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Differences based on fine motor behaviour in Parkinson's patients compared to an age matched control group in proprioceptive and visuo-proprioceptive test conditions*

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Personality differences based on fine motor precision performance were studied in early stage Parkinson's patients and an age-matched control group under two different test conditions: Proprioceptive + visual information and proprioceptive information alone. A comparative data analysis for deviations of three measured movement types (transversal, frontal and sagittal) was done for both hands (dominant and non-dominant) with relation to personality dimensions. There were found significant differences between the two groups in decision making dimension and emotionality. After splitting the data for gender subgroups, some significant differences were found for men but not for women. The differences in fine motor task performance varied, being better in some directions for the Parkinson's patients and worse in others. The findings may suggest that medication has both positive and negative effects on motor performance and provoke personality changes, being more pronounced in men.
Keywords: *Parkinson, fine motor movements, proprioception, medication effects.*

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Diferencias entre pacientes de Parkinson y controles en la conducta motora fina basada en la información visual y propioceptiva *versus* solo propioceptiva

Las diferencias de personalidad basadas en la precisión de la ejecución motora fina fueron estudiadas en pacientes con Parkinson en la etapa inicial de la enfermedad y en un grupo control de edad similar bajo dos condiciones de ensayo diferentes: información propioceptiva + visual y solo información propioceptiva. Se hizo un análisis de datos comparativo de las desviaciones en los tres tipos de movimiento medidos (transversal, frontal y sagital) con las dos manos (dominante y no dominante) y en relación a las dimensiones de la personalidad. Se encontraron diferencias significativas entre los dos grupos en las dimensiones toma de decisiones y emotividad. Después de dividir los datos en subgrupos según el género, se encontraron algunas diferencias significativas para los hombres pero no para las mujeres. Las diferencias en el rendimiento en estas tareas variaron, siendo mejor en algunas direcciones para los pacientes de Parkinson y peor en otras. Los hallazgos sugieren que la medicación puede tener efectos tanto positivos como negativos en el rendimiento motor y provocar cambios en la personalidad, siendo más pronunciados en los hombres.

Palabras clave: *Parkinson, movimientos motores finos, propriocepción, efectos de medicación.*

Introduction

Parkinson's disease (PD) has a set of complex interactive causes (not all clearly defined) which reflects an integrative function of the organism on the individual (genetic-biological and psychological) and social levels (environment and human activity). Research into the condition requires a multiple approach. Although PD is characterised by a unique set of symptoms for each individual, many common non-motor and motor factors of disease have been observed (Ford & Pfeiffer, 2005; Chaud-huri, Healy, & Schapira, 2006). On the one hand we find subjects exposed to toxic environmental elements (such as pesticides and heavy metals) or drugs; on the other, we find "specific" types of personality predispositions that were prevalent before and during the development of PD: Emotional well-being (Dubayova *et al*., 2009), obsessive-compulsive behaviour (punctuality, obsession with details), extreme seriousness (little positive humour), shyness, ambitiousness (although some research has not found significant differences), low novelty-seeking behaviour and less extraversion (Glosser *et al*., 1995), anxiety, pessimism (Bower *et al*., 2010) and low involvement in physical work (Gatto, Bordelon, Gatz, & Ritz, 2011; Steiner *et al*., 2006).

Similar to radiation and stressful lifestyle, oxidative effects in biological tissue caused by toxic elements in Parkinson's patients lead to the formation of

free radicals, future changes of which in the protein packing and functioning can be reduced by consuming foodstuffs that prevent oxidative processes, such as products rich in vitamins C and E, and flavonoids (berries, oranges, green tea, red wine etc.) (Seroka, 2011; Willis, Shukitt-Hale, & Joseph, 2009). The current treatment measures (dopaminergic medication and stem cell transplantation) can improve the state of the disease, but do not cure it. Moreover, recent research has shown that the depletion of dopamine is a signal for the appearance of new cells, and that the introduction of L-dopa interrupts this signalling, resulting in the non-renewal of cells (Berg, Kirkham, Wang, Frisén, & Simon, 2011; Steiner *et al*., 2006). The risk of having PD can be reduced if a number of external causes are controlled by reducing the toxic elements that induce the disease. Individual characteristics and lifestyle are also important parameters and should be taken into account as well, thus, potentiating more adaptive reaction and less vulnerability to stress by doing more physical and intellectual exercises and having a diet rich in antioxidants (Berg *et al.,* 2011; Bower *et al.,* 2010; Dubayova *et al.,* 2009; Guzman *et al.*, 2010; Steiner *et al*., 2006; Willis *et al*., 2009).

