Distraction as a Key Determinant of Impaired Memory in Patients with Fibromyalgia

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ABSTRACT. ***Objective.*** Patients with fibromyalgia (FM) frequently complain of poor memory, severe enough to affect job performance and to lead to disability. Yet common practices in neurocognitive examinations often fail to document cognitive abnormalities that match the severity of their memory complaints. Often, neuropsychologists gauge memory competence with measures free of distraction and produce high rates of normality on neurocognitive examination. We hypothesized that neurocognitive tests encoded with a source of stimulus competition that interferes with the processing and/or absorption of information would be better than others in gauging FM memory competence.

Methods. Thirty-five patients with FM and 35 controls, matched for age and sex, and presenting with complaints of memory loss, completed cognitive measures with and without stimulus competition.

Results. Eleven (31.4%) patients with FM showed impairment on at least one measure of memory encoded free of stimulus competition. By comparison, 30 (85.7%) showed impairment on at least one measure encoded with a source of stimulus competition. The Auditory Consonant Trigram detected impairment in 29 (82.6%) cases, and was by far the most sensitive measure. FM patients lost information at a 58% rate following a 9 second distraction. This loss was disproportionate to the loss shown by both age matched controls with memory problems (40%) and to normative values (20%) based on individuals free of memory problems.

Conclusion. The findings validate the perception of failing memory in patients with FM and are the first psychometric based evidence to our knowledge of short-term memory problems in FM linked to interference from a source of distraction. Adding a source of distraction caused the majority of FM patients to retain new information poorly, and may be integral to an understanding of FM memory problems. Much needs to be learned about why new information is disproportionately lost by FM populations when a source of distraction enters the experiential field. (J Rheumatol 2006;33:127–32)

Key Indexing Terms:
FIBROMYALGIA COGNITIVE IMPAIRMENT MEMORY COMPLAINT
DISTRACTION STIMULUS COMPETITION AUDITORY CONSONANT TRIGRAM

Memory loss is well known to many with fibromyalgia (FM)[1-3], with a prevalence about 2.5-fold greater than in patients with other rheumatic disease disorders[4]. Alterations in memory competence are poorly understood and in many cases fail to register on cognitive measures of memory functioning[2,5]. Grace, *et al* confirmed claims of FM patients, with abnormal neurocognitive (NC) testing in only 22.7% of cases[2], using normative values as the standard against which to judge neurocognitive status[6]. Testing at normative values marginalizes memory claims and reinforces negative stereotypes of FM to the detriment of patients[7]. Yet the same evidence is also subject to other explanations. The alleged normality on examination may be an artifact of neglected coverage of important areas of deficit[6].

NC testing is frequently ordered by clinicians to assess FM patients who complain of cognitive dysfunction. However, NC testing using present techniques is often not helpful because of its insensitivity to skills that individuals may use in encoding new information. Most tests at the disposal of neuropsychologists operate as attention-directed tasks free of distraction[8]. They artificially constrain attending to a single channel of information, thereby eliminating the operation of concurrent cognitive processes that compete for finite amounts of attentional resources[9], a condition we label stimulus competition. The use of non-taxing tests diminishes the likelihood of detecting memory deficiencies rooted in the stimulus competition of daily living, wherein dynamic changes in the environment bring more complex attending and filtering skills into play.

Four premises guided the study: (1) keeping information in mind from a primary task when distracted by secondary tasks is routine in daily living and critical to working memory; (2) patients with FM are less able to minimize the con-

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sequences of distraction from stimulus competition; (3) information recall in a large majority of patients with FM will be sharply diminished by a source of stimulus competition; and (4) the large majority of patients with FM have no difficulty in forming or maintaining memory representations in test conditions free of stimulus competition. The position taken is that putative normal memory in FM is an artifact of NC measures; appropriate NC measures will provide as much psychometric-based evidence of impairment in patients with FM as in comparative groups with memory problems.

