J Neurol (2008) 255:1756–1761
DOI 10.1007/s00415-008-0024-6

ORIGINAL COMMUNICATION

The Frontal Assessment Battery (FAB) in Parkinson's disease and correlations with formal measures of executive functioning

César F. Lima
Laura P. Meireles
Rosália Fonseca
São Luís Castro
Carolina Garrett

Received: 19 February 2008
Received in revised form: 30 May 2008
Accepted: 5 June 2008
Published online: 25 September 2008

C. F. Lima, MSc (✉) · L. P. Meireles, BSc · S. L. Castro, PhD
Faculty of Psychology and Education
University of Porto
Rua do Dr. Manuel Pereira da Silva
4200-392 Porto, Portugal
Tel.: +351-220/400-610
Fax: +351-226/079-725
E-Mail: cflima@fpce.up.pt

R. Fonseca, MSc · C. Garrett, MD, PhD
Dept. of Neurology
Hospital de S. João
Faculty of Medicine
University of Porto
Al. Prof. Hernâni Monteiro
4200-319 Porto, Portugal
Tel.: +351-225/513-600
Fax: +351-225/513-601
E-Mail: cgarrett@med.up.pt

Abstract *Background* The Frontal Assessment Battery (FAB) is a short tool for the assessment of executive functions consisting of six subtests that explore different abilities related to the frontal lobes. Several studies have indicated that executive dysfunction is the main neuropsychological feature in Parkinson's disease (PD). *Goals* To evaluate the clinical usefulness of the FAB in identifying executive dysfunction in PD; to determine if FAB scores in PD are correlated with formal measures of executive functions; and to provide normative data for the Portuguese version of the FAB. *Methods* The study involved 122 healthy participants and 50 idiopathic PD patients. We compared FAB scores in normal controls and in PD patients matched for age, education and Mini-Mental State Examination (MMSE) score. In PD patients, FAB results were compared to the performance on tests of executive functioning. *Results* In the healthy subjects, FAB scores varied as a function of age, education and MMSE. In PD, FAB scores were significantly decreased compared to normal controls, and correlated with measures of executive functions such as phonemic and semantic verbal fluency tests, Wisconsin Card Sorting Test and Trail Making Test Part A and Part B. *Conclusion* The FAB is a useful tool for the screening of executive dysfunction in PD, showing good discriminant and concurrent validities. Normative data provided for the Portuguese version of this test improve the accuracy and confidence in the clinical use of the FAB.

Key words executive functions · Frontal Assessment Battery (FAB) · Parkinson's disease · Portuguese norms

Introduction

Executive functions (EFs) encompass higher order neurocognitive processes such as planning, inhibition of responses and actions, strategy development and goal definition, flexible performance of goal-directed actions, resistance to interference, abstract thinking, problem solving, self-monitoring and self-regulation [3, 5, 16, 17, 26]. These processes are mainly dependent on the frontal lobes [24] and structures connected to them such as the thalamus and the basal ganglia [9, 16]. A great deal of attention has been given to the assessment of EFs. The identification of executive dysfunction is useful for the analysis of the severity of brain injuries and for the diagnosis and prognosis of brain diseases like frontotemporal dementias (although in specific subtypes of frontotemporal dementias executive dysfunction may not be the main deficit). It is also useful to identify vascular dementias and parkinsonian disorders, to discriminate between degenerative disorders and to evaluate the progression of these disorders over time [7].

In Parkinson's disease (PD), the assessment of EFs is particularly relevant. PD is primarily characterized by

JON 3024

resting tremor, bradykinesia, rigidity and postural instability [21], but these motor signs coexist with cognitive deficits ranging from minor disturbances to dementia [6]. The main feature of neuropsychological profiles in PD is an impairment of EFs [6, 18]; deficits in memory, visuospatial reasoning and complex attention are often also present [13], and these may result from impaired executive functioning. Given that the comprehensive examination of this impairment is time consuming and may be distressing for some patients, brief screening tools are very useful.

