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| Table 1. The neuropsychological tests used in the current study. |
| Domain | Neuropsychological tests |
| Executive Function | Modified Wisconsin Card Sorting Test (M-WCST): the number of categories achieved, and perseverative errorsStroop Word-Color Test (SWCT): color-word scoreCategory Fluency (fruit, fish, and vegetable)Color Trails Test (CTT)-part BSimilaritiesaMatrix reasoninga |
| Attention | Attention Test✝ Digit Spana |
| Processing Speed | SWCT: word score and color scoreCTT-part ADigit Symbol SubstitutionaSymbol Searchinga |
| Visuospatial ability | Pentagon copy✝Block designa |
| Memory | Logical Memory (LM)bVisual Reproduction (VR)b |
| Language✝ | NamingRepetitionVerbal comprehension |
| aSubtest of Wechsler Adult Intelligence Scale-Third Edition (WAIS-III)bSubtest of Wechsler Memory Scale-Third Edition (WMS-III)✝Subtest of Mini-Mental State Examination (MMSE) |

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| Table2. the demographic data and neurocognitive function in study groups |
|  | PD (n=94) | NC (n=167) | *p* value |
|  | Mean(SD) | Mean(SD) |  |
| age, y | 63.96(6.17) | 64.88(8.54) | 0.320c |
| Education, y | 12.10(4.05) | 11.94(3.60) | 0.393c |
| **Executive function** |  |  |  |
| M-WCST-C | 4.38(2.04) | 5.56(1.65) | <0.001c\* |
| M-WCST-P | 5.77(8.49) | 3.42(4.80) | 0.024c |
| SWCT-color word score | 29.12(11.69) | 32.50(10.99) | 0.041c |
| Category Fluency | 34.04(8.26) | 38.73(8.83) | <0.001c\* |
| CTT-B | 136.15(90.66) | 108.21(37.71) | 0.013c |
| Similarities | 10.66(2.89) | 11.78(2.69) | 0.002c |
| Matrix Reasoning | 10.86(2.96) | 11.85(2.89) | 0.009c |
| **Attention** |  |  |  |
| Attention test✝ | 7.28(1.15) | 7.61(0.73) | 0.028c |
| Digit Span | 11.45(2.62) | 12.01(2.77) | 0.181c |
| **Processing speed** |  |  |  |
| SWCT-word score | 75.13(20.07) | 84.31(17.89) | <0.001b\* |
| SWCT-color score | 57.66(265.969) | 62.86(14.02) | 0.007b |
| CTT-A | 69.14(38.74) | 52.23(19.06) | <0.001c\* |
| Digit Symbol Substitution | 10.16(2.35) | 12.10(2.38) | <0.001c\* |
| Symbol Searching | 10.35(2.65) | 12.31(2.32) | <0.001c\* |
| **Visuospatial ability** |  |  |  |
| Pentagon copy✝ | 12/82 | 3/164 | <0.001a\* |
| Block Design | 9.93(2.67) | 10.94(2.75) | 0.002c\* |
| **Memory** |  |  |  |
| LM-I(r.s.) | 30.03(13.49) | 35.46(11.51) | 0.002c\* |
| LM-II(r.s.) | 17.43(10.65) | 21.84(9.25) | 0.001b\* |
| LM-recognition(r.s.) | 22.64(4.35) | 24.49(3.75) | 0.001c\* |
| VR-I(r.s.) | 67.05(19.99) | 74.67(14.22) | 0.005c |
| VR-II(r.s.) | 44.99(23.44) | 52.36(21.45) | 0.019c |
| VR-recognition(r.s.) | 41.16(4.13) | 42.24(3.90) | 0.027c |
| **Language**✝ |  |  |  |
| Naming | 0/94 | 0/167 | - |
| Repetition | 1/93 | 4/163 | 0.657a |
| Verbal comprehension | 2/92 | 3/164 | >0.999a |
