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# Personality Style in Behavioural Disturbances in Parkinson's Disease

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## Abstract

**Objective:** Non-motor changes in Parkinson's disease (PD) can include behavioural disturbances, such as apathy and impulse control disorders (ICDs). These behavioural problems impact on quality of life and caregiver burden. In the case of impulsivity, there is some association with specific personality styles at the time of assessment. This study compares current and pre-morbid personality attributes among people with PD who experience a clinically significant ICD, apathy, or no behavioural disturbance.

**Methods:** 94 PD participants without dementia (ICD, n=34; apathy, n=24; control, n=36) were examined for current and pre-morbid (10 years before PD onset) personality style using self- and informant- versions of the NEO Five-Factor Inventory. All informants were knowledgeable about participants' midlife personalities and provided both current and pre-morbid ratings.

**Results:** When key co-variates (depression, anxiety, age and dopamine load) were controlled for, a difference in self-reported current personality style was found among the three PD groups, with the ICD group rating themselves as less agreeable compared to those with apathy or no behavioural disorder. Informant-rated current and pre-morbid measurements of personality style did not differ.

**Conclusion:** While people with PD and clinically significant ICDs currently report themselves as being less agreeable, their informants did not support this finding and reported no change from pre-morbid personality. Differences in personality style with impulsive-compulsive behaviours in PD may not be discernable to others and may be related to transient 'state' factors (i.e. influenced by the disease process or response to treatment), rather than the more enduring trait characteristics exhibited prior to the onset of PD. Until longitudinal investigation of personality determinants has been conducted, there should be a cautious approach in screening for at-risk individuals using specific personality attributes, to avoid overlooking persons with PD who may be vulnerable to developing behavioural complications.

**Keywords:** Parkinson's disease; Impulse control disorder; ICD; Apathy; Personality; NEO, Behavioural disorders; Psychiatry; Premorbid; Agreeableness

## Introduction

Apathy and impulse control disorders (ICDs) are examples of non-motor behavioural changes that may complicate idiopathic Parkinson's disease (PD) [1,2], negatively impacting on quality of life [3] and caregiver burden [4]. Apathy, which has been defined as "a lack of interest, emotion and motivation", can occur in about 50% those with PD [1,5]. ICDs, which include pathological gambling, compulsive sexuality, binge eating, compulsive shopping, and the abuse of dopamine replacement therapy, or "dopamine dysregulation syndrome", can occur in up to 14% of those affected by PD [6]. These behaviours are thought, in part, to be genetically influenced [7-9], and are related to disruptions in neural pathways underpinning reward, impulsivity and motivation [10]. Extra-striatal dopaminergic changes [11] and altered ventral striatal dopamine synthesis capacity [12, 13] have now been observed in people with PD and ICDs, with the latter finding being a predictor of financial extravagance [12].

Dopamine replacement therapy is likely a key precipitant in the development of ICDs, however, several intrinsic risk factors such as higher propensity for "novelty-seeking" [14,15] may also be implicated. Other risk factors include: smoking status, male gender, younger age and younger age of disease onset, co-morbid or previous psychiatric symptoms, previous history of substance abuse, family and personal history of substance and behavioural addictions [2,10,16-21]. The number of variables involved, particularly the relevance of a novelty-seeking personality style, suggests a "vulnerability" model of risk for ICDs, similar to that noted in substance and behavioural addictions in people without PD [22].

In a Danish review of 490 people with PD, those who reported previous or current impulsive-compulsive behaviours also reported more depressive symptoms and more neuroticism, plus a trend towards less agreeableness and more openness, than those who experienced no behavioural disturbance [21]. This finding demonstrates people with PD and impulsive or compulsive behaviour exhibit specific personality attributes, compared to their unaffected counterparts. However, it should be noted that the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's disease (QUIP) [23] used in the study is a presence or absence screening tool for both historical and current symptoms of ICDs. The developers of the tool encourage follow-up by clinical interview to determine severity of the behavioural disturbance [23]. While the authors of the Danish review took care to detail current presence of the behavioural symptoms, individuals positively reporting

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impulsive or compulsive characteristics may not have experienced the clinically significant impact on social and occupational functioning required for confirmation of an ICD.