Changes in dopamine levels may affect some patients who have had sexual problems and a tendency to compulsory-obsessive behaviour, causing hypersexuality and impulsivity, or deficits in the processing of proprioceptive information (Almeidaa *et al*., 2005; Barnett-Cowana *et al*., 2010; Hinnell, Hulse, Martin, & Samuel, 2011; Gatto *et al*., 2011; Glosser *et al*., 1995; Mongeon, Blanchet, & Messier, 2009; Vaugoyeaua, Hakama, & Azulaya, 2010); the natural release of dopamine is commonly observed in highly creative people or people in love (Aron *et al*., 2005). Motor and cognitive functions in patients suffering from neurodegenerative disorders, and PD in particular, can be improved by potentiating their physical activity and their experience of novelty (Steiner *et al*., 2006).

Current research has a purpose to contribute to PD investigation carried out by different specialists, representing the integrative analysis of the fine motor performance in space as an implicit methodology (free of subjective influences). Proprioception acts as a "bridge" between other sensorial modalities, playing an integrative function and reflecting the personality differences. Thus our hypothesis was to check if there are any significant differences in personality based on fine motor performance between PD patients and the age matched control group (general population with the same educational level) in both sensorial condition: PV – proprioceptive-visual (where the integration between both sensory modalities is optimum if not disturbed by PD, for example) and P – proprioceptive condition only (since in PD found proprioceptive deficits as well).

Method

Participants

The study included subjects with normal vision (Parkinson group: *N*=23, men 57%, age 71±8; control group [general population]: *N*=24, men 29%, age 72±15; participants of both groups were of similar educational level with a secondary school compulsive education as a minimum). Parkinson's patients (disease level: UPDRS[1] – III, Hoeh & Yahr [1967] – I/II; affected side - 50%) were tested in medication ON state OFF condition; the medications taken were agonists, Levodopa or IMAO-B. All participants were right-handed, checked by the Lateral Preference Inventory (LPI) for handedness (Coren, 1993). Participants who had been forced to change their hand dominance at school were excluded from the study. All subjects participated voluntarily; they were previously informed of the aim of the research and gave due consent. All tests were carried as per ethical committee agreements in accordance with the Helsinki declaration of human rights.

Instruments

The conditions that might affect the performance on the test were controlled: Mild temperature and silent environment; consumption of any substances that could influence fine motor activity. The computerized test (Tous & Viadé, 2002) was based on its original manual version proposed by Mira (1958) as myokinetic psychodiagnosis (M.K.P.) and comprised a tactile screen (LGE resolution of 1280x1024, optimal frequency of 60 Hz) with a sensory stylus (for hand drawings); laptop computer (Pentium IV); specifically designed test software for the recoding and analysis of data; a piece of cardboard (or opaque screen) for the proprioceptive (P) part of the test to hide the active arm and movement information feedback; a stool, adjustable to the participant's height, and table; and instructions for the correct task procedure and performance.

Procedure

The precision of fine motor movement (tracing over the model lines) was measured in the frontal, transversal, and sagittal directions. Correct posture (body in the upright position looking straight ahead without leaning to the left or right during the performance of movements, with the feet together on the floor) was required, and stool and table heights were adjusted individually to allow free el-

[1] UPDRS – *Unified Parkinson's Disease Rate Scale.*

bow movement. The subjects were seated comfortably without having to bend their back or extend their arms in an unnatural way. The hand not being used in the task rested on the ipsilateral leg and the hand and arm used for the task had tactile contact only with the stylus with which the drawing was performed, while the wrist was kept rigid. Subjects held the stylus in the middle by the thumb, ring, and index fingers, as when painting.

