosed with Alzheimer disease (n = 19), behavioral variant of frontotemporal dementia (n = 16), and primary progressive aphasia (n = 15) were asked to complete 2 versions of the personality inventory NEO Personality Inventory-Revised, one for assessing patients' premorbid personality traits, and the other for assessing current traits. All groups showed changes in several domains and facets of the NEO Personality Inventory-Revised. Globally, the observed pattern of changes was fairly consistent with previous studies based on the same model of personality. Nevertheless, our results regarding disease-specificity were less conclusive. Even if there were some indicators of specific differences between groups, most traits varied similarly across the 3 groups, revealing a pattern of generalized changes in personality expression after illness onset. More studies are needed that help to distinguish real personality changes from other affective or cognitive symptoms that accompany dementia, as well as further data from culturally diverse populations.

Key Words: personality, frontotemporal dementia, Alzheimer, Five Factor Model

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Alzheimer disease (AD) and frontotemporal dementia (FTD) are devastating conditions that involve a plethora of cognitive and behavioral symptoms. Previous research has shown that the profound changes that affect behavior during these illnesses could also carry stable modifications in the personality of the individual. Several studies reported remarkable changes in personality traits of patients with AD after illness onset according to the perception of their caregivers.[1–7] There is also evidence that patients with different variants of FTD show significant personality changes after illness onset.[8–13] Nevertheless, clinical and theoretical implications of these findings are still unclear. From a clinical perspective, changes in personality have been suggested as potential clinical markers that could help to distinguish different conditions and eventually provide tools for early diagnosis.[8,14] Also, from a neurobiological perspective, personality changes in neurodegenerative diseases have been claimed as an opportunity to assess the brain areas that support the normal functioning of stable personality.[13] The 2 assertions are grounded on the idea that changes in personality during dementia are due to the alteration of the biological structures and mechanisms that support the functioning of personality traits. However, for both purposes, it should be necessary to demonstrate that changes in personality are specific for each particular condition, and that the pattern of changes is consistent across different populations.

Despite its conceptual importance, the specificity and universality of personality changes in dementia are far from being well established. A series of related studies by Rankin et al[8,9] and Sollberger et al[10–12] revealed differential patterns of personality change between the frontal and temporal variants of FTD, and between them and AD. These studies employed a measure of personality—the Interpersonal Adjectives Scale[15] based on the Circumplex Model of Personality—that does not allow for direct comparisons with the rest of the existing literature on this topic based on the Five Factor Model (FFM) of personality,[16] a widely disseminated model with a strong empirical background.[17] Recently, a study by Lykou et al[18] compared Greek patients with AD, behavioral variant of frontotemporal dementia (bvFTD), and an mild cognitive impairment with a questionnaire based in the FFM, finding differences between AD and bvFTD, and with mild cognitive impairment having a similar pattern to AD. In addition, a study by Mahoney et al[13] compared subjects with different variants of FTD, but they did not include participants with other types of dementia. Overall, the evidence about specificity and universality of personality changes in dementias is still limited and methodologically heterogeneous, making it necessary to test it more in detail and in culturally diverse populations.

In the present study, we sought to compare personality changes after illness onset in Argentinean patients with AD, bvFTD, and primary progressive aphasia (PPA) as perceived by their caregivers through a measure based on the FFM of personality. The use of a widely disseminated model of personality favors the comparison with findings

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From the *INECO (Institute of Cognitive Neurology); †Institute of Neurosciences, Favaloro University; ‖National Scientific and Technical Research Council (CONICET), Buenos Aires, Argentina; ‡UDP-INECO Foundation Core on Neuroscience (UIFCoN) Diego Portales University, Santiago, Chile; and §Australian Research Council (ACR) Centre of Excellence in Cognition and its Disorders, New South Wales, Australia.

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Reprints: Fernando Torrente, INECO (Institute of Cognitive Neurology), Pacheco de Melo 1860, Buenos Aires CP 1126, Argentina (e-mail: ftorrente@ineco.org.ar).

from previous studies about the topic. As well, the direct comparison between patients with AD, bvFTD, and PPA allowed to test whether the pattern of personality change was either specific for each condition, or else, a generic change attributable to diverse pathogenic processes involved in dementia. Accordingly, the study proposed 2 different alternative hypotheses. First, a specificity hypothesis assumed that there are specific and differential patterns of personality change for each clinical entity. This hypothesis presupposes that neurodegenerative processes affect specific neural areas associated with particular personality traits, and that in consequence changes in personality expression are biologically determined and culturally universal. Second, a general hypothesis assumed that there are significant and reliable global changes in personality traits of people with diverse syndromes, but without specific differences between conditions. These changes may result from different pathologic processes involved in dementia, not necessarily tied with the degeneration of the neural basis of personality traits, and eventually modeled by environmental influences.