To date, little robust evidence regarding the relationship between pre-morbid personality style and ICDs or apathy in PD has been reported [24]. The existence of a putative pre-morbid personality style in PD, also known as the "parkinsonian personality" dates back several years, and has been described as conservative, harm avoidant, low risk taking, low novelty-seeking, inflexible and introverted [25] .

However, studies in people without PD have revealed that pre-morbid personality traits associated with higher levels of introversion or lower levels of extroversion do not necessarily increase the risk of developing PD [26,27]. Nonetheless, a novelty-seeking personality style in people with PD is counterintuitive, of interest and may be accounted for by either medication-related factors (i.e. higher dopaminergic load in those with ICDs) or impulsive behaviour at the time of assessment.

While apathetic and impulsive-compulsive behaviours have prominent, distinguishable characteristics, some individuals with PD present with both apathetic and impulsive features [28,29]. As there may potentially be an overlap in symptoms, or comorbidity, the investigation of personality styles in the two PD-related conditions is warranted. To date, no study has specifically examined pre-morbid personality style in people with PD and clinically significant ICDs alongside those with apathy.

The aim of this study was to compare pre-morbid (10 years before motor symptom onset) and current personality style using self- and informant-ratings on the NEO Five-Factor Inventory (NEO-FFI) [30], among three groups of participants with PD: those with ICDs, those with apathy, and those with neither behavioural disturbance.

## Methods

Informed consent was obtained for both participants with PD and their informants. The study was approved by the regional ethics committee and performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

### PD participants

Ninety-four participants with idiopathic PD, diagnosed according to UK Brain Bank criteria, were included in the study [31,32]. Participants were free from dementia (according to treating clinician and confirmed by the Mini-Mental State Exam score >24) and divided into three groups: those with ICDs, n=34, 27 male; those with apathy, n=24, 18 male; and those with neither behavioural disturbance (controls), n=36, 22 male. Participants were consecutively recruited as a convenience sample from neurology clinics in the North West of England. ICD was defined by clinical examination and whether one or more of the following criteria for the ICDs were met: (1) dopamine dysregulation syndrome; or (2) Diagnostic and Statistical Manual IV, Text Revision (DSM-IV TR) criteria for individual ICDs [33,34]. For those with a diagnosis of pathological gambling, a score above 5 on the South Oaks Gambling Screen (SOGS) was also required [35]. The apathy group was defined by having a score of ≥14 on the Apathy Scale [36]. All participants were stable on their dopaminergic replacement therapy for the three months prior to study participation, and none had previously undergone deep brain stimulation.

### Informant participants

55 (58.5%) of the PD participants had an informant (n=16 for the ICD group; n=15 for those with apathy; n=24 for the control group), who was either a spouse (n=51; 92.7%) or an adult child (n=4; 7.3%). The informants had a minimum of weekly contact with the participant, were considered the primary caregiver. Informants had a substantial relationship with the PD participant that preceded the onset of PD motor symptoms by ten years and were all over 18 years of age at this pre-morbid time point. As such, informants were deemed sufficiently knowledgeable about the participant's midlife personality to provide ratings for the purposes of this study. The mean age of the informants was 62.75 (±10.87) years and 39 (70.9%) were female. Level of informant formal education was as follows: less than 14 years, 6 (10.9%); between 14 and 16 years, 21 (38.2%); and 16 years or more, 21 (38%). None of the informants met clinical criteria for depression.