Dubois, Slachevsky, Litvan and Pillon [7] recently presented a short standardized neuropsychological test for the bedside assessment of EFs, the Frontal Assessment Battery (FAB). The FAB takes about 10 minutes to be administered and can be applied by any practitioner. It consists of six subtests that explore neurocognitive processes related to the frontal lobes: conceptualization (Similarities task), mental flexibility (Phonological Lexical Fluency task), motor programming (Luria's motor series), sensitivity to interference (Conflicting Instructions task), inhibitory control (Go-No-Go task) and environmental autonomy (evaluation of Prehension Behavior). Each subtest is scored between 0 and 3; a composite score ranging between 0 and 18 indicates whether or not executive dysfunction is present and, if yes, its severity.

In the original study [7], the FAB presented good psychometric properties. It was able to discriminate between normal controls and patients with different neurodegenerative diseases (discriminant validity), and it showed good internal consistency, inter-rater reliability and concurrent validity (FAB correlated with the Mattis Dementia Rating Scale and with Wisconsin Card Sorting Test, WCST). Since then, the FAB has been tested in several clinical conditions [15, 19, 20, 22]. Oguro and colleagues [19], for example, have demonstrated that the FAB successfully discriminates normal controls from patients with Alzheimer's disease and vascular dementia and, more importantly, it is sensitive to differences in the executive dysfunction profiles of Alzheimer's and vascular dementia patients (patients with vascular dementia had the worst performance). Normative data have also been provided for healthy population samples. Two studies with the Italian version of the FAB [1, 15] showed that the scores of healthy participants were influenced by age and education (they were lower as age increased and education decreased). A study with an elderly healthy sample (ages 60 to 91 years) indicated a positive effect of education on FAB scores but a null effect of age [4].

One important application of the FAB is screening for executive dysfunction in PD. Because executive dysfunction is a major neuropsychological characteristic of PD [6], a reduced FAB score is predicted. Although some studies have attempted to test the ability of the FAB to identify executive dysfunction in PD with small groups of patients [7, 20], conclusive results are lacking. Such data are of interest because before FAB can be used with confidence with PD patients it should be demonstrated that it is sensitive to executive dysfunction in this disease. Moreover, there is no evidence about how, in PD, FAB results are related with measures of executive functioning such as the WCST, the Trail Making Test (TMT) and verbal fluency tests. Correlations with these measures, if observed, would further establish the concurrent validity of FAB. The goals of the present paper are to establish the usefulness of the FAB for screening executive dysfunction in idiopathic PD (discriminant validity), to determine the correlations between FAB scores and formal measures of executive functioning (concurrent validity), and to establish normative data derived from a healthy sample of the Portuguese population.

Methods

Participants

The normative study involved 122 subjects (68 women and 54 men) who varied widely in age and education (Table 1). They were from various regions of Portugal, mainly northern, from rural and suburban areas as well as cities. Mean age for the whole sample was 57.2 years (SD = 15.8 years; range = 20–81) and mean educational level in years was 8.7 (SD = 5.2; range = 2–22). None of the participants had current or past history of alcohol or drug abuse, current depression or psychiatric diseases, history of traumatic brain injury, neurological illness or other reported conditions that could affect mental state, as assessed by an individual clinical interview. Participants were excluded if they performed lower than the conventional cut-off of 24 in

Table 1 Demographic distribution of the healthy sample

Education (years)	Age (years)				
	20–39	40–59	60–79	> 80	Total
1–3	–	1 (F1)	6 (M1/F5)	–	7 (M1/F6)
4–6	1 (F1)	19 (M4/F15)	30 (M21/F9)	1 (F1)	51 (M25/F26)
7–12	5 (M2/F3)	9 (M4/F5)	18 (M10/F8)	1 (F1)	33 (M16/F17)
> 12	15 (M6/F9)	10 (M3/F7)	6 (M3/F3)	–	31 (M12/F19)
Total	21 (M8/F13)	39 (M11/F28)	60 (35M/25F)	2 (2F)	122 (54M/68F)

M male; *F* female

the MMSE [16]; they scored on average 28.9 (SD = 1.3; range = 24–30).