The motor indicators, such as the directional[2] deviations (D), the formal[3] (F), the line length difference (LL) in each experimental condition of test and the difference between maximum and minimum line length drawn (ΔLL), for each subject in the P test condition were used to assess the precision of the fine motor performance and obtained by a translation from pixels to millimetres. Another application of the program is the transfer of the results representing the systematic deviations of the movements made by participants (population mean tendency of the tested groups), with psychological bipolar dimensions obtained from previous studies and checked using factor analysis (Tous, Viadé, & Muiños, 2007). Tendencies of the upper limb movements, reflecting the balanced work of paired muscles (extenders/flexors of shoulders and elbows and adductors/abduc-tors of elbows) are related to specific personality behaviour (Mira, 1958; Neuman & Strack, 2000; Tous *et al*., 2007). Dimensions represented in the current test were:

– Mood (pessimism-optimism).
– Decision making (submission-dominance).
– Attention's direction (intratension-extratension).
– Emotionality (distant-affective).
– Irritability (inhibition-excitability).
– Impulsivity (rigidity-variability; Tous *et al*., 2007).

Data analysis and results

The comparison of fine motor performance in Parkinson's and control groups found no significant differences in line length differences performance (40 mm as per base model) or any ΔLL difference (fluctuations in repeated strokes for each direction; raw descriptive data are presented in table 1).

[2] Parallel to the required movement direction by the test model.
[3] Perpendicular to the required movement direction by the model.

TABLE 1. DESCRIPTIVE STATISTICS: MEAN AND STANDARD DEVIATION OF DRAWING BIASES FOR BOTH GROUPS (PARKINSON AND CONTROL).

Movement direction	Deviation type	Hand	Means ± *SDs* of groups values							
			Parkinson				Control			
			Male		*Female*		*Male*		*Female*	
			P	*PV*	*P*	*PV*	*P*	*PV*	*P*	*PV*
Frontal	***LL***	*R*	1.35 ±11.67	-5.32 ±3.21	7.52 ±12.20	-3.76 ±2.42	6.63 ±19.81	-1.77 ±3.88	2.89 ±11.78	-4.53 ±3.01
		L	3.20 ±14.79	-5.35 ±2.36	6.64 ±2.42	-5.84 ±2.82	9.03 ±17.64	-6.11 ±1.38	3.78 ±11.58	-5.12 ±3.59
	D	*R*	-8.55 ±22.63	-0.83 ±1.91	3.08 ±13.13	-0.40 ±2.13	-4.15 ±10.64	-2.47 ±1.15	1.60 ±13.25	-0.01 ±1.86
		L	-7.75 ±18.69	0.00 ±1.20	-5.44 ±14.22	-0.04 ±0.91	-13.02 ±14.22	-0.57 ±0.78	-4.54 ±18.57	-0.23 ±0.78
	F	*R*	30.27 ±30.20	0.28 ±1.31	16.60 ±13.31	-0.12 ±1.96	16.15 ±14.57	1.75 ±1.26	22.72 ±23.95	0.30 ±1.66
		L	17.63 ±15.98	0.00 ±1.57	22.40 ±24.84	0.64 ±1.84	15.22 ±24.84	0.03 ±1.17	23.32 ±9.76	-0.06 ±1.17
Transversal	***LL***	*R*	28.83 ±29.59	13.32 ±4.95	28.72 ±15.26	10.72 ±4.13	39.83 ±33.68	14.00 ±3.22	20.87 ±23.27	12.47 ±7.49
		L	23.23 ±21.89	9.57 ±5.07	42.04 ±29.32	12.32 ±4.35	38.17 ±26.60	11.66 ±4.82	29.07 ±31.47	9.74 ±6.07
	D	*R*	5.66 ±23.48	-2.03 ±3.12	-4.48 ±29.04	-1.60 ±3.09	-12.88 ±20.65	-1.52 ±1.83	11.74 ±41.11	-0.87 ±3.91
		L	-3.60 ±31.02	0.22 ±1.72	-15.68 ±26.88	-0.20 ±3.69	10.08 ±22.84	0.15 ±3.18	-8.32 ±28.79	-0.01 ±1.97
	F	*R*	-6.80 ±13.63	-0.62 ±0.95	-14.4 ±15.56	-0.20 ±0.66	-9.60 ±10.13	-0.02 ±0.38	-6.30 ±12.40	-0.76 ±0.87
		L	-2.49 ±15.74	-0.37 ±0.72	-10.48 ±18.67	-0.44 ±1.09	-5.98 ±10.96	-0.22 ±0.76	-5.92 ±14.02	0.00 ±1.02
Sagittal	***LL***	*R*	-4.18 ±18.66	-7.02 ±2.70	1.40 ±11.81	-5.68 ±2.20	0.06 ±16.97	-6.46 ±3.78	0.87 ±15.82	-6.60 ±2.75
		L	1.26 ±13.68	-6.25 ±1.87	-1.84 ±9.08	-6.53 ±2.84	7.89 ±17.67	-6.63 ±2.98	-0.65 ±13.13	-5.77 ±3.40
	D	*R*	9.97 ±13.53	-0.37 ±1.43	6.92 ±16.21	-0.48 ±1.71	10.30 ±8.58	-0.42 ±0.52	10.64 ±12.07	0.09 ±2.90
		L	16.00 ±15.50	-0.55 ±1.21	19.28 ±10.40	-0.67 ±1.33	11.12 ±10.37	-0.72 ±1.00	17.90 ±18.75	-0.49 ±2.07
	F	*R*	-0.49 ±24.94	-0.43 ±0.89	-4.88 ±22.36	-0.48 ±1.51	-8.72 ±17.12	-0.02 ±1.22	-3.74 ±26.37	-0.68 ±1.46
		L	-7.05 ±22.44	-0.55 ±1.40	-13.80 ±27.06	0.24 ±1.24	-2.00 ±18.26	-0.32 ±0.61	-0.69 ±17.77	-0.21 ±1.53