### Assessments

**Personality style:** This was assessed on direct questioning by a trained interviewer using the abbreviated 60-item version of the NEO-FFI [30] in three ways: (1) the participant rated their current personality style; (2) the informant rated the participant's current personality style; and (3) the informant rated the participant's pre-morbid personality style, based on how they remembered their relative 10 years prior to the onset of the motor symptoms of PD. The NEO-FFI is a well-validated scale based on the Five-Factor Model of personality. It is made up of five domains, each consisting of 12 items, including: neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. Items are rated on a five-point scale, and the domains associated with key personality facets, in which high scorers will broadly be: neurotic, more susceptible to emotional distress, irrational ideas and impulses; extraverted, more socially outgoing, assertive, active and enterprising; open to experience, imaginative, variety seeking and intellectually curious; agreeable, altruistic, sympathetic to others and eager to help; conscientious, organised, purposeful, strong-willed, determined, punctual, scrupulous and reliable.

**Behavioural and motor measures in the PD participants:** Apathy was assessed using the clinician version of the Apathy Evaluation Scale (AES-C); impulsivity using the Barratt Impulsiveness Scale-11 (BIS-11) [37,38]. Mood and anxiety were measured using the Hospital Anxiety and Depression Scale (HADS)[39] Motor symptoms were rated during the "on" medication state by the Unified Parkinson's Disease Rating Scale (UPDRS), parts III and IV and the Hoehn-Yahr scale was used to determine disease stage [40,41]. Dopamine load was calculated as levodopa equivalent daily dose (LEDD) according to a previously reported formula [42].

### Data analysis

All data were analyzed using SPSS Versions 16.0 and 22.0. Mean NEO-FFI domain t-scores were compared across the three subgroups using either ANOVA or Kruskall-Wallis in two ways, using: (1) current self- and informant-ratings; and (2) pre-morbid informant-ratings. ANCOVA was used to control for confounding variables, where appropriate. Correlational analyses were performed to determine whether there was any relationship between the self- and informant-ratings of current personality style.

## Results

### Demographic, psychiatric and motor variables of PD participants

Across the entire PD sample, the participants had a mean age of 62.94 (± 10.34) years, and there was no difference in gender distribution between the groups (p=.215). Mean duration of PD was 94.23 (± 64.40)

months with a mean age of onset of motor symptoms of 55.38 (± 11.10) years and mean Hoehn-Yahr score of 2.31 (± 0.71). The sample excluded those with the dementia, and this was substantiated by a mean MMSE score of 28.32 (±1.64), with a median of 29.00. Within the ICD group, 24 (70.6%) participants had more than one type of ICD and the breakdown of ICD primary subtypes was as follows: Pathological gambling, n=12 (35.0%); compulsive sexuality, n=9 (26.5%); compulsive shopping n=6 (17.6%); binge eating, n=4 (11.8%); and dopamine dysregulation syndrome, n=3 (8.8%). All ICDs were severe enough to be of detriment to occupational (where relevant), social and personal functioning. QUIP was not available at the time of data collection. There were no differences between the groups in the historical drug and alcohol abuse by participants (p=.484) or their families (p=.104). Likewise, there were no differences in family history of psychiatric disorders (p=.300) or in participants' psychiatric history prior to the onset of PD (p=.449). Other than diagnosis of ICD or apathy, there were no differences among the groups in frequency of psychiatric diagnoses since onset of PD (p=.153). No participants were receiving treatment with neuroleptics. One participant with apathy was taking a mood stabilizer and three were taking anxiolytics (n=2 ICD; n=1 apathy). Twenty-two were taking anti-depressants and the frequency of use was disproportionate among groups (p=.049; 35.3% of ICD group; 24.0% of apathy group; 10.8% of PD controls).