| aFisher Exact Test; b*t* test; cMann-Whitney U test; \*p < 0.002(Bonferroni correction for multiple comparisons)✝Subtest of Mini-Mental State Examination (MMSE)Abbreviations: please see table 1 and SD, standard deviation; r.s., raw score; LM-I, immediate memory of the logical memory; LM-II, delayed memory of the logical memory; VR-I, immediate memory of the visual reproduction; VR-II, delayed memory of the logical memory; M-WCST-C and M-WCST-P indicate the achieved categories and perseverative, respectively. |

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| Table 3. Gender-stratified analysis of the neurocognitive tests in PD and NCs. |
|  | male NCs(n=53) | female NCs(n=114) | male PD(n=60) | female PD(n=34) | *p*w*value* | *p*x*value* | *p*y*value* | *p*z*value* |
| Mean(SD) | Mean(SD) | Mean(SD) | Mean(SD) |
| age, y | 66.59(8.92) | 64.09(8.28) | 64.45(5.62) | 63.09(7.04) | 0.077c | 0.307b | 0.098c | 0.760c |
| education, y | 12.91(3.31) | 11.49(3.65) | 12.38(4.06) | 11.59(4.05) | 0.012c\* | 0.254c | 0.920c | 0.514c |
| onset age, y | - | - | 60.15(5.86) | 59.09(6.78) | - | 0.429b | - | - |
| Disease duration, y | - | - | 4.47(2.76) | 4.19(3.79) | - | 0.249c | - | - |
| LED | - | - | 557.53(265.38) | 463.92(277.75) | - | 0.085c | - | - |
| H&Y stage | - | - | 1.50(0.893) | 1.26(1.05) | - | 0.329b | - | - |
| **Executive function** |  |  |  |  |  |  |  |  |
| M-WCST-C | 5.47(1.69) | 5.60(1.63) | 4.47(2.054) | 4.24(2.05) | 0.310e | 0.585c | 0.009c | <0.001c\* |
| M-WCST-P | 3.81(6.09) | 3.24(4.08) | 5.43(8.073) | 6.35(9.29) | 0.226e | 0.539c | 0.398c | 0.022c |
| SWCT-color word score | 30.66(11.55) | 33.36(10.66) | 28.33(11.12) | 30.50(12.71) | 0.006e | 0.391b | 0.278b | 0.350c |
| Category Fluency | 34.53(7.71) | 40.68(8.66) | 32.48(7.46) | 36.79(8.97) | <0.001d\* | 0.005c | 0.218c | 0.024b |
| CTT-B | 108.44(36.78) | 108.10(38.30) | 139.40(102.79) | 130.42(64.93) | 0.383e | 0.890c | 0.082c | 0.127c |
| Similarities | 12.00(3.03) | 11.68(2.52) | 10.73(2.85) | 10.53(2.99) | 0.296e | 0.949c | 0.024c | 0.043c |
| Matrix Reasoning | 12.26(2.71) | 11.66(2.95) | 10.95(3.07) | 10.71(2.79) | 0.799e | 0.692c | 0.023c | 0.081c |
| **Attention** |  |  |  |  |  |  |  |  |
| Attention test✝ | 7.57(0.82) | 7.63(0.68) | 7.30(1.18) | 7.24(1.10) | 0.615e | 0.588c | 0.278c | 0.046c |
| Digit Span | 11.81(2.99) | 12.10(2.72) | 11.10(2.72) | 12.06(2.36) | 0.056e | 0.088b | 0.250c | 1.000c |
| **Processing speed** |  |  |  |  |  |  |  |  |
| SWCT-word score | 76.51(16.24) | 87.94(17.52) | 71.23(19.164) | 82.00(20.06) | <0.001d\* | 0.012b | 0.120b | 0.127c |
| SWCT-color score | 58.68(14.31) | 64.81(13.51) | 54.467(14.38) | 63.29(18.12) | <0.001d\* | 0.011b | 0.122b | 0.599b |
| CTT-A | 52.54(21.14) | 52.09(18.10) | 70.07(40.46) | 67.50(36.04) | 0.556e | 0.726c | <0.001c\* | 0.003c |
| DSS | 11.93(2.49) | 12.18(2.34) | 9.88(2.30) | 10.65(2.40) | 0.029e | 0.137c | <0.001c\* | <0.001c\* |
| Symbol Searching | 12.76(2.49) | 12.09(2.21) | 10.50(2.60) | 10.09(2.75) | 0.615e | 0.276c | 0.009c | 0.045 |