Note: Raw data, measured in mm.
Legend: Observable variables: LL – line length difference (line model length is 40 mm), D – directional bias; F – formal bias; L and R – for left and right hands correspondently.

As regards spatial deviations (directional, or parallel to that required by the test model; and formal, or perpendicular to the required movement), significant differences (p<.05) were reached in frontal formal deviation for the right hand in the PV test condition and sagittal directional deviation of left hand in the proprioceptive part of the test (table 2, figure 1). The values for the Parkinson's group were lower for the first deviation and higher for the second one, showing lower emotionality expression in the PV test performance compared to the control group, and problems in the decision-making dimension, related to the hormonal or biological domain since it was expressed in the non-dominant (L) hand.

TABLE 2. COMPARATIVE ANALYSIS OF WILCOXON SIGNED RANKING TESTS FOR THE CONTROL *VS.* PARKINSON GROUP.

			Z-values	
Movement direction	**Deviation type**	**Hand**	**P**	**PV**
Frontal	***LL***	*R*	-0.26	-0.34
		L	-0.20	0.14
	D	*R*	-0.85	-0.13
		L	-0.62	-0.22
	F	*R*	-0.21	**-2.02***
		L	-0.17	-0.47
Transversal	***LL***	*R*	-0.05	-0.65
		L	-0.50	-0.97
	D	*R*	-0.12	-0.59
		L	-0.26	-0.57
	F	*R*	-0.03	-0.35
		L	-0.59	-0.72
Sagittal	***LL***	*R*	-0.34	-0.30
		L	-0.52	-0.19
	D	*R*	-0.38	-0.51
		L	**-2.25***	-0.39
	F	*R*	-1.33	-1.45
		L	-1.37	-0.36

Note: LL –bias in line length; D and F– directional and formal biases; at significance level S (bilateral) of p<.05(*)