MATERIALS AND METHODS

Patients. The participant pool was drawn from a clinical data repository whose core consists of 15 years of patient data. Formation of the data repository has been reviewed and approved by the institutional review board. Inclusion criteria for all participants were age 18 to 65 years, English speaking, and with persistent memory loss of at least 6 months' duration. Exclusion criteria were a history of drug or alcohol abuse, psychiatric treatment in the past 5 years, auditory impairment that might interfere with cognitive testing, or a lack of English fluency.

A consecutive series of 35 patients with a diagnosis of FM were drawn from cases entered into the data repository in the past 3 years and served as the study pool. The diagnosis of FM was based on widespread pain in combination with tenderness of ≥ 11 of 18 specific tender point sites[10]. Thirty-five non-FM patients matched for age (± 3 yrs) and sex, and presenting with a memory complaint, served as the control sample. Common features of their memory complaints were forgetting names, appointments, conversations, directions, schedule of daily activity, intended actions, materials read, difficulty with planning and thinking, misplacing personal items, leaving tasks in state of semicompletion, and word-finding difficulty. A computed tomography (CT) scan or magnetic resonance imaging (MRI) confirmed evidence of central nervous system abnormalities in 10 cases in the control sample; in another 7 cases, findings of uncertain significance were reported. In 8 cases, CT or MRI scans of the head were normal. In 10 cases, neuroimaging data were not available.

Patients with FM and controls were predominantly Caucasian (85.7% vs 79%, respectively), with a median duration of memory problems of about 2 years (1.9 vs 2.3 yrs, respectively). In almost 100% of both groups, memory problems interfered with daily activities associated with employment tasks, social interactions, and family chores. Patients with FM were less likely to be employed (45.8% vs 60.0%), more likely to rely heavily on mnemonic devices to remember (60.0% vs 48.6%), and about equally likely (14.3% vs 17.1%) to have stopped working because of memory problems.

Measurement instruments. The Logical Memory (LM) and Paired Associates (PA) subtests of the Wechsler Memory Scale III (WMS-III) assess memory performance free of stimulus competition at encoding[11]. The LM subtest entails remembering 2 story paragraphs, with recall tested immediately and after a 30 minute delay. Each paragraph contains 25 segments; the score is the number of segments recalled.

The PA subtest assesses formation of associations between 8 word pairs, some unrelated (truck/arrow), over 4 learning trials with cued recall tested after each trial[11]. The scores are the sum of words recalled over 4 trials and a 30 minute delayed cued recall trial.

The Letter-Number-Sequencing [LNS; Wechsler Adult Intelligence Scale III (WAIS-III) subtest][12] and the Auditory Consonant Trigram (ACT)[13] measure working memory encoded under conditions of stimulus competition. The LNS task entails holding an intermixed set of letters and numbers in memory, separating the numbers from the letters, and then processing the numbers first and then the letters in their ascending sequential order, creating competition between different mental activities[12].

The ACT entails remembering 3-item lists (trigram) of consonant letters[13] after performing a distracting task that interferes with the input and encoding of new information (trigram). Immediately after hearing the trigram, subjects count backwards by 3's (distracter task) from a number for intervals of 9, 18, or 36 seconds, followed by free recall of the trigram. Five trials at each distracter interval are administered along with a no-distraction condition (0 s). Maximum score for each interval is 15.

The WAIS-III-R Vocabulary subtest served as an estimate of general intelligence[12]. Participants provided definitions of words presented in the order of increasing difficulty.

Digit span assesses full attention and concentration[12]. Subjects are presented increasingly longer strings of single digit numbers at a rate of one digit per second and asked to repeat them immediately following presentation either in forward (forward digit span – Trial 1) or in reverse order (backward digits span – Trial 2). The score is the number of correct digit from both trials.