METHODS

Participants

The closest living relatives of 50 patients diagnosed with AD (n = 19), bvFTD (n = 16), and PPA (n = 15; 9 with semantic dementia and 6 with nonfluent progressive aphasia) were recruited for this study. Patient diagnosis was made on the basis of published criteria for AD,[19] bvFTD,[20,21] and PPA.[22] Each patient's diagnosis was individually considered in the context of a multidisciplinary clinical meeting, where cognitive neurologists, psychiatrists, and neuropsychologists discuss each case based on the results of a series of clinical interviews and assessment batteries that include neurological, neuropsychiatric, and neuropsychological examinations, as well as magnetic resonance imaging-single-photon emission computed tomography. All patients in this study showed either characteristic atrophy profiles on magnetic resonance imaging or hypoperfusion on single-photon emission computed tomography, or both, when available. Major psychiatric disorders were ruled out by means of a psychiatric interview. Final diagnosis for the patients being included in the protocol was established by 2 experts in dementia (F.M. and M.P.) whose interrater reliability was excellent (Cohen $\kappa = 0.92$). When the experts' diagnoses did not overlap, final diagnosis was established according to the consensus of the aforementioned multidisciplinary group. Relatives were spouses (64%) or children (36%) of the patients, and gave their informed consent before inclusion in this study. There were no significant differences in the proportion of spouses and children across the 3 groups ($\chi^2 = 2.181$, $df = 2$, $P = 0.34$).

Procedure

Relatives of patients received 2 versions of the NEO Personality Inventory-Revised (NEO-PI-R),[23] one of which referred to the patient's current personality profile, whereas the other enquired about the patient's personality traits 10 years ago and before the onset of the disease. The NEO-PI-R is a 240-item measure based on the FFM of personality.[23] The FFM is an empirically derived taxonomy of personality traits in terms of 5 basic domains—Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A), and Conscientiousness (C)—each of which is made up of 6 low-order components, called facets.[17] The NEO-PI-R provides scores for the 5 general domains and for each of the 30 facets included in the model. Responses are made on a 5-point Likert scale, from strongly disagree to strongly agree. Originally developed as a self-report measure, a form for observer ratings has been developed, in which the items have been rephrased in the third person. The Spanish third-person version applied in the present study has been previously adapted and utilized in Argentina in a large multicultural study.[24] Raw scores have been reported in the present study.

Statistical Analyses

Demographic and clinical information was compared across the groups using 1-way ANOVA with "group" as the independent variable. Bonferroni test was employed for post hoc comparisons. For establishing the specificity of changes in NEO-PI-R scores, we examined both the pattern of changes within each group and the comparison of change scores (present scores minus past score) between groups. For intragroup comparisons between past and present time, paired-sample t tests were conducted. For between-groups comparisons, the method employed was ANCOVA with age as covariate, as there were differences in this variable between AD group and both bvFTD and PPA. Again, Bonferroni tests were conducted for post hoc pairwise comparisons. Because of its categorical nature, sex was compared between the groups using a χ^2 on a 3 (groups) $\times 2$ (male vs. female) contingency table. Correlations were conducted using Pearson correlation coefficient. All statistical analyses were performed using SPSS 17.0 with the α-threshold set at.05, 2-tailed.

RESULTS

Demographics

As expected, a significant difference was found between the patient groups on age at present ($F_{2,47} = 8.32$, $P = 0.001$), with AD patients being significantly older than both bvFTD and PPA patients (Table 1). Yet, no other significant differences were found between the groups, including disease duration ($F_{2,47} = 0.43$, $P = 0.65$), years of education ($F_{2,47} = 1.98$, $P = 0.16$), sex ($\chi^2 = 0.34$, $df = 2$, $P = 0.85$), and dementia severity as measured by the Clinical Dementia Rating Scale's[25] transformed score ($\chi^2 = 13.3$, $df = 8$, $P = 0.12$) or sum of boxes ($F_{2,47} = 0.43$, $P = 0.63$).

