

# Religiosity in patients with Parkinson's disease

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**Objective:** To study clinical correlates of religiosity in Parkinson's disease (PD).

**Methods:** Measures of life goals, religiosity, mood, and neuropsychologic function were assessed in 22 persons with mid-stage PD and 20 age-matched healthy controls. Levodopa dose equivalents (LDE) were also computed for the patients.

**Results:** Relative to other major life goals parkinsonian patients were significantly more likely to report that "my religion or life philosophy" was less important than were age-matched controls. Scores on a battery of religiosity scales were consistently lower for Parkinson's patients than those of age-matched controls. While Mini Mental State Exam, logical memory recall, Stroop, and selected (depression and anxiety) mood scales reliably distinguished patients from controls, only measures of prefrontal function correlated with religiosity scores.

**Conclusions:** Patients with PD express less interest in religion and report consistently lower scores on measures of religiosity than age-matched controls. Prefrontal dopaminergic networks may support motivational aspects of religiosity.

**Keywords:** religiosity, Parkinson's disease, neuropsychology, mood, executive functions, dopamine agonists

## Introduction

Religiousness or life philosophy can be a potent factor in people's mental and behavioral make-up, influencing every level of personality from daily habits/practices to long-term strategies and goals (Batson et al 1993; Emmons and Paloutzian 2003), yet it has only recently received significant experimental attention from the cognitive neuroscience community. Several recent carefully controlled neuroimaging (Newberg et al 1997, 2001; Azari et al 2001) and neuropsychological (Ramachandran et al 1997; McNamara 2001; McNamara et al 2003) investigations of potential brain correlates of religiosity consistently implicate neo-striatal, limbic, and prefrontal cortical networks as key nodes in the widely distributed neural networks that apparently support common religious practices such as prayer and meditation.

If the neuroimaging and neuropsychological studies of religiousness have indeed uncovered reliable brain correlates of religiosity, then religiosity should vary significantly in clinical populations that exhibit significant alterations in neo-striatal and limbic-prefrontal brain functions. Although no direct test of this hypothesis has yet been conducted, circumstantial evidence is consistent with the prediction. Religiosity-related symptomology is relatively common in disorders that are associated with neo-striatal and limbic-prefrontal alterations such as schizophrenia (Siddle et al 2002), obsessive-compulsive disorder (Tek and Ulug 2001), and certain forms of temporal lobe epilepsy (Dewhurst and Beard 1970; Geschwind 1983). To our knowledge, however, there are no published reports of similar religiosity-related symptomology in Parkinson's disease (PD) – another prominent disorder of neo-striatal and prefrontal dysfunction (Agid et al 1987; Starkstein and Merello 2002). We therefore sought to conduct a pilot investigation into PD patients' religious attitudes and practices as well as whether these attitudes and practices correlate with

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key clinical aspects of PD such as age, medication regimes, mood, and cognitive function.

## Methods

### Participants

Twenty-two male patients with PD were recruited from the outpatient Movement Disorders Clinic at the VA Boston Healthcare System, Boston, MA. Patients were individually diagnosed by Dr Raymon Durso, director of the clinic, and all met standard criteria for idiopathic PD. Twelve of the patients were at Hoehn-Yahr stage II, and 10 at stage III (Hoehn and Yahr 2001). None of the patients were demented according to clinical examinations and DSM-III criteria. All were on some form of dopaminergic medication and were tested while on medications. Patients with a history of substance abuse or head injury were excluded. Twenty healthy control subjects (5 of whom were female) were recruited from the community and were matched in age to the group of PD patients.

While the two groups did not differ significantly in terms of age (PD mean 72.1 (6.9), range 54–82; controls mean 70.5 (6.0), range 55–79,  $p=0.19$ ), the controls reported higher levels of education (PD mean 13 years; controls mean 16 years,  $p=0.002$ ). Mean Mini Mental State Exam (MMSE) Score was 27.6 (1.4) for PD patients and 29.2 (0.8) for healthy controls ( $p<0.003$ ). Demographic characteristics of the two groups are summarized in Table 1.

A wide range of religious preferences were represented by patients and controls who participated in these pilot studies (see Table 2). While Roman Catholics made up the bulk of the parkinsonian sample (45%), several other faiths were represented in both the PD and control samples.