Demographic, disease- and PD treatment-related variables across the three study groups are shown in Table 1. Briefly, the mean age at assessment (p<.001) and UPDRS motor score (p<.01) was significantly greater in the apathy group compared to both the ICD and control groups. Mean duration of disease was greater in both the apathy (p<.01) and ICD (p<.05) groups, compared to the control group. The mean age at onset of motor symptoms was lower in those with ICD than with apathy (p<.01), but not controls. Mean LEDD (p=.03) and anxiety scores (p<.001) were greater in the group with ICDs compared to the other two groups. The ICD group had higher mean depression (p<.01) and BIS-II (p=.01) scores than the controls. In contrast, mean depression score and apathy score were greatest in the apathy group, compared to the other two groups (p<.001 for both). Four participants with PD and ICD were treated with a dopamine agonist (DA) as the primary intervention, a further twenty received a DA as adjunctive therapy and the remaining ten were treated with levodopa alone. Of those with apathy, ten received adjunctive DA therapy and fourteen were treated with levodopa. Six participants from the PD control group were treated with a DA as the primary intervention, a further sixteen received a DA as adjunctive therapy and the remaining fourteen were treated with levodopa. When DA-only LEDD for was examined, there was no significant difference between the groups (p=.841, Table 1).

| | **Impulsivity (n = 34)** | **Apathy (n = 24)** | **Control (n = 36)** | **Statistic 3-group comparisons (ANOVA / Kruskall-Wallis or chi-square)** |
|---|---|---|---|---|
| Mean (SD); *median (for non-normal data) | | | | |
| Age at assessment | 58.65 (9.09) | 69.92 (6.91) | 62.33 (11.14) | F=10.12, p<.001 ‡‡‡ † |
| Age at onset of motor PD (years) | 50.85 (8.84) | 59.96 (9.99) | 55.44 (12.91) | F=5.02, p=.009 ‡‡ |
| *Disease duration (months) | 91.76 (44.91); 90.00 | 125.00 (82.81); 96.00 | 76.06 (60.11); 60.00 | H(2)=8.02, p=.02 # †† |
| UPDRS[1] motor | 26.87 (10.13) | 37.42 (11.79) | 23.65 (10.51) | F=12.12, p<.001 ‡‡ ††† |
| *UPDRS[1] complications | 4.62 (3.33); 4.00 | 3.79 (3.47); 3.00 | 2.72 (3.07); 1.50 | H(2)=7.85, p=.02 ## |
| *Hoehn-Yahr stage | 2.21 (0.72); 2.00 | 2.63 (0.73); 3.00 | 2.19 (0.65); 2.00 | H(2)=6.95, p=.03 ‡ † |
| *Levo-dopa daily equivalents (LEDD)[2] | 988.27 (592.93); 843.46 | 790.14 (507.08); 706.98 | 679.70 (608.63); 627.44 | H(2)=7.39, p=.03 # ‡ (trend) |
| *Levo-dopa daily equivalents, DA agonists only (DA-LEDD)[2] | 243.16 (161.24) | 223.45 (59.52) | 257.98 (162.71) | F(2)=.174, p=.841 |
| *HADS[3] anxiety subscale | 8.47 (4.34); 8.50 | 5.96 (4.02); 5.50 | 4.29 (3.26); 3.00 | H(2)=18.16, p<.001 ### ‡ † |
| *HADS[3] depression subscale | 6.18 (3.14); 6.50 | 9.13 (3.43); 10.00 | 4.03 (2.84); 3.00 | H(2)=26.06, p<.001 ## ‡‡ ††† |
| BIS-II[4] | 61.85 (16.82) | 57.6 (9.54) | 51.40 (15.40) | F=4.25; p=.01 # |
| *AES-C[5] Total score | 25.03 (11.52); 19.00 | 46.21 (12.24); 44.00 | 21.75 (4.87); 19.50 | H(2)=42.23; p<.001 ‡‡‡ ††† |