The Paced Auditory Serial Addition Task (PASAT) measures sustained and divided attention, auditory information processing speed, and stimulus competition filtering skill[14]. Subjects add consecutive numbers (1 to 9) presented by auditory tape and respond orally with a sum. As each digit is presented, patients sum that number with the digit that was presented prior to it (i.e., the second is added to the first, the third to the second, and so forth). Digits are presented at a rate of 3.0 seconds in trial 1 and 2.0 seconds in trial 2. The score for each rate is the number of correct responses over 60 trials[15].

On the PASAT, task demands change rapidly, creating competition between different mental activities. Once a response has been given, the individual must suppress the answer in order to monitor the appropriate digits and generate the next answer (which is to add the new number to the previous number presented). If the subject's answer carries over to the next trial, it distracts from adding the next appropriate set of digits.

Beck Depression Inventory II is a 21-item, 4-point self-report scale for measuring the severity of depression[16].

Statistical analysis. Means (± standard deviation) were used to define the demographic and clinical features of patients studied. Differences between grouped data were compared by Student's t test for continuous variables. Categorical variables were compared by Pearson chi-square. A 2-tailed p value < 0.05 was regarded as statistically significant.

For data with different metrics to be meaningfully compared across NC tests, all raw scores were transformed to age-related z scores using appropriate norms and then calibrated on the same metric with a mean of 10 and a standard deviation of 3. Impairment was defined as a test score below the 5th percentile of the normative mean (< 1.67 SD) following criteria of Vercoulen, *et al*[17]. Participants were categorized as normal or impaired according to performance on each cognitive test.

To assess group differences on the NC measures, we used multivariate analysis of covariance (MANCOVA), with the 8 NC measures as the dependent variables, clinical groups as the between-subjects variable, and age, education, vocabulary knowledge and depression as covariates. With a significant overall multivariate effect, univariate effects were examined to assess differences between groups on individual cognitive tests.

To examine the effects of distraction on retention, group differences were compared with a repeated measure analysis of covariance (ANCOVA) with 3 levels of distraction (9, 18, and 36 s) the within-subject variable, and age, education, vocabulary and depression the covariates.

RESULTS

Demographic, mood, and intellectual characteristics and clinical data of FM patients and control patients are given in Table 1. There were no significant differences for age, education, and depression. FM patients scored slightly higher ($p < 0.05$) in baseline performance on the intellectual measure.

Table 2 shows how well FM patients performed cognitively compared to age-appropriate norms and a matched

Table 1. Patient information.

	Patients with FM, n = 35	Controls, n = 35
Age, yrs	42.4 ± 10.1	41.6 ± 12.4
Education, yrs	14.0 ± 1.8	14.1 ± 2.3
Vocabulary	12.3 ± 2.4	11.0 ± 2.0*
Depression	17.8 ± 10.3	19.1 ± 10.9

* $p < 0.05$

control sample. Test scores are expressed in scale scores rather than raw scores to enable direct comparison across different tests. The standardized normative mean score for each test is 10 (SD 3). Individuals with scores near 10 generally have the skills necessary to function effectively. On cognitive measures free of stimulus competition, patients with FM performed < 0.5 of a standard deviation below the normative mean. By contrast, they achieved mean scores significantly below the established average value on 2 measures with a source of stimulus competition (PASAT 2-second: 1.6 SD below the normative mean; ACT: 2.5 SD below the normative mean).

Relative to the control sample on tasks free of stimulus competition, they recalled more information immediately after exposure on Paired Associates, as well as after a time delay on both Logical Memory and Paired Associates. By contrast, on tasks involving a source of stimulus competition, they processed information less effectively than controls on the PASAT, and recalled less information on Letter-Number-Sequencing and ACT.