The clinical group consisted of 50 patients (31 men) with idiopathic PD diagnosed by a senior neurologist, who were on stage 3 or 4 of the Hoehn and Yahr Disease Severity Scale [14]. PD patients were potential candidates for surgical intervention of deep brain stimulation and underwent neuropsychological assessment as part of their pre-surgical evaluation. Mean age for this group was 59.9 years (SD = 6.0; range = 43–70) and mean duration of education was 5.5 years (SD = 3.7; range = 3–23). All PD patients were taking dopaminergic medication at the time of testing; they had no history of neurological illnesses other than PD and were not demented (mean MMSE = 28; SD = 1.3; range = 25–30). Depression was assessed with the Beck Depression Inventory [25]; 26 patients were not depressed, 18 were mild to moderately or moderately to severely depressed, and 6 were severely depressed.

Materials and procedures

The healthy participants were tested individually by a neurologist or a psychologist. Information was provided about the purpose of the research and participants gave their informed consent. After a brief clinical interview, they completed the MMSE [8, 11 for the Portuguese version] and the FAB. The FAB was adapted from the original English version [7] into Portuguese. The battery was first translated independently by two fluent bilinguals; these translations were then compared, minor inconsistencies solved, and a preliminary version was produced. A cultural/linguistic adaptation was made in one of the subtests: the letter used in the original Lexical Fluency subtest, "S", was replaced by "P", which is as frequent in Portuguese as "S" is in English. This is because in Portuguese the letters S and C may correspond to the same sound (e.g., in the beginning of words as in "cego", *blind*), and this might be confusing especially for people with lower levels of education. After reaching consistency for all verbal instructions and performing some pilot administrations, the final version of the Portuguese FAB was produced.[1]

For PD patients, the data were collected by a psychologist in a comprehensive neuropsychological assessment. Patients were tested in the "on" state, when the medication minimizes or eliminates motor symptoms. As for the healthy participants, the MMSE and the Portuguese FAB were administered. In addition, the patients also performed the following tests of executive functioning: phonemic and semantic verbal fluency tests [16], TMT Part A and Part B [2] and the WCST [10]. The Raven's Colored Progressive Matrices [23] (a measure of visuospatial reasoning), the Digit Span Test [25] (a measure of verbal short-term memory), and the Beck Depression Inventory [25] were also administered.

Results

Normative data for the healthy Portuguese sample

Table 2 presents means and standard deviations of the total FAB scores stratified by age and education, for the healthy participants. The mean total FAB score was 15.14 (SD = 2.43). A multiple regression analysis was performed in order to check the influence of demographic variables and MMSE scores. Total FAB scores were taken as the dependent variable, and age, gender, education and MMSE total score as independent variables. The resulting regression model excluded gender; age, education and MMSE were able to explain 45.3 % of the total variance of the FAB [$R^2 = 0.453$; $F(4,117) = 32.59$, $p < 0.00001$]. There was a strong positive effect of education [coefficient = 0.412, $t(117) = 4.77$, $p < 0.00001$], a negative effect of age [coefficient = –0.231, $t(117) = -2.851$, $p < 0.01$] and a positive effect of the MMSE score [coefficient = 0.2, $t(117) = 2.68$, $p < 0.01$]; thus, FAB results are lower in older and less educated subjects with lower MMSE scores.

Table 2 Mean total FAB scores by age and education for the healthy sample (standard deviations are given in parenthesis)

Education (years)	Age (years)				
	20–39	40–59	60–79	> 80	Total
1–3	–	15 (0)	12.2 (2.6)	–	12.6 (2.6)
4–6	16 (0)	14.2 (1.9)	13.6 (2.6)	15 (0)	13.9 (2.3)
7–12	16.2 (0.8)	16.4 (1.6)	15.3 (1.7)	12 (0)	15.6 (1.7)
> 12	17.8 (0.4)	16.8 (0.9)	16.7 (1)	–	17.3 (0.9)
Total	17.3 (0.9)	15.4 (2)	14.3 (2.6)	13.5 (1.5)	15.14 (2.43)

Table 3 reports the frequency distribution of the scores in each FAB subtest. Three of them, Similarities, Fluency and Go-No-Go, were the most discriminative. By contrast, all subjects had the maximum possible on Prehension Behavior. The distribution of the subscores as well as of the total score is skewed towards higher values. Cronbach's alpha coefficient between FAB subscores (Prehension Behavior was not included because it had zero variance) was 0.69, suggesting good internal consistency.