TABLE 1. Demographic Data for bvFTD, PPA, and AD Patients

	bvFTD (n = 16)	PPA (n = 15)	AD (n = 19)
Age at present (y)	69.9 (6.6)	70.4 (10.1)	73.7 (9.0)*
Disease duration (y)	4.36 (2.7)	3.57 (3.6)	5.25 (4.6)
Sex (M: F)	8 : 8	9 : 6	10 : 9
Education (y)	13.1 (5.5)	15.5 (5.4)	12.4 (3.3)
CDR-transformed score	1.28 (0.9)	0.90 (0.8)	1.24 (0.7)
CDR-sum of boxes	6.78 (5.6)	5.37 (5.5)	6.87 (3.7)

A significant difference was only found on the groups' mean age at present (AD > bvFTD, AD > PPA).

*$P < 0.05$.

AD indicates Alzheimer disease; bvFTD, behavioral variant of frontotemporal dementia; CDR, Clinical Dementia Rating Scale; PPA, primary progressive aphasia.

TABLE 2. Paired-Samples *t* Test Results Comparing NEO-PI-R Scores at Past and Present Times for Each Patient Group

	bvFTD (n = 16)				PPA (n = 15)				AD (n = 19)			
	Mean (SD)				Mean (SD)				Mean (SD)			
	Past	Present	*t*	*P*	Past	Present	*t*	*P*	Past	Present	*t*	*P*
Total Neuroticism	85.3 (22)	96.3 (26)	1.95	NS	57.9 (23)	82.6 (24)	4.6	< 0.001	77.9 (21)	97.1 (23)	4.76	< 0.001
Anxiety	15.9 (5.2)	18.2 (5.9)	1.38	NS	12.8 (5.4)	15.8 (6.5)	3.39	< 0.01	15.0 (4.8)	17.5 (4.6)	2.18	0.042
Hostility	16.1 (6.0)	16.7 (7.1)	0.37	NS	8.80 (7.3)	13.9 (6.9)	4.32	0.001	13.4 (6.9)	17.0 (6.3)	2.51	0.022
Depression	12.4 (4.7)	14.1 (5.8)	1.07	NS	9.53 (4.4)	14.1 (5.1)	3.23	< 0.01	12.3 (5.4)	14.8 (5.6)	2.45	0.025
Self-consciousness	13.4 (4.3)	13.1 (5.1)	−0.2	NS	9.60 (3.7)	12.7 (3.1)	3.17	< 0.01	14.3 (5.1)	15.2 (5.0)	0.7	NS
Impulsiveness	16.9 (5.3)	15.9 (5.7)	−0.35	NS	9.20 (4.5)	12.3 (5.0)	2.95	0.01	12.3 (5.0)	15.3 (4.0)	2.78	0.012
Vulnerability	11.2 (5.1)	18.2 (6.2)	5.0	< 0.001	7.93 (4.7)	14.9 (6.1)	4.26	0.001	10.4 (4.5)	17.3 (5.2)	5.32	< 0.001
Total Extraversion	106 (22)	88.7 (25)	–2.50	0.024	117 (21)	97.3 (20)	−3.12	< 0.01	102 (26)	89.6 (20)	−2.8	< 0.01
Warmth	19.6 (6.0)	17.1 (6.9)	−1.77	NS	24.0 (6.3)	21.3 (6.1)	−1.94	NS	21.0 (5.9)	19.3 (5.4)	−1.69	NS
Gregariousness	17.2 (6.3)	16.2 (4.6)	−0.74	NS	19.1 (6.0)	16.1 (4.7)	−3.3	< 0.01	17.1 (6.2)	16.0 (5.2)	−0.9	NS
Assertiveness	17.9 (4.5)	12.2 (4.9)	−3.41	< 0.01	18.0 (5.5)	13.1 (4.6)	−2.7	< 0.02	16.1 (6.4)	13.6 (5.9)	−2.35	0.030
Activity	19.0 (4.3)	14.4 (5.6)	−2.89	0.01	19.7 (3.5)	16.7 (4.9)	−2.2	0.04	18.3 (5.4)	14.1 (4.9)	−3.49	< 0.01
Excitement-seeking	13.9 (4.8)	11.2 (4.7)	−2.63	0.02	14.4 (4.3)	12.3 (4.7)	−1.66	NS	12.1 (4.7)	10.9 (4.9)	−1.35	NS
Positive Emotions	18.7 (5.5)	17.6 (7.0)	−0.59	NS	22.4 (5.7)	17.9 (6.7)	−2.7	0.017	18.0 (6.7)	15.8 (4.6)	−2.05	0.05