The proportion of scores falling in the impaired range for each group on each NC test is shown in the right panel of Table 2. Impairment was defined as scores at least 1.67 standard deviations (< 5th percentile) below the age-appropriate normative mean. These data show that the cognitive performance of FM patients was disproportionately impaired by stimulus competition. Based on the criterion (< 5th percentile), a high proportion of FM patients obtained impaired scores on the ACT (82.6% impaired) and the PASAT 2-second rate (51.4% impaired). These proportions were significantly higher than results for the matched control sample. Patients with FM had a much lower percentage of impaired scores on cognitive measures free of stimulus competition, such as on Digit Span (0% impaired scores), Immediate and Delayed Recall Logical Memory (14.3% and 8.6%, respectively), and Immediate and Delayed Recall Paired Associates (11.4% and 8.6%, respectively).

Among FM patients, the number showing impairment (< 5th percentile) on at least one NC memory measure encoded under conditions of stimulus competition was more than 2.7 (30/11) times greater than the rate detected by memory measures of information encoded without stimulus competition. Relative to controls, impaired scores were detected in a larger percentage of FM patients ($p < 0.05$).

On the ACT, a forgetting rate for the 3 distracter intervals (9, 18, 36 s) was calculated for each group based on the following formula: number of letters forgotten/15. The performance of FM patients and controls at each distraction level is shown in Table 3. For purposes of comparison, the means, standard deviations, and percentages of consonants

Table 2. Mean summary data and percentage of impaired scores in patients with FM and age matched controls.

Test	Standardized Normative Mean	FM	Age Matched Controls	Impaired, % FM, n (%)	Impaired, % Control, n (%)
Full attention					
Digit Span	10.0 ± 3.0	10.2 ± 2.4[ab]	10.3 ± 2.8	0 (0.0)[c]	2 (4.0)
Attention with stimulus competition					
PASAT					
3 seconds	10.0 ± 3.0	7.2 ± 2.9*	8.3 ± 2.4*	10 (31.3)	4 (11.4)
2 seconds	10.0 ± 3.0	5.2 ± 2.5	7.1 ± 2.8**	18 (51.4)	7 (20.8)**
Memory: no stimulus competition					
Logical Memory	10.0 ± 3.0	8.6 ± 2.0	8.0 ± 2.3	5 (14.3)	9 (25.7)
Logical Memory – delayed	10.0 ± 3.0	8.7 ± 2.4	7.2 ± 2.7*	3 (8.6)	12 (34.2)**
Paired Associate	10.0 ± 3.0	9.8 ± 2.2	8.3 ± 2.2*	4 (11.4)	4 (11.4)
Paired Associate – delayed	10.0 ± 3.0	8.9 ± 2.7	7.4 ± 2.5*	3 (8.6)	11 (31.4)*
Memory: stimulus competition					
Letter-Number-Sequencing	10.0 ± 3.0	8.2 ± 2.3	9.5 ± 3.4*	8 (22.9)	3 (8.6)
Auditory Consonant Trigram	10.0 ± 3.0	2.5 ± 2.6	6.2 ± 4.3***	29 (82.6)	14 (40.0)***
Pooled data[c]					
Memory Tests – No stimulus competition				11 (31.4)	20 (57.1)*
Memory Tests with stimulus competition				30 (85.7)	16 (45.7)***
Combined Memory Tests				31 (88.6)	23 (65.7)*

[a] Values are mean ± SD. [b] Adjusted for age, education, vocabulary, depression. [c] Number deficient (< 5th percentile) on at least one neurocognitive test. * $p = 0.05$; ** $p = 0.01$; *** $p = 0.001$. PASAT: Paced Auditory Serial Addition Task.

Table 3. Recall errors of patients with FM and age matched controls with distraction delays of 0, 9, 18, and 36 seconds.