**Table 2** Religious preferences of participants

|                | Parkinson's disease | Control | Totals |
|----------------|---------------------|---------|--------|
| none           | 3                   | 1       | 4      |
| agnostic       | 0                   | 1       | 1      |
| atheist        | 1                   | 0       | 1      |
| Catholic       | 10                  | 3       | 13     |
| Greek orthodox | 0                   | 2       | 2      |
| Jewish         | 4                   | 3       | 7      |
| Protestant     | 0                   | 3       | 3      |
| Unitarian      | 1                   | 0       | 1      |
| Baptist        | 1                   | 1       | 2      |
| Episcopalian   | 1                   | 1       | 2      |
| Methodist      | 1                   | 1       | 2      |
| unknown        | 0                   | 4       | 4      |
| Totals         | 22                  | 20      | 42     |

## Measures

### Medication effects

To assess effects of medication type and dose on cognitive and affective functions we compared different medications directly at dosages of equivalent efficacy. We followed Razmy et al (2004) who used a formula to convert medication dosages to levodopa dosage equivalents (LDE). The only relevant medications taken by patients in our sample were carbidopa–levodopa and pramipexole. Consequently our formula was a simplified version of Razmy's, namely:

$LDE=67 * (\text{pramipexole dose}) + (\text{regular levodopa dose})$ .

### Measures of religiosity and life goals

We used the Brief Multidimensional Measure of Religiousness/Spirituality (BMMRS; Fetzer Institute 1999) to measure religious attitudes and practices. The BMMRS

**Table 1** Demographic and neuropsychological variables on Parkinson's disease (PD) subjects and controls

|                               | PD-N | PD-mean (SD) | Control-N | Control-mean (SD) | P value (Bonferroni corrected) |
|-------------------------------|------|--------------|-----------|-------------------|--------------------------------|
| Age                           | 22   | 72.1 (6.9)   | 20        | 70.5 (6.0)        | 0.19                           |
| Education                     | 22   | 13 (3.1)     | 17        | 16 (1.8)          | 0.002*                         |
| MMSE                          | 17   | 27.6 (1.4)   | 20        | 29.2 (0.8)        | 0.003                          |
| Logical memory recall         | 22   | 9.2 (2.8)    | 20        | 12.7 (3.5)        | 0.001*                         |
| Tower of London (TAS)         | 20   | 14.9 (4.8)   | 20        | 16.9 (4.4)        | 0.19                           |
| Ravens (B) total              | 20   | 26.7 (9.2)   | 18        | 21.9 (7.7)        | 0.09                           |
| Stroop interference–switching | 19   | 107.4 (56.4) | 20        | 72 (22.4)         | 0.016*                         |
| DASS total                    | 21   | 15.3 (8.1)   | 18        | 8.7 (7.9)         | 0.01*                          |
| DASS anxiety                  | 21   | 5.1 (2.9)    | 18        | 1.8 (3.2)         | 0.003*                         |
| DASS depression               | 21   | 4.8 (3.8)    | 18        | 2.1 (2.6)         | 0.01*                          |
| DASS stress                   | 21   | 5.6 (3.6)    | 18        | 4.8 (3.4)         | 0.47                           |
| LDE                           | 22   | 570 (81)     | -         | -                 | -                              |

\* $p<0.01$

**Abbreviations:** DASS, Depression Anxiety and Stress Scale; LDE, levodopa dose equivalents; MMSE, Mini Mental State Exam, TAS, total achievement score.

contains 38 statements with Likert scale formats that cover 11 religious domains. These are: daily spiritual experiences, values-beliefs, forgiveness, private religious practices, religious and spiritual coping, religious support, religious-spiritual history, commitment, organizational religiousness, religious preference, and overall self-ranking (eg, "To what extent do you consider yourself a religious person?"). The BMMRS was developed by a panel of experts on religion and health convened by the Fetzer Institute and the National Institutes of Health and Aging. It has excellent psychometric properties as well as publicly available norms for healthy older individuals. Higher scores indicate less religiosity on these scales.

We used the Rivermead Life Goals inventory (Nair and Wade 2003) to measure participant's subjective estimations of their major life goals. These included 9 areas of personal concern ranging from residential domestic arrangements and ability to personally care for oneself, to financial status and work-related goals. Participants were asked to rate each life goal domain in importance from 0 (no importance) to 3 (extreme importance). After subjects rated the importance of these life goals we then asked them to go back and rate each domain as to whether they felt it was on track or off track (0=totally off track to 3=totally on track). We used the question "My religion or life philosophy is...", to assess the subjective importance of religion to PD patients.

### Neuropsychological measures

Our cognitive test battery was chosen with an emphasis on examining prefrontal neuropsychological function. These tests have previously been shown to be altered in patients with PD (Taylor and Saint-Cyr 1995).