Total Openness	97.2 (19)	81.6 (27)	−2.8	0.013	101 (17)	87.9 (17)	−2.11	0.05	80.2 (23)	80.2 (20)	−0.015	NS
Fantasy	17.2 (5.1)	15.2 (5.7)	−1.56	NS	17.3 (4.4)	16.5 (3.8)	−0.77	NS	13.3 (4.1)	14.6 (3.6)	1.36	NS
Aesthetics	15.6 (7.1)	13.2 (7.8)	−1.25	NS	16.3 (8.0)	14.3 (6.5)	−1.27	NS	12.4 (7.2)	12.4 (7.0)	−0.09	NS
Feelings	18.4 (2.5)	15.2 (5.9)	−1.95	NS	19.2 (2.8)	17.3 (3.1)	−1.43	NS	17.0 (3.4)	16.2 (3.3)	−0.71	NS
Actions	12.6 (4.2)	11.4 (5.0)	−0.85	NS	13.5 (4.8)	10.6 (3.6)	−2.69	0.017	10.0 (4.7)	10.5 (4.2)	0.52	NS
Ideas	16.2 (7.1)	10.7 (7.3)	−3.21	< 0.01	17.4 (6.3)	14.3 (5.0)	−1.88	NS	12.7 (5.4)	10.2 (6.2)	−2.35	0.03
Values	17.1 (4.1)	15.9 (4.2)	−1.66	NS	17.1 (3.6)	14.8 (2.9)	−2.37	0.03	14.9 (4.1)	16.4 (4.0)	1.85	NS
Total Agreeableness	103 (25)	108 (24)	1.57	NS	123 (24)	120 (23)	−0.78	NS	109 (23)	108 (22)	−0.169	NS
Trust	18.2 (7.0)	18.5 (6.6)	0.18	NS	24.1 (6.6)	22.3 (5.4)	−1.91	NS	19.7 (6.0)	19.1 (5.7)	−0.544	NS
Straightfowardness	17.1 (5.0)	19.2 (5.1)	1.91	NS	21.1 (6.0)	21.5 (5.8)	0.29	NS	19.8 (6.7)	21.2 (6.9)	1.214	NS
Altruism	16.9 (3.1)	16.4 (3.7)	−0.56	NS	18.5 (1.9)	16.9 (1.8)	−3.0	< 0.01	18.2 (1.9)	17.3 (3.5)	−1.285	NS
Compliance	14.6 (6.1)	16.3 (5.1)	1.25	NS	18.9 (5.8)	18.8 (6.4)	−0.05	NS	16.5 (6.7)	16.2 (6.2)	−0.453	NS
Modesty	16.4 (6.8)	18.9 (7.5)	2.27	0.04	19.1 (6.2)	20.5 (5.7)	1.42	NS	15.1 (8.4)	16.4 (8.1)	2.04	0.05
Tendermindedness	19.8 (4.9)	18.4 (4.2)	−1.75	NS	21.7 (4.0)	20.5 (4.1)	−1.42	NS	19.5 (4.4)	18.4 (4.6)	−1.781	NS
Total Conscientiousness	130 (17)	90.4 (37)	−4.81	< 0.001	147 (18)	119 (31)	−2.9	0.012	135 (20)	106 (19)	−4.5	< 0.001
Competence	23.6 (3.8)	14.9 (6.1)	−6.1	< 0.001	25.8 (3.7)	19.5 (5.0)	−3.7	< 0.01	24.7 (4.7)	18.8 (4.7)	−3.88	0.001
Order	17.5 (4.4)	15.1 (6.0)	−1.62	NS	19.4 (3.8)	16.9 (5.4)	−1.83	NS	19.0 (4.8)	15.7 (4.5)	−3.1	< 0.01
Dutifulness	23.8 (3.7)	16.9 (7.6)	−3.76	< 0.01	27.1 (4.0)	21.9 (5.7)	−3.1	< 0.01	24.7 (3.7)	21.1 (3.7)	−2.8	0.011
Achievement Striving	22.9 (3.8)	13.7 (8.4)	−4.7	< 0.001	25.6 (4.5)	21.9 (6.2)	−1.74	NS	22.8 (4.6)	17.0 (4.6)	−3.9	0.001
Self-discipline	23.1 (4.0)	14.3 (7.7)	−4.22	0.001	26.1 (3.5)	20.0 (6.6)	−2.83	0.013	23.8 (5.0)	16.3 (4.6)	−4.4	< 0.001
Deliberation	18.7 (5.7)	15.4 (7.4)	−1.95	NS	23.4 (4.5)	18.7 (6.5)	−3.38	< 0.01	20.2 (5.3)	17.1 (5.0)	−2.5	0.022

AD indicates Alzheimer disease; bvFTD, behavioral variant of frontotemporal dementia; PPA, primary progressive aphasia.