| **Visuospatial ability** |  |  |  |  |  |  |  |  |
| Pentagon copy✝ | 1/52 | 2/112 | 4/56 | 8/26 | >0.999a | 0.026a | 0.369a | <0.001a\* |
| Block Design | 11.57(2.74) | 10.65(2.72) | 9.87(2.94) | 10.03(2.14) | 0.187e | 0.934c | 0.003c | 0.086c |
| **Memory** |  |  |  |  |  |  |  |  |
| LM-I(r.s.) | 33.13(13.07) | 36.54(10.60) | 27.97(13.58) | 33.68(12.73) | 0.001e\* | 0.037c | 0.060c | 0.317c |
| LM-II(r.s.) | 20.00(10.08) | 22.70(8.76) | 15.78(10.59) | 20.32(10.26) | 0.002e\* | 0.041c | 0.043c | 0.357c |
| LM-recognition(r.s.) | 24.04(4.00) | 24.70(3.61) | 22.08(4.48) | 23.62(3.97) | 0.039e | 0.128c | 0.015c | 0.163c |
| VR-I(r.s.) | 74.83(16.38) | 74.59(13.18) | 66.15(21.31) | 68.65(17.62) | 0.672e | 0.587c | 0.029c | 0.138c |
| VR-II(r.s.) | 50.57(24.94) | 53.19(19.68) | 43.62(24.36) | 47.41(21.87) | 0.084e | 0.376c | 0.131c | 0.248c |
| VR-recognition(r.s.) | 42.34(4.17) | 42.19(3.79) | 41.15(4.20) | 41.18(4.07) | 0.591e | 0.991c | 0.094c | 0.179c |
| **Language**✝ |  |  |  |  |  |  |  |  |
| Naming | 0/53 | 0/114 | 0/60 | 0/34 | - | - | - | - |
| Repetition | 2/51 | 2/112 | 0/60 | 1/33 | 0.592a | 0.362a | 0.218a | >0.999a |
| Verbal comprehension | 2/51 | 1/113 | 1/59 | 1/33 | 0.237a | >0.999a | 0.599a | 0.408a |
| aFisher Exact Test; b*t* test;cMann-Whitney U test; dANCOVA(adjusted for years of education as covariates); erank analysis of covariance (adjusted for years of education as covariates); ✝Subtest of Mini-Mental State Examination (MMSE); \*p < 0.002(Bonferroni correction for multiple comparisons)Abbreviations: please see table 1&2; SD, standard deviation; LED, levodopa equivalent dose; H&Y stage, Hoehn and Yahr Staging Scale; DSS, Digit symbol substitution; r.s., raw score; LM-I, immediate memory of the logical memory; LM-II, delayed memory of the logical memory; VR-I, immediate memory of the visual reproduction; VR-II, delayed memory of the logical memory; M-WCST-C and M-WCST-P indicate the achieved categories and perseverative, respectively.wComparisons between male NCs and female NCs; xComparisons between male PD and female PD; yComparisons between male NCs and male PD; zComparisons between female NCs and female PD. |

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| **Table 4.** Correlations between the clinical characteristics and the neurocognitive performances in male PD |
| male PD | onset age | Disease duration | LED | Stages |
| *r* | *p* | *r* | *p* | *r* | *p* | *r* | *p* |
| **executive function** |
| M-WCST-C | -0.143 | 0.275 | 0.003 | 0.980 | -0.122 | 0.353 | -0.222 | 0.088 |
| M-WCST-P | 0.293 | 0.023\* | -0.155 | 0.238 | 0.065 | 0.622 | 0.188 | 0.150 |
| SWCT-color word score | -0.224 | 0.085 | -0.120 | 0.361 | -0.197 | 0.131 | -0.116 | 0.377 |
| Category Fluency | -0.042 | 0.753 | -0.024 | -0.855 | -0.166 | 0.205 | -0.151 | 0.248 |
| CTT-B | 0.466 | <0.001\*\* | 0.115 | 0.383 | 0.003 | 0.980 | 0.294 | 0.023\* |