The data were split further into gender subgroups (PD group: Men [n=13], age 69±8, women [n=10]: 73±8; control group: Men [n=7], age 74±15, women [n=17]: 72±15) to check whether there were any substantial changes according to gender (Dluzen & McDermott, 2000; Munro *et al*., 2006; Tamás, Lubics, Szalontay, Lengvári, & Reglödi, 2004) using the non-parametric Wilcoxon signed test. No significant gender-related differences were found for the Parkinson's group (table 3) but differences were found in the control group: Five in the PV

test condition compared to one in the P condition. To test differences between subjects of the same gender (M - male, and F - female) between Parkinson (PD) and control (C) group, no significant gender-related differences were found in the women in both groups but significant difference were found for men in the following deviations: Line length (LL), directional (D) and formal (F) for right hand in the frontal movement type and PV sensory test condition, and for D for right hand, in the transversal movement direction and P sensory test condition (table 3).

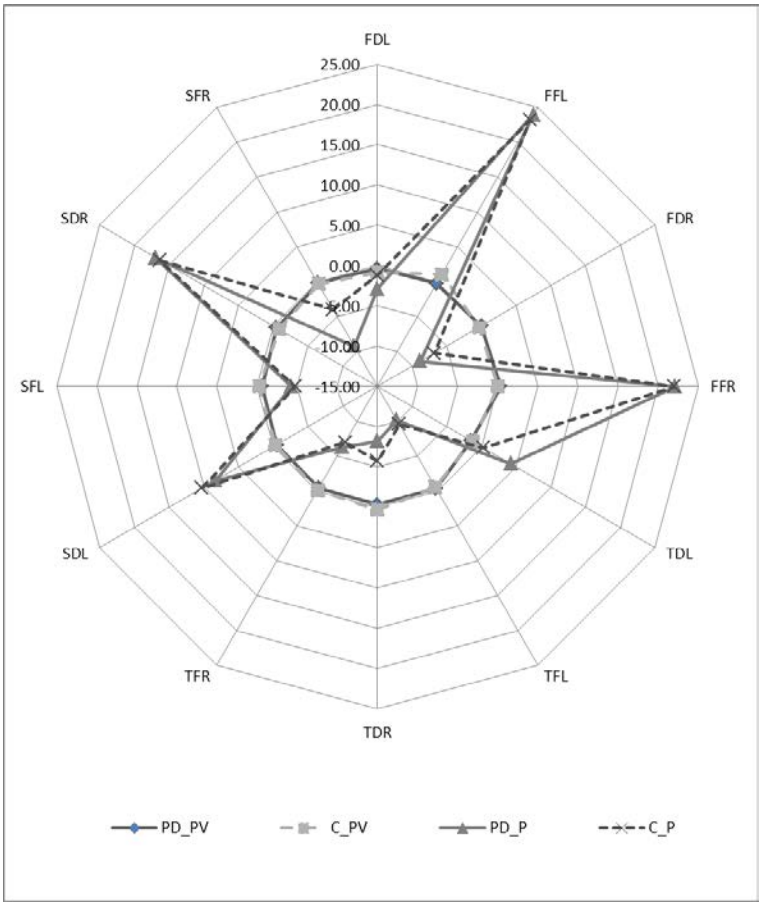

Figure 1. Spatial representation of deviation means for Parkinson (PD) and control group (C) in PV and P test conditions.

Legend for deviation type abbreviations: first letter stands for movement type (F – frontal, T – transverse, and S – sagittal); the second letter, for deviation type (D – directional, F – formal), and the third one, for hand (L – left and R – right).

TABLE 3. PAIRED DIFFERENCES STATISTICS FOR TRACING BIASES IN P AND PV SENSORY TEST CONDITIONS.