The Stroop color-word interference procedure (Stroop 1935) requires the subject to name the color of the ink or to name the word of a color-word that is printed. The task involves four test cards: the first containing rows of colored rectangles with the task being to name the colors as quickly as possible, the second containing rows of color words (printed in black ink) with the task being to read the words as quickly as possible, and the third "interference" test consisting of rows of color words printed in ink colors incongruent with the word represented, with the task being to name the ink colors as quickly as possible. The fourth card is the "switching card" where subjects are prompted to either name the color of the ink or to read the word depending on whether the item is in a box or not. For both the interference card and some of the switching cards the subject must ignore the word and name the color. In this

paper we focus on the score derived from the fourth or "switching" task. Susceptibility to cognitive interference is calculated as the total time taken to name the colors and read the words. PET studies show that frontal cortex is activated in normals during the Stroop task (Bench et al 1993; Vendrell et al 1995).

In the Tower of London (TOL) task (Shallice 1982), disks have to be moved from a starting configuration on three sticks of equal length to a target arrangement, which is presented as a colored drawing. The starting position of the disks is varied, and in each trial there is a minimum number of moves in which the solution can be reached. The subject's task is to solve the problem as quickly as possible in as few moves as possible. We tabulated the total achievement score (TAS) for this task, which takes into account whether the subject completed each trial within a given time and how many errors were made. A SPECT study has demonstrated left prefrontal cortex activation in subjects attempting to plan their moves (Morris et al 1993).

We administered a logical memory test adapted from the version presented in the Wechsler Memory Scales – Revised (WMS-R; Wechsler 1987). Briefly, participants are read a story and then asked immediately, and again after a delay of 20 minutes, to recall the story. They are given points for each of the major elements of the story they recall. The greater the number of points received the better the recall. Episodic recall of stories and other verbal material is thought to be mediated by widely distributed diencephalic structures deep to the temporal lobes (Lezak 1995).

The Ravens Colored Progressive Matrices (RCPM Series B; Raven 1965) consists of a series of abstract, complex, non-representational visual designs that progress in design complexity as the test progresses. Subjects are presented with an array of designs from which they must select a target design that will visually complete a problem target design. The RCPM is a test of general intelligence as it requires the subject to conceptualize complex spatial and numerical relationships in order to successfully select the correct match from the array of false lures. Lezak (1995) reviews the evidence for sensitivity of RCPM to posterior cortical lesions.

### Mood tests

We assessed depression, stress and anxiety with the Depression, Anxiety and Stress Scale (DASS) developed by Lovibond and Lovibond (1995). Crawford and Henry (2003) and Antony et al (1998) have demonstrated excellent

reliability, validity, and other psychometric properties for the three subscales of the DASS. The test includes 21 questions, 7 in each of the depression, anxiety, and stress subscales. For each of the items on the DASS the patient was asked to “Please read each statement and circle a number 0, 1, 2 or 3 that indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.” The response scale is presented as: 0=Did not apply to me at all, 1=Applied to me to some degree or some of the time, 2=Applied to me to a considerable degree, or a good part of the time, 3=Applied to me very much, or most of the time. Included on the depression subscale are items such as, “I felt I had nothing to look forward to” and “I felt I wasn’t worth much as a person”. On the anxiety subscale were such items as “I felt scared without any good reason” and “I was worried about situations in which I might panic and make a fool of myself”. The stress subscale included items such as: “I found it difficult to relax” and “I felt that I was rather touchy”.

## Results

### PD vs control differences on Rivermead Life Goals Scale

The comparisons between PD and controls may be seen in Table 3. Both controls and PD patients reported that their residential domestic arrangements, personal care, work, relationship with primary partner, family life, contact with friends, and financial affairs were “on track” and important to them. PD patients, however, rated their leisure activities—hobbies and their religion as less important than their age-

**Table 4** Measures of religiosity (lower scores = higher religiosity)

|                       | Parkinson's disease | Control    | P value |
|-----------------------|---------------------|------------|---------|
| Daily spirituality    | 26.8 (6.9)          | 23.7 (7.1) | 0.20    |
| Values index          | 4.8 (1.6)           | 4.3 (1.7)  | 0.34    |
| Forgiveness           | 7.5 (2.2)           | 6.4 (2.5)  | 0.18    |
| Private practices     | 33.3 (7.2)          | 26.3 (7.9) | 0.050*  |
| Coping                | 25.4 (6.0)          | 22.7 (4.1) | 0.13    |
| Support               | 13.6 (2.5)          | 12.7 (2.7) | 0.32    |
| Organized religiosity | 9.3 (2.7)           | 8.4 (3.0)  | 0.37    |
| Overall religiosity   | 7.1 (.9)            | 5.3 (1.4)  | 0.04*   |

\* p values are Bonferroni corrected.