The FAB and the assessment of executive functions in Parkinson's disease

The performance of PD patients on the FAB and the other tests is shown in Table 4. As for normal controls, a multiple regression analysis was calculated in order to check the influence of age, sex, education and MMSE on the total FAB scores; depression scores (Beck Depression Inventory) were also entered as an independent variable. The regression model excluded gender, education and depression, but it included age and MMSE. It was able to explain 39.5 % of the total variance [$R^2 = 0.395$; $F(4,44) = 5.44$, $p < 0.0002$]. There was a negative effect of age [coefficient = –0.275, $t(44) = -2.19$, $p < 0.03$] and a positive effect of the MMSE score [coefficient = 0.48, $t(44) = 3.93$, $p < 0.0004$]. As with normal controls, mean FAB scores were lower as age increased and MMSE decreased. Education and depression levels did not impact on FAB performance ($p > 0.05$).

Even after adjusting for age, education and MMSE,

[1] A copy of the Portuguese version of the FAB may be requested to the corresponding author by e-mail.

Table 3 Frequency distributions of the scores in the single subtests of the FAB for the healthy sample (N = 122; numbers in brackets represent percentages)

Score	Subtest					
	Similarities	Fluency	Luria´s Motor Series	Conflictual Instructions	Go-No-Go Task	Prehension Behavior
0	3 (2.5)	3 (2.5)	0 (0)	0 (0)	2 (1.6)	0 (0)
1	39 (32)	17 (13.9)	4 (3.3)	4 (3.3)	27 (22.1)	0 (0)
2	48 (39.3)	31 (25.4)	21 (17.2)	16 (13.1)	25 (20.5)	0 (0)
3	32 (26.2)	71 (58.2)	97 (79.5)	102 (83.6)	68 (55.7)	122 (100)

Table 4 Mean scores on the neuropsychological tests for patients with Parkinson's disease and correlations with total FAB scores

Tests of general cognitive function, visuospatial reasoning and verbal short-term memory					
	n	mean	s.d.	Correlation with FAB total score (r)	P value
MMSE	50	28.04	1.28	0.50	< 0.01
Raven's Colored Progressive Matrices	47	22.83	4.31	0.43	< 0.01
Digit Span – Digits Forward	49	5.04	1.02	0.19	ns (0.19)
Digit Span – Digits Backward	49	3.31	1.07	0.09	ns (0.55)
Tests of frontal executive function					
Verbal fluency – phonemic (total F-A-S[a])	49	18.69	8.7	0.41	< 0.01
Verbal fluency – semantic (animals)	50	13.42	3.75	0.28	0.05
Wisconsin CST – number of categories	45	2	1.69	0.19	ns (0.21)
Wisconsin CST – perseverative errors	45	40.82	21.48	–0.43	< 0.01
Trail Making Test A (sec to complete)	49	92.14	45.05	–0.41	< 0.01
Trail Making Test B (sec to complete)	47	376.96	208.98	–0.41	< 0.01
FAB (total score)	50	13.04	1.81	1	< 0.01
FAB – similarities	50	1.26	0.75	0.56	< 0.01
FAB – lexical fluency	50	1.92	0.83	0.49	< 0.01
FAB – motor series	50	2.72	0.57	0.35	< 0.05
FAB – conflicting instructions	50	2.58	0.76	0.49	< 0.01
FAB – Go-No-Go	50	1.56	0.84	0.48	< 0.01
FAB – prehension behavior	50	3	0	[b]	[b]

[a] Letters used in the phonemic verbal fluency test; [b] Not computed because the variable Prehension Behavior is constant (all subjects 100% correct)

which were entered as covariates in an ANCOVA, PD patients obtained lower total FAB scores than normal controls [PD = 13.7 vs. normal controls = 14.9; ANCOVA, $F(1,166) = 15.6$, $p < 0.0001$]. This result indicates good discriminant validity of the FAB. The total FAB score was also applied to a discriminant analysis between normal controls and PD patients; it proved able to correctly classify 70.3 % of the cases ($F = 30.45$; Wilke's lambda = 0.848, $p < 0.00001$). ANCOVAS on the FAB subscores were carried out to determine which subtests discriminate better PD patients from normal controls. PD patients performed significantly worse in Similarities [PD = 1.5; normal controls = 1.8; ANCOVA, $F(1,166) = 15.6$, $p < 0.02$] and Go-No-Go subtests [PD = 1.6; normal controls = 2.3; ANCOVA, $F(1,166) = 20.51$, $p < 0.0001$]. In the remaining FAB subtests, PD patients and normal controls did not differ significantly ($Fs < 1$).

