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STRUCTURAL EQUATION MODEL OF MOTOR SYMPTOMS OF PARKINSON'S DISEASE

INTRODUCTION

The identification of symptom groups of neurological syndromes such as the combination of hypokinesia, rigidity, resting tremor and postural abnormalities in Parkinson's disease (PD) is important because the knowledge about the co-occurrence of symptoms may help to define disease phenotypes and provide clues for differential diagnosis. The number of symptom groups (dimensionality) can be inferred through statistical analysis of the measurement tool for evaluation of impairment. Within the Motor Section of the Unified Parkinson Disease Rating Scale (MS UPDRS), main motor symptoms of PD (tremor, rigidity and bradykinesia) and axial symptoms, such as speech, posture, postural stability and gait, define symptom groups as being evaluated according to their respective severity. This paper discusses the dimensionality of the MS UPDRS and the structure of motor symptoms of Parkinson's disease within the framework of structural equation modeling (SEM).

METHODS

Four hundred and five consecutive patients (237 men, 168 women; mean age 61, range 35-80 years) with PD were included in the research. Each patient was evaluated by one member of a group of certified neurologists specializing in movement disorders who had been routinely using the MS UPDRS.

For analyzing the latent structure of the 27 items of the Motor Section of the UPDRS the LISREL program was used. Since the level of measurement of MS UPDRS is ordinal, the matrix of polychoric correla-

tions was analyzed using the Diagonally Weighted Least Squares (DWLS) method for parameter estimation.

RESULTS

Figure 1 demonstrates the final (the best fitting) model of the Motor Section of the UPDRS. Following this conclusion the Motor Section of the UPDRS consists of seven dimensions (factors). Five of them are substantial and reflect each motor symptom of PD – tremor, rigidity (Rig), bradykinesia of the extremities (Brad), axial/gait bradykinesia (BBrad) and speech/hypomimia (Face). These factors are accompanied with another two factors (Left, Right) reflecting the asymmetry of tremor, rigidity and bradykinesia of the extremities.

Factors of rigidity, bradykinesia of the extremities, speech/hypomimia and axial/gait bradykinesia are highly correlated (up to 0.85), which indicates that there is a strong relationship between these symptoms. On the other hand tremor seems to be a PD symptom occurring independently of other motor PD symptoms.

The fit indices and values in the residual matrix suggest this model need not to be rejected. Generally, CFI and GFI suggest close fit whereas RMSEA, SRMR and NFI indicate mediocre fit of the model (see Table 1). Values in the matrix of residual correlations range from -0.40 to 0.34. Values of regression coefficients range from 0.11 to 0.92. Values of standard errors of the estimates are also quite satisfactory (ranging from 0.02 to 0.17; median = 0.07; standard deviation = 0.04).

Table 1. Fit indices and Standard Errors Summary

Satorra-Bentler Scaled Chi-Square = 899.33; df=300; P = 0.0
Root Mean Square Error of Approximation = 0.070; Standardized Root Mean Square Residual = 0.077
Normed Fit Index = 0.96; Comparative Fit Index = 0.97; Goodness of Fit Index = 0.99
Fitted Residuals: Range = <-0.40; 0.34>; Median = 0.00
Standard Errors: Range = <0.02; 0.17>; Median = 0.07; Standard Deviation = 0.04