**NOTES:** Daily spirituality: index of “daily spiritual experience” items, sum of Fetzer items 1–6 (Fetzer Institute 1999). Possible range is 6–36. Lower score indicates higher religiousness; Values index: index of “values-beliefs” items, sum of Fetzer items 7 and 8. Possible range is 2–8, and lower scores indicated higher religiousness; Forgiveness: index of “forgiveness” items, sum of Fetzer items 9–11. Possible range is 3–12. Lower score indicates higher religiousness; Private practices: index of “private religious practices”, sum of Fetzer items 12–16. Possible range is 5–40. Lower score indicates higher religiousness; Coping: index of “religious and spiritual coping”, sum of Fetzer 17–23. Possible range is 7–28. Lower score indicates higher reliance on religion for coping strategies; Support: index of “religious support”, sum of Fetzer 24–27. Possible range is 4–16. Lower score indicates more involvement with congregation; Organized religiosity: index of “organized religious activities”, sum of Fetzer items 34 and 35. Possible range is 2–12. Lower score indicates higher religiousness; Overall religiosity: sum of Fetzer “overall self-ranking” items 37 and 38. Possible range is 2–8. Lower score indicates higher overall religiousness.

matched counterparts, despite rating these same activities as being “on track”.

### PD vs control differences on religiosity scales

Scores on religiosity scales can be seen in Table 4. PD patients were significantly less religious than controls (overall index mean PD=7.1 (0.9); controls=5.3 (1.4);  $p<0.04$ , higher scores indicate less religiosity). It can be

**Table 3** Parkinson's disease (PD) vs control means on the Rivermead Life Goals Scale

|   | PD patients  |            | Controls     |            |
|---|--------------|------------|--------------|------------|
|   | “importance” | “on track” | “importance” | “on track” |
| My residential and domestic arrangements                          | 2.5 (0.7)    | 2.5 (0.6)  | 2.4 (0.7)    | 2.6 (0.5)  |
| My ability to manage my personal care (dressing, toilet, washing) | 2.4 (0.6)    | 2.3 (0.8)  | 2.7 (0.5)    | 3.0 (0)    |
| My leisure, hobbies and interests including pets                  | 1.5 (0.8)*   | 2.4 (0.6)  | 2.0 (0.8)    | 2.5 (0.6)  |
| My work, unpaid or paid is  | 2.0 (0.9)    | 1.9 (0.8)  | 2.1 (0.7)    | 2.5 (0.5)  |
| My relationship with my partner (or my wish to have one) is       | 2.3 (0.9)    | 2.1 (1.0)  | 2.4 (0.7)    | 2.3 (0.9)  |
| My family life (including those not living at my home) is         | 2.4 (0.8)    | 2.1 (0.6)  | 2.5 (0.7)    | 2.6 (0.7)  |
| My contacts with friends, neighbors and acquaintances are         | 2.0 (0.7)    | 2.1 (0.7)  | 2.2 (0.8)    | 2.5 (0.5)  |
| My religion or life philosophy is                                 | 1.3 (0.9)*   | 2.0 (0.7)  | 2.2 (0.9)    | 2.5 (0.6)  |
| My financial status is  | 2.0 (0.8)    | 2.0 (0.7)  | 2.2 (0.7)    | 2.5 (0.6)  |

**Key:** 0 = of no importance; 3 = of extreme importance; 0 = totally off track; 3 = totally on track.

seen that although PD patients reported less religiosity on every scale compared with age-matched controls, the difference was significant only for the overall index and for the scale on private practices (ie, prayer and meditation, private devotional reading; PD mean=33.3 (7.2); controls 26.3 (7.9),  $p=0.050$ ).

## PD vs control differences on neuropsychological and mood function.

The two groups differed significantly on MMSE, logical memory recall, and Stroop interference-switching score (Table 1). They did not differ significantly on the Tower of London total achievement score (PD 14.9 (4.8); controls, 16.9 (4.4);  $p=0.19$ ) and the Ravens Progressive Matrices Task (PD 26.7(9.2); controls 21.9(7.7),  $p=0.09$ ). With respect to mood function, the two groups differed significantly on total score on the Depression Anxiety Stress Scale ( $p=0.01$ ), the DASS anxiety ( $p=0.003$ ), and depression ( $p=0.01$ ) sub-scales.