Concurrent validity was analyzed by calculating partial correlations between scores on the FAB and the other measures of EFs. Significant correlations were found for almost all measures (Table 4). Patients with higher scores on the FAB produced more words on the phonemic ($r = 0.41$, $p < 0.01$) and semantic lexical fluency tests ($r = 0.28$, $p = 0.05$); they made fewer perseverative errors on the WCST ($r = –0.43$, $p < 0.01$) and were faster on TMT Parts A ($r = –0.41$, $p < 0.01$) and B ($r = –0.41$, $p < 0.01$). As for normal controls, a positive correlation between FAB and MMSE scores was observed ($r = 0.5$, $p < 0.01$). A positive correlation with Raven's Colored Matrices was also obtained ($r = 0.43$, $p < 0.01$). Results on the short-term memory measure were not correlated with the FAB ($p > 0.05$ for both forward and backward digit span). Finally, with the exception of Prehension Behavior, all of the FAB subscores were significantly correlated with the

total score. So, five out of six subtests contribute to the total FAB score.

Discussion

The usefulness of the FAB for the assessment of executive dysfunction in PD was put under scrutiny. Our main findings can be summarized as follows. There was a reduction in the total FAB scores in PD patients as compared to healthy participants, indicating that this battery has good discriminant validity. Significant correlations were obtained between results on the FAB and on the other measures of EFs, which indicate that the FAB also has good concurrent validity. Good internal consistency, measured by Cronbach's alpha in healthy participants, was also observed. Overall, these results confirm the good psychometric properties of the FAB initially established by Dubois et al. [7] and further extend it to PD.

In healthy participants, FAB scores were positively influenced by education and negatively influenced by age. The influence of age was also manifest in PD patients. These results are consistent with previous ones from Italian samples [1, 15] and highlight that it is important to consider these two factors in neurocognitive assessment. We also obtained a positive correlation between FAB and MMSE scores in healthy and PD participants. Although such a correlation was not observed by Dubois et al. [7] nor by Appollonio et al. [1], it was also reported in Beato et al.'s study with the elderly healthy subjects [4]. This correlation could be interpreted as a weakness in the discriminant validity of the FAB; however, the MMSE also examines some frontal/executive processes (e.g., attention and calculation; subtest Language, 3-stage command) and this overlap could explain the correlation. Nevertheless, more data are needed to clarify the relation between the FAB and the MMSE, as well as the general question of how the FAB relates to more general measures of cognitive functions. Paviour and colleagues [20], for example, have documented correlations of FAB scores with verbal IQ (WAIS-R), and with the general index of cognitive level measured by the Nelson Adult Reading Test, NART.

It was also observed that the FAB subtests are not equally discriminative, the finer ones being Similarities, Fluency and Go-No-Go. Similarities and Fluency were also found to be the most discriminative by Appollonio et al. [1]. The least discriminative was Prehension Behavior, a subtest that aims to evaluate environmental autonomy (after asking the patient to put his/her hands palms up on his/her own knees, the examiner brings his/her hands close to the patient's left and right hand-palms and touches them without saying anything; the patient is given the maximum score if he/she does not spontaneously grasp the examiner's hands). This subtest has rarely elicited a score lower than 3 in healthy participants [1, 15], and in clinical groups such as Alzheimer disease [19]. In our study, all participants, healthy and PD, had the maximum score.