Change Among Groups

Total domain scores of the NEO-PI-R were compared before disease onset versus present time within each clinical group (Table 2). Significant differences were found in the AD group on Neuroticism (B < P), Extraversion (B > P), and Conscientiousness (B > P). Regarding the BvFTD group, significant differences were found on Extraversion (B > P), Openness (B > P), and Conscientiousness (B > P). Finally, significant differences were found in the PPA group on Neuroticism (B < P), Extraversion (B > P), Openness (B > P), and Conscientiousness (B > P).

As shown, decreases in Extraversion and Conscientiouness appear as common pre versus post changes in the 3 groups, whereas Agreeableness did not change after onset of the conditions included in this study. In contrast, Neuroticism showed increases in PPA and AD, but not in bvFTD, and Openness showed decreases in bvFTD and PPA, but not in AD.

Also NEO-PI-R facet scores were compared before disease onset versus present time, showing significant differences on several facets for each group (Table 2).

Group Differences at Baseline

At domain level, there were differences between groups in past scores on Total Neuroticism (bvFTD > PPA, PPA = AD, AD = bvFTD), Total Openness (bvFTD = PPA, PPA > AD, bvFTD = AD), and Total Conscientiousness (bvFTD < PPA, PPA = AD, bvFTD = AD) (Table 3).

Also, a significant difference was found across groups at facet level on Hostility (bvFTD > PPA, PPA = AD, AD = bvFTD), Social Anxiety (bvFTD = PPA, PPA < AD, AD = bvFTD), Impulsivity (bvFTD > PPA, PPA = AD, AD = bvFTD), and Fantasy (bvFTD > AD, PPA > AD, bvFTD = PPA).

Notably, most between-group differences existing before the estimated onset of the illness involve the PPA group, which differed from both AD and bvFTD at the domain and facet level. Meanwhile, AD and bvFTD were similar to each other, exception for 1 facet in particular (Fantasy).

Group Differences at Follow-up

There were no differences across groups at domain level in the present scores. A significant difference was found between groups at facet level on Achievement striving (AD = PPA, PPA < bvFTD, AD = bvFTD) (Table 3).

Group Differences in Change Scores

Change scores for each group were obtained subtracting past scores from present scores in every domain and facet (Table 3). Then, changes scores were compared between the 3 samples for detecting specificities, with age as confounding covariate. There were no differences in between-groups comparisons of change scores at domain level (all $P > 0.05$). At facet level, a significant difference was found across groups exclusively on Impulsivity (AD > bvFTD; PPA = AD, PPA = bvFTD) and Values (PPA > AD, AD = bvFTD, PPA = bvFTD).

DISCUSSION

The aims of this study were to compare the nature of personality changes in an Argentinean sample of patients with AD, bvFTD, and PPA, and to test the specificity of that change according to the FFM of personality. The obtained data confirmed previous reports concerning global changes in personality traits in the 3 conditions examined. Patients with AD, bvFTD, and PPA all showed changes in various facets and domains of the NEO-PI-R based on the report of their closest caregivers. Moreover, the observed pattern of changes is mostly congruent with previous studies that employed the same measure of personality, adding reliability to the present study. However, results regarding disease-specificity of changes in personality traits are less conclusive. Even if there were some facets and domains that changed differentially in AD and PPA versus bvFTD, most involved domains were equally affected in the 3 groups. As well, direct comparison of change scores between groups did not reveal any significant difference at domain level.

Globally, the present study supports the idea of a change in personality ratings in these conditions. When the 3 groups were considered altogether, 4 of the 5 domains of personality, and 22 of the 30 facets featured in the FFM showed changes after illness onset. There were significant increments in Neuroticism, and decreases in Extraversion, Openness, and Conscientiousness. Only Agreeableness domain did not evidence changes in any of the conditions examined. The amplitude of the observed changes makes it clear that the way that affected subjects are perceived by their caregivers is substantially different before and after illness onset in all the groups examined. Taken as a whole, this pattern of widespread changes distributed across conditions supports the idea that there are global personality changes when comparing traits before and after the onset of diverse dementia syndromes.