## Correlates of overall religiousness in PD patients vs controls

We next performed a series of correlational analyses using the Bonferroni correction for multiple comparisons. We correlated the BMMRS overall index of religiosity with demographic, mood, and neuropsychologic variables in order to further explore determinants of religiosity in PD. Correlations are displayed in Table 5. Within the PD group, overall religiousness correlated with the Stroop interference-switching score (indicating the greater the frontal dysfunction the *less* the religiosity). Overall religiousness correlated negatively with the Ravens score, indicating that the better the performance on the Raven visual intelligence test the *more* the religiousness. Within the healthy control group religiosity was correlated with a measure of stress and inversely correlated with logical memory recall scores.

Reasoning that severity of PD might be correlated with indices of religiosity we next ran Spearman correlations (data not shown) between all of the major religiosity indexes from the BMMRS scale and Hoehn-Yahr stage. All of these correlations except for the Coping Index were below  $r=0.24$  and none but the Coping Index were significant. Spearman's  $r$  for the association between H-Y stage and the Coping Index, however, was significant and equal 0.48 ( $p=0.01$ ) indicating (paradoxically perhaps) that the more severe or advanced the PD disorder the less likely patients used religion to cope.

**Table 5** Pearson product moment correlations between the BMMRS Overall Index religiosity scale and demographic, mood, and neuropsychological measures

|                               | Parkinson's disease | Controls |
|-------------------------------|---------------------|----------|
| Age                           | 0.09                | -0.17    |
| Education                     | -0.17               | -0.11    |
| MMSE                          | -0.14               | -0.22    |
| Logical memory recall         | 0.07                | 0.59*    |
| Ravens (B)                    | -0.48*              | 0.33     |
| Tower of London (TAS)         | -0.12               | 0.23     |
| LDE                           | -0.16               | —        |
| Stroop interference/switching | 0.48*               | -0.21    |
| DASS Anxiety                  | -0.12               | -0.35    |
| DASS Depression               | 0.37                | -0.21    |
| DASS Stress                   | 0.09                | -0.43*   |

\*  $p<0.01$ , Bonferroni corrected.

**NOTES:** Logical memory recall: number of elements of story remembered at 20 minutes; Stroop interference-switching time: total time (secs) taken to read through the switching card of the Stroop test; Tower of London TAS: composite score reflecting how many towers were completed correctly within allotted time, and how many moves tower was completed in; Ravens: total score on the B series where a subject needs to match an abstract visual design in one panel with a series of similar abstract designs in a separate panel. There is only one correct match; DASS Anxiety, DASS Depression, DASS Stress: sum of scores on anxiety-depression subscale from the DASS.

**Abbreviations:** BMMRS, Brief Multidimensional Measure of Religiousness-Spirituality; DASS, Depression Anxiety and Stress Scale; LDE, levodopa dose equivalents; MMSE, Mini Mental State Exam, TAS, total achievement score.

## Discussion

We found that patients with PD reported significantly lower levels of religiousness than did age-matched controls, and that this low level of religiosity was related primarily to a measure of prefrontal neuropsychological function rather than to age, education, mood, or to medication-related factors. Since we had a rather homogenous PD group (all mid-stage patients) we could not directly test an association between severity of disease and religiosity. On the other hand, a rank-order Spearman correlational analysis between Hoehn-Yahr stage scores and the religiosity scales revealed that the more severely affected patients were *less likely* to use religion as a coping method. To our knowledge, this is the first study to quantitatively explore neuropsychological and neuropsychiatric correlates of religiosity in PD patients.

Why should PD patients report less religiousness than age-matched healthy controls? We found that the PD patients were more depressed than age-matched controls, but religiousness scores were not significantly related to depression scores. One argument that has been presented is that religiousness may be inversely related to intelligence or education levels, in that people with higher intelligence or more education would be less likely to be religious. Our sample of PD patients performed marginally better than



controls on a measure of visual intelligence (Ravens) and this measure was in turn significantly and inversely correlated with religiousness scores in PD patients but not controls. The latter finding suggests that in our sample, the higher the visual intelligence the greater the religiousness, indicating a possible *positive* relationship between intelligence and religiosity in this sample of Parkinson's patients.