Movement direction	Deviation type	Hand	Paired differences							
			M *vs.* F				PD *vs.* C			
			PD		*C*		*M*		*F*	
			P	*PV*	*P*	*PV*	*P*	*PV*	*P*	*PV*
Frontal	***LL***	*R*	0.97	1.25	1.35	0.73	1.35	**3.37***	1.07	0.31
		L	0.97	1.15	1.35	**2.03***	1.35	0.52	1.02	1.12
	D	*R*	0.71	0.06	0.93	**2.37***	0.34	**2.37***	0.20	0.91
		L	0.05	0.00	1.18	0.54	1.35	1.29	0.46	0.00
	F	*R*	0.26	0.35	1.01	**2.20***	0.68	**2.23***	0.66	0.41
		L	0.15	0.40	0.00	0.74	0.17	0.09	0.05	1.39
Transversal	***LL***	*R*	0.46	0.76	1.86	0.34	1.52	1.02	1.27	0.51
		L	1.68	1.74	**2.03***	0.17	1.18	0.17	1.89	1.25
	D	*R*	0.56	0.10	1.35	0.25	**2.20***	0.68	0.46	0.87
		L	1.48	0.54	1.01	0.17	0.51	0.54	1.27	0.71
	F	*R*	1.87	0.28	1.35	**2.04***	1.18	0.65	0.97	1.55
		L	1.30	0.00	1.36	0.34	0.00	0.33	0.46	0.66
Sagittal	***LL***	*R*	0.10	1.60	1.35	0.85	0.68	1.19	1.38	0.46
		L	0.56	0.00	1.86	**2.26***	1.52	0.00	0.89	0.77
	D	*R*	0.71	0.12	0.51	0.32	0.00	0.14	0.05	0.76
		L	0.61	0.06	0.52	0.09	0.68	1.03	0.77	0.77
	F	*R*	0.26	0.12	0.42	1.68	0.85	0.85	0.34	0.63
		L	0.56	1.54	0.09	0.51	0.34	0.32	0.59	1.19

Note: Wilcoxon signed test for paired (M – men vs. F –female participants; and PD – Parkinson amd C – control groups) in both sensorial conditions (PV – prorioceptive-visual and P – proprioceptive only); significance level (bilateral) of $p<.05$ (*).
Legend: LL – line length difference (line model length is 40mm), D – directional bias; F – formal bias; L and R – for left and right hands correspondently.

Finally, as regards behavioural variability, represented in fluctuations of the line length during the P test condition (in the visual deprivation test condition it is higher), although the sum of all deviations did not show significant difference either between groups or between gender subgroups, the mean of total SUMΔLL in men with Parkinson's was lower than in women of the same groups and in both genders in the control group (table 4). Checking for the differences for each of the three movement types of both hands, there was a significant difference between men with Parkinson's and the control group in transversal movement of the left hand (table 4), showing less variability and more behavioural rigidity than the other subgroups.

TABLE 4. VARIABILITY OF THE LINE LENGTHS (ΔLL) IN THREE TYPES OF MOVEMENTS: FRONTAL, TRANSVERSAL AND SAGITTAL, FOR THE R (RIGHT) AND LEFT (L) HANDS, REPRESENTED BY DIFFERENCES IN GENDER AND TESTED GROUPS.

		Parkinson				**Control**			
Gender		***Male***		***Female***		***Male***		***Female***	
Mov. type	**Hand**	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Frontal	R	13.82	5.03	20.08	10.73	15.94	7.64	14.62	5.62
	L	14.31	6.17	16.20	8.45	13.91	5.60	16.30	10.79
Transversal	R	30.12	20.14	26.24	10.73	32.34	15.53	22.92	8.59
	L	**24.09***	9.05	26.98	13.92	26.34	11.62	27.41	17.14
Sagittal	R	14.92	12.90	18.16	12.01	12.17	3.88	14.89	8.82
	L	13.60	7.41	13.24	7.25	13.77	5.81	13.11	8.37
SUMΔLL		**86.77**	**60.70**	**120.9**	**63.09**	**114.47**	**50.08**	**109.25**	**59.33**

Note: SUMΔLL is a sum of all movement types x hand; *the difference is significant for men at $p < .05$.

Discussion

The significant differences obtained in pooled data for formal bias type for right hand in the frontal movement type and PV sensory condition (FFR PV) have lower values in the Parkinson's group than controls in the test condition with vision. In the P-test condition the highest value for directional bias in the left hand, sagittal movement direction and proprioceptive sensory condition (SDL P) was found, being greater for the Parkinson's group.