**Table 1:** Comparison of demographic and disease variables in the three PD groups [1]Unified Parkinson 's disease Rating Scale; [2]Levodopa equivalent daily dose as per formula outlined in Tomilson et al., 2011 [42]; [3]Hospital Anxiety & Depression Scale; [4]Barrett Impulsiveness Scale-II; [5]Apathy Evaluation Scale, Clinician version
Post-hoc Scheffe or Mann Whitney U for two-group comparison:
# ICD versus control at p<0.05, ## at p<0.01, and ### at p<0.001;
‡ ICD versus apathy at p<0.05, ‡‡ at p<0.01, and ‡‡‡ at p<0.001;
† Apathy versus control at p<0.05, †† at p<0.01, and ††† at p<0.001

| Personality domain | ICD (n = 34) | Apathy (n = 24) | PD-control (n = 36) | ANOVA (F; p) |
|---|---|---|---|---|
| *Current self-rated domains Mean (SD)* | | | | |
| Neuroticism | 57.03 (11.71) | 55.22 (14.03) | 48.1 (11.00) | 5.24; .007 ## †(trend) |
| Extraversion | 49.41 (12.80) | 42.07 (9.44) | 47.71 (11.50) | 3.08; .04 ‡ |
| Openness | 53.10 (10.84) | 43.61 (11.65) | 49.76 (10.40) | 5.47; .004 ‡‡ |
| Agreeableness | 44.84 (8.81) | 54.01 (9.52) | 53.12 (12.50) | 7.42; .005 ## ‡‡ |
| Conscientiousness | 45.14 (12.60) | 48.23 (12.90) | 52.20 (11.62) | 2.95; .06 # |
| *Current informant-rated domains Mean (SD)* | | | | |
| Neuroticism | 62.80 (12.23) | 60.57 (10.62) | 55.48 (11.45) | 2.04; .14 |
| Extraversion | 39.80 (10.80) | 35.71 (10.31) | 42.65 (13.95) | 1.42; .25 |
| Openness | 47.60 (8.14) | 41.64 (10.43) | 45.04 (10.22) | 1.39; .26 |
| Agreeableness | 46.33 (13.68) | 52.07 (5.17) | 51.09 (12.99) | 1.06; .36 |
| Conscientiousness | 39.87 (13.20) | 38.21 (14.43) | 47.09 (12.86) | 2.26; .12 |
| *Pre-morbid informant-rated domains Mean (SD)* | | | | |
| Neuroticism | 45.53 (9.16) | 47.57 (8.09) | 44.77 (10.41) | 0.38; .69 |
| Extraversion | 58.13 (12.28) | 53.00 (7.50) | 56.41 (13.52) | 0.71; .50 |
| Openness | 47.07 (9.52) | 44.14 (9.67) | 45.63 (10.44) | 0.31; .73 |
| Agreeableness | 50.20 (12.39) | 52.21 (7.88) | 52.05 (11.97) | 0.16; .86 |
| Conscientiousness | 53.87 (12.24) | 54.64 (6.96) | 53.91 (12.17) | 0.24; .98 |

**Table 2:** Comparison of self- and informant-rated NEO-FFI domain scores in the three PD behavioural groups; current and pre-morbid assessments
*Post-hoc Scheffe or Mann Whitney U for two-group comparison:*
*# ICD versus control at p<.05, ## at p<.01, and ### at p<.001;*
*‡ ICD versus apathy at p<.05, ‡‡ at p<.01, and ‡‡‡ at p<.001;*
*† Apathy versus control at p<.05, †† at p<.01, and ††† at p<.001*

## Current personality style

The mean current *self-rated* personality domain scores revealed that the ICD group had *higher* neuroticism ($p$=.007) and *lower* agreeableness ($p$=.004) scores than the control group. The group with ICDs also had *higher* extraversion ($p$=.04) and openness ($p$=.004) scores and *lower* agreeableness ($p$=.005) scores than those with apathy. In turn, the apathy group reported a trend towards *greater* neuroticism, compared to the control group ($p$=.08; see upper portion of Table 2).