We did not find a significant correlation between the overall religiousness index and years of education in either the patients or the controls. The relationship between educational level and religiosity in healthy samples is, in any case, complex: high educational levels generally are positively correlated with frequent church attendance but negatively correlated with the occurrence of mystical or religious experiences (Batson et al 1993, p 40). The correlation of religiosity with Stroop interference-switching scores (a measure of cognitive inhibitory capacity and perhaps frontal lobe integrity), furthermore, argues against the "too intelligent" explanation for the lack of religiosity in PD patients. It therefore appears that intelligence level is not a likely explanation of religiosity in these PD patients.

An alternative explanation for our major finding starts with this same correlation between frontal dysfunction and decreased religiousness scores in PD patients. It may be that long-term forms of religiosity require participation of the motivational support normally supplied by the dopaminergic drive centers housed in neo-striatal and limbic-prefrontal circuits. The previously cited neuroimaging and neuropsychological studies linking religious practices with prefrontal network activation is consistent with this hypothesis. Recent reports (Comings et al 2000; Hamer 2004) linking scores on religiosity and measures of "self-transcendence" with genetic markers for the dopamine transport molecule and the *DRD4* gene coding for a dopaminergic receptor (which is densely represented in prefrontal cortex) supports this hypothesis as well. PD patients experience relatively global reduction in central and forebrain dopamine activity as the disease progresses. If dopaminergic activity supports key aspects of religiosity then it would not be surprising to find PD patients lacking in overt signs of religiosity. Our finding of a correlation between severity of disease (H-Y stage score) and the Coping Index with more severely affected patients *less likely* to use religion as a coping device is consistent with the idea that prefrontal dopamine is crucial for long term support of religiosity.

Religiosity has traditionally been linked to the temporal lobes (Geschwind 1983). But most of the evidence for a role of the temporal lobes in religious experience was based on observations of the behaviors of a small subset of temporal lobe epileptics who exhibited the interictal behavioral syndrome (Dewhurst and Beard 1970). The syndrome included hyper-religiosity as one of its signs. d'Aquili and Newberg (1999), however, very sensibly suggest that *all* the major association areas of the cortex generate some aspect of the total religious experience. In their models of religiosity the temporal lobes attach meaning and significance to events while posterior parietal sites participate in construction of both the sense of self and the accompanying sense of the dissolution of the self during mystical states. With respect to the frontal lobes, d'Aquili and Newberg (1999) reviewed a number of studies that apparently established a link between sustained attention associated with the practice of meditation and EEG theta waves above the prefrontal cortex. The EEG data therefore suggests that sustained meditation results in activation of prefrontal networks. Newberg et al (1997, 2001) later confirmed these EEG data using SPECT imaging techniques. Regional cerebral blood flow changes were studied in six highly experienced meditators while they meditated. Results demonstrated significantly increased blood flow to the inferior frontal and dorsolateral prefrontal cortical regions while subjects engaged in "intense meditation". More recently and using functional magnetic resonance imaging (fMRI) techniques, Azari and Nickel (2001) reported greater dorsolateral frontal, dorsomedial frontal and medial parietal cortex activation during religious recitation in self-described religious subjects. McNamara et al (2003) reported significant correlations between frequency of prayer and performance on a battery of prefrontal tasks in a large sample of community dwelling elderly. Taken together, the data summarized in this report and the available evidence reviewed indicate that the neural substrates of sustained religiosity likely include mesocortical dopaminergic systems that likely support motivational and goal oriented behavioral systems.

This was a pilot study with a relatively small patient number and thus our conclusions should be treated with caution. We also did not record the side of onset of disease in this convenience sample of patients. In most patients with PD, damage to the basal ganglia is asymmetric in that there is more extensive damage on either the right or the left side of the brain, and thus the dopaminergic corticostriatal circuits would be differentially affected. This inference is

supported by several SPECT studies that have shown greater dopamine depletion in the hemisphere contralateral to the side of motor symptom onset (Antonini et al 1995; Booij et al 1997; Tissingh et al 1998; Mozley et al 2000), by studies demonstrating that asymmetrical dopamine depletion persists after motor symptoms appear bilaterally (Leenders et al 1990; Antonini et al 1995), and by post-mortem studies that found significant neuronal loss in the hemisphere contralateral to the side of the body on which motor symptoms first appeared (Kempster et al 1989). One wonders, therefore, if neuropsychological functions might also be differentially affected by side of symptom onset. Thus, with left striatal damage, verbal mediation of cognitive tasks might be more difficult, and with right striatal damage, mood and perhaps religiosity might be more affected. We thank an anonymous reviewer for this intriguing suggestion.

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