The absence of statistically significant differences between men and women in PD patients may be due to the effects of medication and to the low differentiation between gender differences in the yearly stages of PD. Other investigators have reported that sex differences are more pronounced in patients with more than 5 years of PD (Dluzen & McDermott, 2000) and that postural disorders appear at later stages of PD (Vaugoyeaua *et al*., 2010), suggesting that proprioceptive "problems" appear with disease progression. However, some of the differences, obtained between men in the Parkinson's and control groups, were the same as the ones found between men and women in the control group. Similar behaviour was observed for frontal directional right hand (FDR) and frontal formal right hand (FFR) deviations in the PV test condition, suggesting that medication or disease state could affect Parkinson's patients and bring them closer to the female control state: Men and women with Parkinson's in both subgroups had fewer errors for FDR and FFR (PV) compared to the male control subgroup, indicating less pessimistic mood and less affective emotionality (the PD women subgroup was even more skewed to the

negative emotional state since FFR had a negative sign). In contrast, in the proprioceptive test condition the FFR value (for PD men) was greater, showing the highest emotional lability, although the difference was not statistically significant.

The rest of the significant deviation errors are specific only for differences between male Parkinson's and control subgroups. Line length difference (LL), with the biggest and the only significant difference in the current sample in the frontal type of movement (PV test, R hand) indicates that the inhibition may be stronger with vision, and is more pronounced in vertical than in horizontal or sagittal movements, meaning that PD men have less orientation in gravitation force in the PV test condition (for all subgroups the vertical gravitation means were negative in PV test condition and positive in the P test condition, having less inhibition and gravitation impacts).

The only significant proprioceptive difference between men in the two subgroups was found for transversal directional right hand TDR (P) deviation type, which was again similar to that of women in the control group. Even though both subgroups had a negative sign in the PV-test for this movement type, they had a positive sign in the P-test (for mean values). This tendency towards extratension, or external attention in Parkinson's men may be induced by changes in mood due to medication or social situation: They move more and have more contact with doctors, social agents, and family due to the disease, whereas almost half of the control males were from geriatric institutions and may well have fewer individual social communication possibilities.

As regards rigidity of behaviour, with lower values for the Parkinson's group (not significant for the sum of all deviations, and significant in the transversal type of movement), these results show slight differences, preserving the tendency of rigid behaviour (a tendency towards compulsive, serious, introvert, punctual or perfectionist types that are described as characteristic personality types for this disease; Gatto *et al*., 2011; Glosser *et al*., 1995); however, this type may change into its opposite, an impulsive personality type, due to the effect of medication (Cannas *et al*., 2009; Hinnell *et al*., 2011; Lee *et al*., 2010). In our case the transformation was not pronounced, because the patients were in the early stages of the disease and the test was in the take-off stage (when the effects of medication were less marked). As for the significant differences between men in the Parkinson's and control groups, it is curious that they all belong to the dominant hand (R). A possible interpretation is that they are due to changes obtained as learnt behaviours, and that these differences, as well, can be re-educated by therapy, such as, for example, inhibition in step length (in view of all the LLs of the test and the significant result obtained for frontal movement of right hand [FLLR], showing that this difference is higher for vertical movements and when vision and proprioception are integrated, i.e. in the PV test): Physical training accompanied by verbal instructions has been reported to change these short steps that are typical of Parkinson's (Jacobsa & Horaka, 2006; Lehman, Toole, Lofald, & Hirsch, 2005).

Since Parkinson's patients did not show worse performance on all types of movements (nor greater errors in the P test condition), the proprioceptive deficits accompanied by Parkinson's disease in early-middle stage (medication ON, state OFF) may not be the main reason for the disease development; proprioception (together with posture, gait and balance) worsened with disease development and medication effects, as other researchers have found (Almeidaa *et al*., 2005; Barnett-Cowana *et al*., 2010; Mongeon *et al*., 2009; Vaugoyeaua *et al*., 2010). In general, since significant differences were found in men but not in women between Parkinson's and control subgroups, medication and disease development seem to have a greater "target" effect on men; however, female subgroups made more errors in the absolute fine motor performance, especially in the P test condition (see table 5), although the differences were not significant (table 4). In order to assess the absolute mean errors of all subgroups, the prevalence rates were calculated as the ratios corresponding to different test conditions and movement type categories (table 5):

a) $R_{F/M}$ = Nº(F>M)/T as a ratio of number (Nº) of movement types in which women (F) exceeded men (M) divided by the total number of movement types (T).

b) $R_{PD/C}$ = Nº(PD>C)/T as a ratio of number (Nº) of movement types in which Parkinson's patients (PD) exceeded the controls (C) divided by the total number of movement types (T).