However, since factors other than behavioural type may contribute to differences in personality style, ANCOVA with relevant covariates (depression, anxiety, age and LEDD) was undertaken, using the self-rated domains as dependent variables. Initial differences among the groups were no longer evident for the neuroticism (F(1,119)=0.37, p=.77), extraversion (F(1,119)=0.50, p=.68), openness (F(1,119)=0.45, p=.72), and conscientiousness (F(1,119)=0.72, p=.54) domains. In the agreeableness domain, age was a significant covariate (p=.002), and the ICD group had a lower mean agreeableness score compared to both other groups (F(1,119)=3.54, p=.02).

Mean scores on key demographic and disease variables of the sub-sample of 55 PD participants who had informants did not differ significantly from the original study sample of 94 participants (all $p$>.45). In contrast to the self-rated current findings, mean *informant-rated* current NEO-FFI domain scores did not differ across the three behavioural groups for any of the personality domains (Table 2).

Correlations were performed on self- and informant personality ratings, to examine if there were discrepancies in perceived aspects of personality, between the types of rater. The apathy group ratings correlated on the openness domain only (ρ=0.67; $p$=.01), whereas correlations in the ICD group were seen in three of the five domains (neuroticism, ρ=0.66; $p$=.01; extraversion, ρ=0.64, $p$=.01; openness, ρ=0.52, $p$=.04). When all three groups considered were together, there was a strong correlation between self- and informant-ratings on the first four domains (neuroticism, ρ=0.53, $p$<.001; extraversion, ρ=0.45, $p$=.001; openness, ρ=0.63, $p$<.001; and agreeableness, ρ=0.29, $p$=.04) and a trend towards correlation in the last domain, conscientiousness (ρ=0.26, $p$=.07).

**Pre-morbid personality style:** As shown in Table 2, significant differences across the three behavioural groups were not seen in any of the five personality domains on informant-rated pre-morbid personality style.

**Correlations between personality style and other key variables:** When all three groups considered were together, Pearson bivariate analysis of the five NEO-FFI domains (current, self-rated) and various other factors revealed some correlations. Degree of *impulsiveness* (BIS-11 total score), had a strong positive correlation with neuroticism (ρ=0.40; $p$<.001) and negative correlation with agreeableness (ρ=-0.28; $p$=.002) and conscientiousness (ρ=-0.47; $p$<.001). Degree of *apathy* (AES-C total score), had a strong negative correlation with extraversion (ρ=-0.41; $p$<.001) and openness (ρ=-0.37; $p$<.001), and a positive correlation with neuroticism (ρ=0.22; $p$=.04). Following Bonferroni correction for multiple comparisons, the negative correlations between apathy, extraversion and openness remained significant. The negative correlation between impulsivity and agreeableness sat on the cut-off point for significance ($p$>.002). The positive correlation between impulsivity and neuroticism and negative correlation between impulsivity and conscientiousness remained significant.

## Discussion

These findings do not support the association of people with PD and ICDs as having personalities consistent with being more emotionally reactive, prone to irrational ideas and impulsive (high neuroticism), such as those reported in the Danish review [21]. Instead, we found that people with PD and ICD describe themselves as less agreeable (less cooperative and more competitive) than their PD control or apathy counterparts. Current ratings, supplied by informants who had extensive knowledge of participants' mid-life personalities, did not corroborate this finding. Furthermore, according to informants, there were no changes in personality since diagnosis with PD irrespective of behavioural complication.

Although the individuals with PD and ICD believe they have become less agreeable, it may be the case that, of the five personality domains, agreeableness has the potential to be the most internalised and less outwardly observable by informants. For example, one may think a disagreeable thought but withhold a disagreeable answer,

whereas extraverted or neurotic behaviour may be less well concealed. Certainly, any changes in agreeable demeanour were not noticeable to others and therefore not significantly disruptive or burdensome for caregivers of this population, as can sometimes arise from behavioural complications of PD [4]

While we cannot rule out recall bias, recall by family and friends are preferable to relying on self-assessment [24]. The present findings suggest that any differences seen among groups at the time of the behaviour disturbances may be minor and related to transient 'state' factors, rather than the more enduring trait characteristics exhibited prior to the onset of PD. The reason for these behavioural changes may be multi-faceted as it has been reported that novelty seeking behaviour in PD is independent to combined treatment with levodopa and dopamine agonists [43]. This suggests that dopaminergic therapy (both levodopa and agonist) may not be the only factor influencing personality change in PD.