Regarding the disease-specificity of changes, the comparison between the 3 profiles of personality changes reveals several commonalities and few differences between conditions. The AD group presented significant changes in 3 domains—Neuroticism, Extraversion, and Conscientiousness, consistently with most previous findings.[16] The bvFTD group revealed differences after illness in 3 domains—Extraversion, Openness, and Conscientiousness. The 2 latter domains overlapped with the findings by Mahoney et al[13] and the first and the last with Lykou et al.[18] Finally, the PPA group manifested variations in 4 domains—Neuroticism, Extraversion, Openness, and Conscientiousness, congruently with the results obtained by Mahoney et al[13] for primary progressive nonfluent aphasia patients. As it can be seen, Conscientiousness and Extraversion appear as common areas of change across disorders. In contrast, Neuroticism, and, to a lesser extent, Openness, showed a differential pattern of change between conditions. Particularly, Neuroticism manifested significant pre-post variations both at the domain and facet levels in AD and PPA, but not in bvFTD, thus being the most distinctive trait across the different groups. However, the comparison of change scores (present scores minus past scores) between groups did not reveal significant differences at domain level, and only Impulsivity and Values manifested differences at facet level. In addition, there were no idiosyncratic changes associated with bvFTD, as most of the changes observed in bvFTD were shared with another group. Specifically, changes in Conscientiousness were not significantly bigger in bvFTD than in the other conditions in our sample, as opposed to what Lykou et al's[18] report. Also, there was no decrease in Neuroticism, in contrast with Lykou et al,[18] and in agreement with Mahoney et al.[13] Consequently, our results do not support the hypothesis of a double dissociation of personality traits between bvFTD

TABLE 3. Group Differences in NEO-PI-R at Baseline, Follow-up, and Change Scores

	Baseline Scores*			Follow-up Scores†			Change Scores‡		
	F§	*P*	Post Hoc Comparisons	*F*§	*P*	Post Hoc Comparisons	*F*§	*P*	Post Hoc Comparisons
Total Neuroticism	4.22	0.01	bvFTD > PPA	1.23	NS	—	1.28	NS	—
Anxiety	0.98	NS	—	0.72	NS	—	0.15	NS	—
Hostility	2.99	0.04	bvFTD > PPA	0.83	NS	—	1.40	NS	—
Depression	1.39	NS	—	0.10	NS	—	0.80	NS	—
Self-consciousness	3.74	0.017	PPA < AD	1.58	NS	—	1.93	NS	—
Impulsiveness	6.09	0.001	bvFTD > PPA	2.65	NS	—	3.35	< 0.05	AD > bvFTD
Vulnerability	1.3	NS	—	1.11	NS	—	0.23		
Total Extraversion	1.61	NS	—	1.65	NS	—	0.37	NS	—
Warmth	2.08	NS	—	1.59	NS	—	0.16	NS	—
Gregariousness	0.55	NS	—	0.52	NS	—	0.56	NS	—
Assertiveness	0.62	NS	—	1.63	NS	—	1.20	NS	—
Activity	0.36	NS	—	1.27	NS	—	0.34	NS	—
Excitement-seeking	1.27	NS	—	1.78	NS	—	0.67	NS	—
Positive Emotions	1.62	NS	—	0.38	NS	—	0.77	NS	—
Total Openness	3.49	0.023	PPA > AD	0.68	NS	—	2.07	NS	—
Fantasy	3.42	0.025	bvFTD > AD, PPA > AD	1.10	NS	—	1.61	NS	—
Aesthetics	1.02	NS	—	0.33	NS	—	1.37	NS	—
Feelings	1.79	NS	—	1.55	NS	—	0.70	NS	—
Actions	2.26	NS	—	0.15	NS	—	1.61	NS	—
Ideas	1.76	NS	—	1.4	NS	—	0.84	NS	—
Values	1.20	NS	—	0.54	NS	—	4.09	< 0.05	PPA > AD
Total Agreeableness	2.5	NS	—	2.06	NS	—	1.31	NS	—
Trust	2.41	NS	—	1.47	NS	—	0.45	NS	—
Straightfowardness	1.45	NS	—	1.92	NS	—	1.26	NS	—
Altruism	1.45	NS	—	0.25	NS	—	0.36	NS	—
Compliance	1.55	NS	—	1.04	NS	—	0.62	NS	—
Modesty	1.29	NS	—	2.08	NS	—	0.85	NS	—
Tendermindedness	0.94	NS	—	0.92	NS	—	0.04	NS	—
Total Conscientiousness	3.09	0.036	bvFTD < PPA	2.37	NS	—	0.57	NS	—
Competence	0.955	NS	—	2.25	NS	—	0.79	NS	—
Order	0.752	NS	—	0.46	NS	—	0.69	NS	—
Dutifulness	2.67	NS	—	2.63	NS	—	0.73	NS	—
Achievement Striving	1.85	NS	—	4.03	0.013	PPA < bvFTD	1.52	NS	—
Self-discipline	1.99	NS	—	2.31	NS	—	0.88	NS	—
Deliberation	2.09	NS	—	0.69	NS	—	0.23	NS	—

*Past cores.
†Present scores.
‡Present minus past scores.
§ANCOVA with age as covariate.
AD indicates Alzheimer disease; bvFTD, behavioral variant of frontotemporal dementia; PPA, primary progressive aphasia.

and AD, as reported by Rankin et al[8] and overall, our data do not provide clear evidence favoring the "specificity hypothesis" of personality change.