In PD patients, the prediction that the FAB scores would be reduced, reflecting the executive dysfunction that characterizes this disease [6], was confirmed. They scored lower than normal controls, even after correcting for significantly related covariates such as age, education and MMSE scores. It is noteworthy that this result cannot be explained by the patients' levels of depression, since this variable did not impact the performance on FAB in the regression analysis. Because the relatively low mean age of our sample (59.9 yrs; in community based studies: 65.4 yrs in [20]; 70.5 yrs in [21]) might limit the generalizability of this result, we calculated a separate ANCOVA for a subgroup of older patients ($n = 12$, aged 65 to 70 years). The difference between controls and patients was again obtained ($p < 0.03$), thus confirming that the decrement in FAB scores brought about by PD occurs for older patients as well as for younger ones. Regarding FAB subscores, differences between controls and patients were significant only in the Similarities and Go-No-Go subtests. In Prehension Behavior, as indicated above, all the patients had the maximum score. These results, together with those from healthy participants in ours and other's studies [1, 15], lead us to suggest that the discriminative power of FAB might increase if the scores of the different subtests were differently weighted. Because Similarities, Fluency and Go-No-Go are more discriminative, these subtests should have a stronger contribution to the total score; on the other hand, given that Prehension Behavior reaches almost always the maximum score, it could be given less weight.

Another goal of this study was to establish the concurrent validity of the FAB for use with PD patients. FAB scores were significantly correlated with verbal fluency tests, with perseverative errors in the WCST, and with TMT. These correlations strongly indicate that the FAB does measure executive functioning (it has good concurrent validity). A correlation with the Raven's Colored Progressive Matrices (that tests visuospatial reasoning) was also observed. This may be due to the fact that visuospatial deficits tend to coexist with frontal deficits in PD [5, 6]. By contrast, and indicating a good discriminant validity, the performance on the FAB was not correlated with short-term memory as measured by the Digit Span Test. Regarding diagnostic issues, a limitation of the present study is the absence of a direct comparison between clinical groups; in further studies, the inclusion of patient control groups with other akinetic-rigid syndromes should be considered since the differential diagnosis between these syndromes and PD is of clinical relevance [20].

In sum, our results show that the FAB is a useful tool to identify executive dysfunction in PD, giving helpful

information for the diagnosis of this disease and for the evaluation of cognitive decline. The finding that FAB scores correlate with well established measures of frontal lobe function is important for clinical purposes because it indicates that a valid and objective measure of the EFs can be obtained with a test requiring minor training and only about 10 minutes to be administered. Furthermore, normative data for a Portuguese healthy sample are useful to improve the confidence and accuracy in the application of the FAB to Portuguese-speaking patients.

Conflict of interest The authors declare no conflict of interest.

Acknowledgements The authors would like to thank Joana Guimarães, MD, Miguel Gago, MD and Maria José Rosas, MD, for their help in the assessment of healthy participants, and two anonymous reviewers for their comments on an earlier version of the manuscript. This study was supported by the Portuguese Foundation for Science and Technology through a grant to the Language Group (SL Castro) of the Center for Psychology at the University of Porto.