The existence of an introverted, conservative and rigid pre-morbid parkinsonian personality has been debated for a long time, and the evidence thus far cautiously supports the notion of disease-related changes in personality in PD [24]. The consequences of such behavioural traits are lower rates of smoking, alcohol and caffeine consumption, all of which have been associated with PD [44]. Hence, the converse, that those lacking these typical traits and with a more extroverted, novelty-seeking-type personality may lead to the development of behavioural and substance addictions, such as ICDs, appears logical. Dagher and Robbins [44] suggested the "personality dopamine addiction" model to explain ICDs based on a vulnerability hypothesis of non-PD addictive disorders and suggested that ICDs are largely driven by a dopamine overload. This is in contradistinction to non-PD addiction models, which may be due to a "dopamine deficiency" syndrome resulting in behavioural over-compensation. The "personality dopamine addiction" model stresses the added risk of developing an ICD in the presence of a pre-morbid novelty-seeking personality style. The findings from the current study, which is the first to explore pre-morbid personality style in both PD-related ICDs and PD-related apathy, do *not* support this notion since *no* pre-morbid differences among those with ICD, apathy and PD control groups were identified. While these findings should be interpreted with caution, they do lend support to the idea that the personality styles seen in PD people with could be acquired, and not due to any inherent pre-morbid personality type.

Dopamine load as a significant covariate is worthy of note since associations between dopamine and novelty-seeking exist [46]. Higher novelty-seeking and impulsive traits are encompassed under the "neuroticism" domain on the NEO-FFI and the degree of impulsivity measured here did correlate with neuroticism, when the sub-groups were considered together. Depression and anxiety, high in both behavioural groups, also appeared to drive personality variables. Both these states may be associated with changes in serotonin, which is also implicated in higher impulsivity, and possibly the ICDs [47, 48]. Finally, age as a significant covariate of personality style is relevant since behavioural and associated acquired personality changes may in part be age-related. It has been hypothesized that any personality changes associated with PD are more pronounced in older rather than younger people with PD, likely due to more extensive dopaminergic, noradrenergic and serotonergic pathway changes in older individuals [49].

A limitation to the current study is that the determination of "pre-morbid" personality style was done retrospectively, albeit using a tool validated for such purpose. Determining the exact pre-morbid point is difficult since, without adequate biomarkers, the onset of preclinical PD cannot be accurately identified. Ideally, a prospective longitudinal study should be undertaken to account for these limitations. However, such a study poses many challenges as it would involve regularly assessing personality style in a substantial number of healthy older participants over a long time period. The initial sample size would need to be sufficiently large enough for a sub-group to develop PD and, eventually, for a further cohort to develop ICD complications.

Strengths of the current study are that informant recall bias was minimised by giving a very specific time point for the pre-morbid rating, as well as asking only close, adult family members who knew the PD participant well enough to be able to provide accurate ratings. Furthermore, the NEO-FFI is reliable as an informant-reported measure of pre-morbid personality style in neurodegenerative disorders using retrospective recall [50]. Finally, by examining both self- and informant-ratings, any potential bias of self-rating due to impairments in level of insight, particularly in the case altered mood or behavioural state, was controlled for.

In conclusion, this study found no differences in pre-morbid personality style in individuals with PD and apathy or no behavioural disorder. Individuals with PD and ICDs rated themselves as more disagreeable than their apathetic counterparts and those without either behavioural condition. The lack of corroboration of these current reports of personality change by informants and lack of any observable difference in pre-morbid and current personality ratings suggest we cannot yet rule out a subtle acquired change, rather than vulnerability, personality risk model for development of ICDs and apathy in PD.

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