Theoretical and Clinical Considerations

The results of this study outlined a mixed scenario. Numerous traits showed widespread changes across conditions, whereas others, more restrictedly, evidenced some differences. How can we sort the puzzle in a coherent way? In our opinion, it is very difficult to answer this question without the support of a well-organized theory of personality. According to the Five Factor Theory (FFT) of the personality system,[26] personality traits are components of a wider dynamic personality system that coordinates behaviors and experiences of an individual. Personality traits are neither observable patterns of behavior nor cognitive structures that guide behavior, but basic biological-based tendencies. As McCrae and Costa[26] acknowledge, biological bases of personality are plausibly rooted in genes and specific neural substrates[27] that may be altered by different diseases. Neuroticism is known to reflect traits relating to anxiety and vulnerability to stress as well as negative emotionality and has been associated with temporal cortices.[28,29] With PPA and AD patients presenting a primary involvement of temporal structures, it is thus coherent that these conditions had the most marked changes in this domain. Interestingly, preonset versus postonset scores differed at the level of facets differently for each condition, perhaps reflecting the fact that there is a stronger lateral involvement in PPA and a more specific medial involvement in AD. This should be tested in future studies relating neuroimaging and volumetry with changes on the NEO-PI-R. Conscientiousness, strongly associated with control, planning and goal-oriented behavior, has been found to rely on a widespread network of brain areas including prefrontal networks[30,31] and the insula, among

other structures.[29] Because of the diffuse involvement of brain structures underlying Conscientiousness, it is reasonable to expect that different conditions affecting specific areas within this network result in similar patterns of change. Similarly, Extraversion has been associated with the anterior cingulate cortex[30] and other distributed frontotemporal structures.[29] While bvFTD affects primarily the prefrontal, anterior temporal, and insular cortices,[32] and PPA and AD selectively disrupt circuits within the lateral and medial temporal cortex, respectively, all 3 conditions are neurodegenerative in nature and progressively affect many areas. In sum, it is expected that personality domains that rely on such diffuse brain networks be affected in a wide variety of conditions. It will be worthy of further research to determine more specific traits of change between different neurodegenerative diseases. Even if this task is not straightforward, a direct influence of neurodegenerative disease over traits was assumed in most previous studies that have tried to establish a relationship between altered neural structures and personality change.[10,13] However, as we will discuss next, there are other possible mechanisms for understanding such relationship.

As an alternative putative mechanism, personality system may be disturbed by the so-called "pathoplastic effects" of psychopathology.[33] Psychopathological disturbances such as depression and anxiety have been identified as sources of changes in the appearance, presentation, or perception of personality in psychiatric patients. Notably, these pathoplastic effects over personality may revert after an adequate treatment of the comorbid conditions.[33] Thus, the augmented Neuroticism in AD and PPA observed in our results may be explained as pathoplastic effects of a sustained comorbid affective or anxiety disorder.[34,35] Otherwise, increased anxiety, depression, and vulnerability, could be eventually interpreted as understandable psychological reactions to the undermining impact of neurological disease over the self. As well, changes in Conscientiousness or Extraversion could be accounted for by an enduring increase in apathy, very frequent in the 3 diseases.[36–39]

Also, as stated by the FFT, the output of the personality system depends on the functioning of numerous dynamic processes that connect the different components of the system. Dynamic processes include diverse cognitive, emotional, and volitional functions that are necessary for the performance of the output behaviors favored by personality tendencies. For instance, the expression of low Neuroticism traits depends on the right functioning of emotion-regulation mechanisms, high Extraversion depends on social cognition abilities, and high Conscientiousness depends on strong executive functions. As a third mechanism, dementia could obstruct the dynamic processes that ensure the correct functioning of the personality system. According to this idea, the disruption of generic low-order functions—such as executive functions, memory systems, or inhibitory control—would plausibly alter higher-order organizations of personality, and could thus interfere and potentially distort the expression of basic traits. Sollberger et al[11] showed that personality changes may be associated with the disturbance of basic cognitive components of a distributed neural network that subserves personality, such as executive, verbal, and emotional functions. In this regard, it is important to note here that even if these functions are necessary for the right functioning of personality system, they are not specific to personality, but rather general cognitive tasks tied to a variety of mental processes structures.