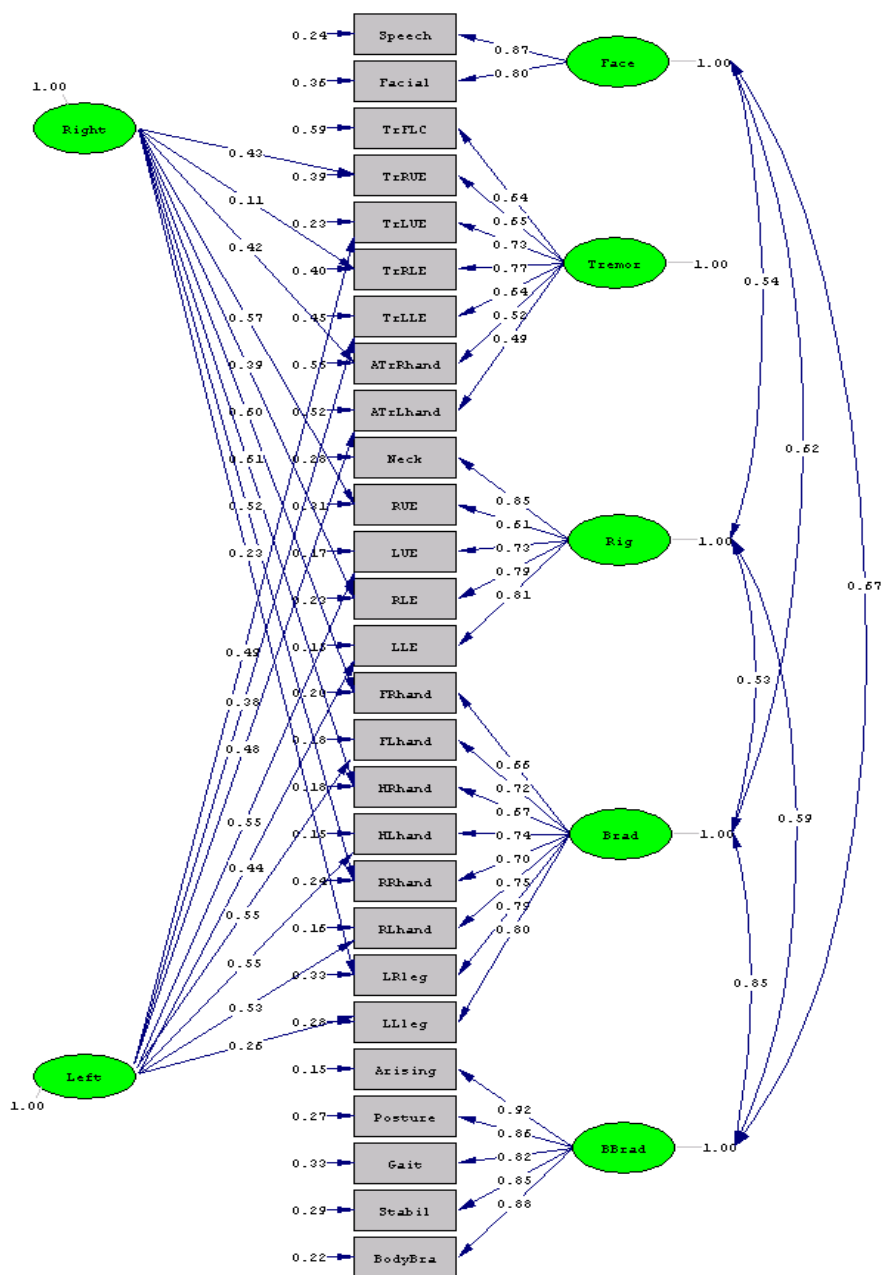


Figure 1. Path diagram of the seven-factor model of the MS UPDRS

DISCUSSION

In the presented study, the structure of motor symptoms of Parkinson's disease was investigated. This is inferred through statistical modeling of the Motor Section of the Unified Parkinson's Disease Rating Scale (MS UPDRS). For this purpose the structural equation modeling (SEM) was employed. The suitability of this method for this kind of scale is based on the sample size, sample distributions of the items, ordinal measurement level of the items, and from the assumptions of the estimators of SEM.

Several studies [1, 4, 5, 7, 8] assessed the construct validity and the dimensionality of the MS UPDRS through exploratory factor analysis (EFA). These studies found between three and six factors that accounted for a proportion ranging from 59% to 78% of the total scale variance (without reporting how these proportions were computed). However, as only EFA was performed, the conclusions about the dimensionality may not be trustworthy because using factor analysis models and corresponding estimation methods (Principal Component Analysis, Maximum Likelihood) requires the fulfillment of several assumptions: (1) Principal Component Analysis (PCA) requires a continuous measurement level [3]; (2) Maximum likelihood (ML) estimation requires continuous measurement level and either normally distributed item responses or a large number of observations which may compensate for small degrees of nonnormality. Previous studies with the UPDRS had not referred to the item distribution and, moreover, low sample sizes of $n < 300$ were used to make inferences about dimensionality. In addition, the measurement of the MS UPDRS is obviously ordinal instead of continuous, which may also pose problems when using an ML estimator or PCA [3]. Therefore the confirmatory factor analysis (CFA) and SEM using the Diagonally Weighted Least Squares (DWLS) estimator were employed.

In the present analysis, seven dimensions were established: tremor, rigidity, bradykinesia of the extremities, axial/gait bradykinesia, speech/hypomimia and two factors accounting for laterality of tremor, rigidity and bradykinesia of the extremities. Factors of rigidity, bradykinesia of the extremities, axial/gait bradykinesia and speech/hypomimia are correlated, whereas tremor seems to be an isolated PD symptom.

Two factors of laterality (Left, Right) reflect the asymmetry of occurrence of tremor, rigidity, and bradykinesia of the extremities. Indeed, in a clinical cohort it has been shown that initial PD symptoms start more frequently on the right-sided extremities than on the left. This might account for more independent behavior of the right-sided items in group comparisons. Using EFA methods, side-sensitivity of bradykinesia of the extre-

mities was mentioned before [7, 8] as well as that of action/postural tremor [1]. Side-sensitivity of rigidity and rest tremor, however, has never been reported so far.

High correlations among the factors of rigidity, bradykinesia of the extremities, axial/gait bradykinesia and speech/hypomimia can be an indicator of co-occurrence of these symptoms of PD. However, for most patients in common PD populations, the main symptoms co-occur, whereas isolated tremor may be solely present in very early stages of PD. Furthermore, the relative independence of tremor from rigidity and bradykinesia can be viewed as an indicator of the lack of significant relationship between tremor and PD disability, which is consistent with other reports [2, 6].

In conclusion, the findings of the present study should be considered in the context of structural equation modeling. Such analyses require follow-up cross-validation studies confirming the (factor) structure of the MS UPDRS.

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