| Similarities | 0.166 | 0.206 | -0.104 | 0.428 | -0.196 | 0.133 | 0.073 | 0.577 |
| Matrix Reasoning | 0.010 | 0.942 | -0.010 | 0.941 | -0.024 | 0.856 | 0.096 | 0.466 |
| **Attention** |  |  |  |  |  |  |  |  |
| Attention test✝ | -0.224 | 0.085 | -0.080 | 0.541 | 0.123 | 0.348 | -0.144 | 0.271 |
| Digit Span | -0.110 | 0.402 | -0.013 | 0.922 | -0.208 | 0.112 | 0.070 | 0.596 |
| **Processing speed** |  |  |  |  |  |  |  |  |
| SWCT-word score | -0.257 | 0.047\* | -0.071 | 0.590 | -0.156 | 0.235 | -0.154 | 0.241 |
| SWCT-color score | -0.257 | 0.048\* | -0.160 | 0.222 | -0.145 | 0.267 | -0.269 | 0.037\* |
| CTT-A | 0.446 | <0.001\*\* | 0.014 | 0.913 | 0.087 | 0.507 | 0.292 | 0.024\* |
| Digit Symbol Substitution | -0.089 | 0.498 | 0.043 | 0.745 | -0.235 | 0.071 | -0.235 | 0.070 |
| Symbol Searching | -0.147 | 0.264 | 0.054 | 0.684 | -0.214 | 0.100 | 0.000 | >0.999 |
| **Visuospatial ability** |  |  |  |  |  |  |  |  |
| Pentagon copy✝ | -0.177 | 0.756 | 0.119 | 0.366 | -0.005 | 0.969 | 0.075 | 0.566 |
| Block Design | -0.206 | 0.114 | -0.058 | 0.658 | -0.144 | 0.271 | 0.032 | 0.806 |
| **Memory** |
| LM-I(r.s.) | -0.103 | 0.435 | -0.230 | 0.077 | -0.075 | 0.567 | -0.144 | -0.272 |
| LM-II(r.s.) | -0.163 | 0.215 | -0.216 | 0.098 | -0.110 | 0.401 | -0.160 | 0.221 |
| LM-recognition(r.s.) | -0.232 | 0.075 | -0.018 | 0.889 | -0.061 | 0.644 | -0.040 | 0.760 |
| VR-I(r.s.) | -0.409 | 0.001\*\* | -0.0110 | -0.939 | -0.045 | 0.730 | -0.100 | 0.446 |
| VR-II(r.s.) | -0.347 | 0.007\*\* | -0.224 | 0.086 | -0.160 | 0.223 | -0.113 | 0.391 |
| VR-recognition(r.s.) | -0.285 | 0.027\* | -0.045 | 0.729 | -0.046 | 0.729 | -0.174 | 0.183 |
| **Language**✝ |
| Naming | - | - | - | - | - | - | - | - |
| Repetition | - | - | - | - | - | - | - | - |
| Verbal comprehension | -0.377 | 0.003\*\* | 0.070 | 0.596 | 0.053 | 0.686 | 0.074 | 0.577 |
| Abbreviations: please see table 1, 2, and 3. |

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| **Table 5.** Correlations between the clinical characteristics and the neurocognitive performances in female PD |
| female PD | onset age | Disease duration | LED | Stages |
| *r* | *p* | *r* | *p* | *r* | *p* | *r* | *p* |
| **Executive function** |
| M-WCST-C | -0.566 | <0.001\*\* | -.254 | 0.146 | -0.236 | 0.178 | -0.156 | 0.377 |
| M-WCST-P | 0.303 | 0.082 | 0.472 | 0.005\*\* | 0.428 | 0.011\* | 0.287 | 0.100 |
| SWCT-color word score | -0.338 | 0.051 | -0.276 | 0.114 | -0.312 | 0.072 | -0.237 | 0.178 |
| Category Fluency | -0.370 | 0.031\* | -0.429 | 0.011\* | -0.335 | 0.053 | -0.296 | 0.090 |
| CTT-B | 0.406 | 0.017\* | 0.207 | 0.240 | 0.146 | 0.410 | 0.155 | 0.383 |
| Similarities | -0.008 | 0.963 | 0.226 | 0.199 | 0.171 | 0.333 | 0.348 | 0.044\* |
| Matrix Reasoning | -0.053 | 0.766 | 0.383 | 0.026\* | 0.276 | 0.114 | 0.099 | 0.576 |
| **Attention** |  |  |  |  |  |  |  |  |
| Attention test✝ | -0.238 | 0.175 | -0.062 | 0.728 | -0.163 | 0.356 | -0.029 | 0.870 |