The fact that neurodegenerative disease may affect personality through different mechanisms has several important theoretical and clinical implications. First, we cannot assume that all of the observed changes in personality descriptions are of the same nature. Degenerative diseases may alter the neural basis of personality traits—the upper level of the system—or, else, may disrupt common basic blocks that are necessary to construct the stable structure of personality, or both. Therefore, we believe that it is necessary to discriminate between different mechanisms of personality change. Otherwise, we are at risk for duplicating the same finding at 2 different levels, and treating them as independent events when they are naturally not. In other words, it is of dubious advantage to claim that a depressed patient with AD also evidenced a personality change in the Neuroticism domain, when they may be related findings, or even a unique phenomenon. Also, we should be cautious when it comes to establishing relationships between personality traits and neural areas. In this respect, we consider that one could infer that changes in personality traits are directly attributable to alterations of specific neural areas, only if lower-order dysfunctions are strictly controlled. If not, there is a risk of erroneously assigning localizations to personality traits, when the implicated neural areas are actually related with lower level, general cognitive, or affective processes, that in turn affect personality expression. Finally, from a clinical point of view, observed changes in personality would be of utility as disease markers only if they are specific for each condition, as we claimed earlier, but also if they are clearly distinguished from other pathologic affective or cognitive components that accompany dementia.

Limitations and Further Research

The main limitation of this study is the small sample size of the 3 groups. As a consequence, more subtle differences between groups may have been missed due to a lack of statistical power. However, the number of participants is similar to other previous studies about the topic and for that reason we believe that the sample sizes of the present study were adequate to test the specificity of personality changes in conditions analogous to previous reported findings. As well, the PPA group involved different variants (semantic dementia and nonfluent progressive aphasia), which could potentially introduce an undesirable heterogeneity to the sample. Unfortunately, the current small size of each PPA subgroup precluded any possibility of interpreting the results separately for semantic dementia and progressive nonfluent aphasia. Future studies with larger sample sizes should indeed attempt to analyze PPA variants separately. Another limitation of the present research concerns the use of observer's retrospective ratings for estimating personality traits before illness onset. In this respect, our study reproduces the methodology adopted in previous research concerning this issue. Another limitation which is also shared with most of previous reports is that patients were evaluated after the onset of dementia. Because of that, diverse pathologic phenomena associated with dementia may confound the interpretation of the results about personality change. To avoid this shortcoming, some studies[12] included patients in early stages of dementia. However, it is a well-known fact that even patients in early stages of dementia show substantial

cognitive deficits.[40] Finally, the existence of premorbid differences in personality traits between the PPA group and the other 2 groups may obscure the interpretation of between-group differences after illness onset. However, for this purpose, we calculated a change score for each group by subtracting present scores (ie, after disease onset) from past scores (ie, before disease onset) for establishing a common measure of change independent of the basal differences. In other terms, we compared the amount of change for each trait irrespective of their starting point. When using that change score, we obtained no significant differences at the domain level in between-group comparisons.

As a matter of further research, it would be important to address the distinction of the diverse processes that may alter the expression of personality. For this purpose, it could be of help to study patients at very early stages of the disease, when cognitive functions are yet preserved, or when patients are free of neuropsychiatric symptoms. As an alternative strategy, it would be useful to measure and report concomitant neuropsychiatric confounding symptoms, like depression or apathy, as well as neuropsychological measures associated with changes in personality ratings. With these data, it would be possible to carry a strict statistical control of neuropsychiatric symptoms and cognitive deficits in an attempt to determine whether personality changes are secondary phenomena that can be explained by pathoplastic effects or deficits in general cognitive functions, rather than primary manifestations of the disease. Also, it would be feasible to compare the extent of personality changes in subgroups with and without clinically meaningful neuropsychiatric manifestations or cognitive deficits. Finally, even if data from different populations showed until now fairly convergent results, it should be necessary to further replicate the findings in culturally diverse environments for establishing the universality of personality changes.

CONCLUSIONS

Results of our study evidenced a complex set of changes in the expression of personality among patients with neurodegenerative conditions. On the one hand, results favor the hypothesis of a general change of personality in diverse types of dementia, with numerous traits presenting shared changes across conditions. On the other hand, fewer differences were found across conditions, only partially supporting the hypothesis of specific personality changes in different neurodegenerative disorders. This complex pattern of results and their interpretation within the frame of a structured theory of personality reinforce the necessity of dissecting and controlling the multiple processes that could affect the output of the personality system before claiming specific changes at personality traits level.

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