References

1. Appollonio I, Leone M, Isella V, Piamarta F, Consoli T, Villa M, Forapani E, Russo A, Nichelli P (2005) The Frontal Assessment Battery (FAB): Normative values in an Italian population sample. Neurol Sci 26:108–116
2. Baeta E (2002) Bateria para avaliação neuropsicológica de adultos com epilepsia (Battery for neuropsychological assessment of adults with epilepsy). Psicologia 16:79–96
3. Barkley RA (2001) The executive functions and self-regulation: An evolutionary neuropsychological perspective. Neuropsych Rev 11(1):1–29
4. Beato R, Nitrini R, Formigoni A, Caramelli P (2007) Brazilian version of the Frontal Assessment Battery (FAB): Preliminary data on administration to healthy elderly. Dement Neuropsychol 1:59–65
5. Burgess P (2003) Assessment of executive function. In: Halligan P, Kischka U, Marshall J (eds) Handbook of Clinical Neuropsychology. Oxford University Press, Oxford, pp 302–321
6. Calabresi P, Picconi B, Parnetti L, Di Filippo M (2006) A convergent model for cognitive dysfunctions in Parkinson's disease: the critical dopamine-acetylcholine synaptic balance. Lancet Neur 5:974–983
7. Dubois R, Slachevsky A, Litvan I, Pillon B (2000) The FAB: A frontal assessment battery at bedside. Neurology 55:1621–1628
8. Folstein M, Folstein S, McHugh P (1975) Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. J Psych Res 12:189–198
9. Funahashi S (2000) Neuronal mechanisms of executive control by the prefrontal cortex. Neurosci Res 39: 147–165
10. Grant D, Berg A (1993) Wisconsin Card Sorting Test. USA: Psychological Assessment Resources, Inc
11. Guerreiro M, Silva AP, Botelho MA, Castro-Caldas A, Garcia C (2003) Avaliação Breve do Estado Mental (Brief assessment of mental state). In: Mendonça A, Garcia C, Guerreiro M (eds) Grupo de Estudos de Envelhecimento Cerebral e Demência: Escalas e Testes na Demência, pp 27–32
12. Heyder K, Suchan B, Daum I (2004) Cortico-subcortical contributions to executive control. Acta Psychologica 115:271–289
13. Higginson C, King D, Levine D, Wheelock V, Khamphay N, Sigvardt K (2003) The relationship between executive function and verbal memory in Parkinson's disease. Brain and Cognition 52:343–352
14. Hoehn MM, Yahr MD (1967) Parkinsonism: Onset, progression and mortality. Neurology 17(5):427–442
15. Lavarone A, Ronga B, Pellegrino L, Loré E, Vitaliano S, Galeone F, Carlomagno S (2004) The Frontal Assessment Battery (FAB): Normative data from an Italian sample and performance of patients with Alzheimer's disease and frontotemporal dementia. Func Neurol 19(3):191–195
16. Lezak M, Howieson D, Loring D (2004) Neuropsychological assessment (4th Edition). Oxford University Press, New York
17. Manchester D, Priestley N, Jackson H (2004) The assessment of executive functions: coming out of the office. Brain Injury 18(11):1067–1081
18. Morris R, Worsley C (2003) Neuropsychological presentation of Alzheimer's disease and other neurodegenerative disorders. In: Halligan P, Kischka U, Marshall J (eds) Handbook of Clinical Neuropsychology. Oxford University Press, Oxford, pp 506–527
19. Oguro H, Yamaguchi S, Abe S, Ishida Y, Bokura H, Kobayashi S (2006) Differentiating Alzheimer's disease from subcortical vascular dementia with the FAB test. J Neurol 253:1490–1494
20. Paviour D, Winterburn D, Simmonds S, Burgess G, Wilkinson L, Fox N, Lees A, Jahanshahi M (2005) Can the frontal assessment battery (FAB) differentiate bradykinetic rigid syndromes? Relation of the FAB to formal neuropsychological testing. Neurocase 11: 274–282
21. Riedel O, Klotsche J, Spottke A, Deuschl G, Forstl H, Henn F, Heuser I, Oertel W, Reichmann H, Riederer P, Trenkwalder C, Dodel R, Wittchen H (2008) Cognitive impairment in 873 patients with idiopathic Parkinson's disease: Results from the German Study on Epidemiology of Parkinson's Disease with Dementia (GEPAD). J Neurol 255(2):255–264
22. Rodriguez del Alamo A, Catalán Alonso MJ, Carrasco Marín L (2003) FAB: A preliminar Spanish application of the frontal assessment battery to 11 groups of patients. Rev Neurol 36(7): 605–608
23. Simões MR (2004) Matrizes Progressivas Coloridas de Raven. In: Almeida L, Simões MR, Machado C, Gonçalves M (eds) Instrumentos de avaliação psicológica validados para a população portuguesa (Psychological assessment tools validated for the Portuguese population). Editora Quarteto: Coimbra, pp 141–171 (Vol II)
24. Stuss D, Alexander M (2000) Executive functions and the frontal lobes: A conceptual view. Psychol Res 63:289–298
25. Wechsler D (in press). Wechsler Memory Scale – Third Edition (WMS-III). Lisboa: Cegoc-Tea
26. Worthington AD (2003) The natural recovery and treatment of executive disorders. In: Halligan P, Kischka U, Marshall J (eds) Handbook of Clinical Neuropsychology. Oxford University Press, Oxford, pp 322–339