TABLE 5. PREVALENCE RATIOS FOR THE FINE MOTOR PERFORMANCES OF TESTED SUBGROUPS PARKINSON'S (PD) AND CONTROL (C) GROUPS OF BOTH GENDERS (F – FEMALE AND M – MALE) AND DIFFERENT MOVEMENT TYPES: SPATIAL (D/F – DIRECTIONAL/FORMAL) AND SIZE PERFORMANCE (LL).

Test condition	**F/M ratio**				**PD/C ratio**			
	PD		***C***		***F***		***M***	
	D/F dev	**LL**	**D/F dev**	**LL**	**D/F dev**	**LL**	**D/F dev**	**LL**
P-test	7/12 (58%)	4/6 (67%)	5/12 (42%)	1/6 (17%)	8/12 (67%)	6/6 (100%)	5/12 (42%)	1/6 (17%)
PV-test	6/12 (50%)	3/6 (50%)	3/12 (25%)	1/6 (17%)	8/12 (67%)	3/6 (50%)	5/12 (42%)	2/6 (17%)

The ratio results show the equal gender prevalence for Parkinson's group in the PV test condition and the poorer performance of women in the P-test condition, reaching 58% for the directional and formal deviation types, and 67% in LL size performance. As for the control group female/male ratios, the inverse results were observed, with men performing worse (table 5). As for the ratios of Parkinson's versus control group performance, the higher number of movement types with greater absolute errors were found in women in the Parkinson's group com-

pared to controls, especially in LL size performance in the P-test condition, which reached 100% (table 5). This could be suggested as one of possible "markers" or control variables for the development of the disease in women.

After analysing the results of this study together with updated data from recent investigations, we conclude that there appear to be gender-related differences in fine motor performance and that medication improves some states and worsens others. In order to compare a proprioceptive state without residual medication effects, pre-tests are required at the very beginning of the diagnosis. The first check should be made prior to the consumption of any medication in order to assess the changes that occur after the treatment has started.

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ANNEX

ABBREVIATION LIST

ΔLL – difference between maximum and minimum line length for the same subject and figure (from rigidity –low values– to variability –high values–)

LL – line length (irritability: From - inhibition to + excitation)

FDL – frontal directional deviation for the left hand (mood: From – pessimism to + optimism)

FDR – frontal directional deviation for the right hand (idem to anterior psychological interpretation)

FFL – frontal formal deviation for the left hand (related emotional state: From - no emotion to + high emotion)

FFR – frontal formal deviation for the right hand (idem to anterior)

FLLL and FLLR – length line drawn in frontal plane (L and R for left and right hands correspondingly)

TDL – transversal directional deviation for the left hand

TDR – transversal directional deviation for the right hand

TFL – transversal formal deviation for the left hand (related emotional state: From - no emotion to + high emotion)

TFR – transversal formal deviation for the right hand (idem to anterior)

TLLL and TLLR – length line drawn in transversal plane (L and R for left and right hands correspondingly)

SDL – sagittal directional deviation for the left hand (decision making: From – submission to + dominance)

SDR – sagittal directional deviation for the right hand (idem to anterior interpretation)

SFL – sagittal formal deviation for the left hand (related emotional state: From - no emotion to + high emotion)

SFR – sagittal formal deviation for the right hand (idem to anterior interpretation)

SLLL and SLLR – length line drawn in sagittal plane (L and R for left and right hands correspondingly)

Note: For all observable biases, abbreviations should be interpreted as: First letter stands for movement direction type (F – frontal, T – transversal and S – sagittal), the last letter for the hand (L – left and R – right), in the middle – error type: LL – line length difference, D – directional and F – formal biases.