| Digit Span | 0.026 | 0.883 | -0.016 | 0.930 | -0.017 | 0.923 | 0.335 | 0.053 |
| **Processing speed** |  |  |  |  |  |  |  |  |
| SWCT-word score | -0.517 | 0.002\*\* | -0.251 | 0.152 | -0.226 | 0.152 | -0.080 | 0.652 |
| SWCT-color score | -0.405 | 0.018\* | -0.231 | 0.188 | -0.231 | -0.188 | -0.160 | 0.367 |
| CTT-A | 0.427 | 0.012\* | 0.094 | 0.596 | 0.094 | 0.596 | 0.121 | 0.497 |
| Digit Symbol Substitution | -0.104 | 0.557 | 0.021 | 0.906 | 0.021 | 0.906 | 0.062 | 0.727 |
| Symbol Searching | -0.165 | 0.351 | 0.020 | 0.910 | 0.020 | 0.910 | 0.013 | 0.943 |
| **Visuospatial ability** |  |  |  |  |  |  |  |  |
| Pentagon copy✝ | 0.018 | 0.921 | -0.065 | 0.717 | 0.002 | 0.992 | 0.008 | 0.965 |
| Block Design | -0.055 | 0.759 | 0.188 | 0.286 | 0.154 | 0.384 | 0.091 | 0.610 |
| **Memory** |
| LM-I(r.s.) | -0.358 | 0.037\* | -0.039 | 0.828 | 0.051 | 0.774 | 0.239 | 0.173 |
| LM-II(r.s.) | -0.432 | 0.011\* | 0.097 | 0.584 | 0.081 | 0.649 | 0.199 | 0.259 |
| LM-recognition(r.s.) | -0.445 | 0.008\*\* | 0.024 | 0.892 | 0.049 | 0.782 | -0.127 | 0.473 |
| VR-I(r.s.) | -0.331 | 0.056 | -0.116 | 0.512 | -0.034 | 0.850 | -0.047 | 0.792 |
| VR-II(r.s.) | -0.367 | 0.033\* | -0.224 | 0.203 | 0.023 | 0.899 | -0.092 | 0.606 |
| VR-recognition(r.s.) | -0.555 | 0.001\*\* | -0.050 | 0.777 | -0.076 | 0.671 | -0.025 | 0.887 |
| **Language**✝ |
| Naming | - | - | - | - | - | - | - | - |
| Repetition | 0.002 | 0.990 | 0.149 | 0.401 | 0.169 | 0.343 | -0.123 | 0.487 |
| Verbal comprehension | -0.154 | 0.384 | 0.056 | 0.755 | -0.023 | 0.897 | 0.044 | 0.803 |
| Abbreviations: please see table 1, 2, 3, and 4. |

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| **Table 6.** Multiple linear regression analyses in male PD with various tests |
| male PD | Color Trails Test-part B |  | Stroop Word-Color Test -color score |  | Color Trails Test-part A |  | Digit symbol substitution |
| *△R2* | *β* Value | *p*-Value |  | *△R2* | *β* Value | *p*-Value |  | *△R2* | *β* Value | *p*-Value |  | *△R2* | *β* Value | *p*-Value |
| *Model 1* | 0.306 |  |  |  | 0.231 |  |  |  | 0.226 |  |  |  | 0.162 |  |  |
| Age, y |  | 0.554 | <0.001 |  |  | -0.364 | 0.003 |  |  | 0.826 | <0.001 |  |  | -0.076 | 0.535 |
| Education, y |  | -0.054. | 0.629 |  |  | 0.336 | 0.005 |  |  | -0.192. | 0.100 |  |  | 0.400 | 0.002 |
| *Model* 2 | 0.048 |  |  |  | 0.058 |  |  |  | 0.057 |  |  |  | 0.065 |  |  |
| Age, y |  | 0.522 | <0.001 |  |  | -0.329 | 0.006 |  |  | 0.442 | <0.001 |  |  | -0.039 | 0.745 |
| Education, y |  | -0.067 | 0.537 |  |  | 0.351 | 0.003 |  |  | -0.206 | 0.070 |  |  | 0.415 | 0.001 |
| Stages |  | 0.222 | 0.046 |  |  | -0.245 | 0.036 |  |  | 0.241 | 0.036 |  |  | -0.258 | 0.035 |
|  | **Total *R2* =0.354** ***p* = < 0.001** |  | **Total *R2* =0.289** ***p* = < 0.001** |  | **Total *R2* =0.283** ***p* = < 0.001** |  | **Total *R2* =0.227** ***p* = 0.002** |