	Distraction Interval, s (percentage of 15 consonant letters forgotten)			
	0	9	18	36
FM	0 (0)†	8.8 ± 2.7* (58)^{a}	11.0 ± 2.9** (74)^{b}	11.7 ± 3.2** (78)^{b}
Controls	0 (0)	6.1 ± 2.5 (40)^{a}	7.3 ± 3.8 (49)^{b}	9.1 ± 3.8 (61)^{c}
Normative values	0 (0)	3.0 ± 2.2 (20)	4.5 ± 2.5 (30)	5.1 ± 2.4 (32)

Means with the same superscript (a,b,c) across the last 3 columns of the same row are not significantly different; means with different letter superscripts are significantly different (Scheffe test). * $p < 0.05$, FM vs controls; ** $p < 0.001$ FM vs controls. † Adjusted for age, education, vocabulary, depression.

forgotten for each level of distraction are also reported. As can be seen, recall was essentially perfect for both groups with no distraction. Difference between FM and control groups in forgetting consonants with distracter delays of 9, 18, and 36 seconds was highly significant. FM patients recalled fewer consonants at each level of distraction. In addition, the rate of forgetting by FM patients was much sharper. They lost 58% of a small amount of new information when attention was diverted by a distracting task for 9 seconds. In comparison with the age matched control group with memory problems, the FM sample lost 44% more information, and almost 3 times more information than the normative sample at the 9 second distraction interval. There was no significant difference in recall between the 18 second delay and the 36 second delay in the FM sample ($p = 0.182$). By comparison, the control sample lost smaller amounts of information and in a more gradual fashion with distraction.

DISCUSSION

The cognitive costs of distraction appear to be considerable and may be a defining feature of memory vulnerability in patients with fibromyalgia. It was a key parameter along which patients with FM differ. With no distraction on the ACT, immediate memory was largely intact. They fully remembered a small file of information. However, following a distraction of 9 seconds, the loss of information was disproportionately large. This distraction erased almost 58% of the same information, suggesting that even limited distraction harms recall of new information. Indeed, people with FM lost simple information at a rate that was 44% greater than an age matched group presenting with memory problems and almost 3 times greater than the normative sample. Inability to filter the effects of distraction may be one reason why new information erodes so quickly in real-life situations. These findings might be taken to indicate that the ability to inhibit cognitively irrelevant information may be weakened in patients with FM.

Some insight into why FM patients largely perform psychometrically normally on routine tests of memory, yet are troubled by memory gaps for everyday events, may be gained by highlighting skills that are assessed by memory measures in routine use. Most measures encode information into storage in highly structured, distraction-free situations. These conditions are not representative of difficulties encountered in real life, which is full of stimulus competition that actively interrupts the encoding of new information before it can be rehearsed and stored. For example, a clerical employee talking with a customer could be distracted by a telephone ringing, by someone speaking in the background, or by the movement of another person walking by.

This study shows different cognitive measures have different degrees of utility in detecting the presence of cognitive impairment in patients with FM because some aspects of memory are working adequately and other aspects are significantly impaired[6]. The test with the best utility (ACT) introduced distraction at encoding. When distraction-activated cognitive processes compete for attentional resources at encoding[18], the majority of patients with FM produced a measurable deficit on NC tests. In the aggregate, psychometric-based evidence of cognitive abnormality was found in 88.6% of the cases. This finding provides robust documentation of psychometric-based cognitive loss in a large majority of patients with FM. Adding a source of distraction to NC testing is essential to demonstrating significant memory problems in patients with FM.

Paradoxically, the WMS-III is generally viewed as the single best measure of memory functioning, yet it is unsuitable for measuring cognitive deficits linked to stimulus competition[19]. Its 2 primary subscales for assessing memory status, Logical Memory and Paired Associates, identified only a small percentage (8% to 14%) of FM patients as cognitively impaired. These findings show that the majority of FM patients possess age-appropriate ability to form and maintain memory representations in test conditions free of stimulus competition. Taken into clinical practice, the ramifications of relying on WMS-III to assess memory efficacy in FM could be profound, as the primary subscales of the WMS-III failed to identify the majority [54.3% (85.7%–31.4%)] of patients with FM who demonstrated objective evidence of impaired memory on other tests. The 54.3% of subjects might be erroneously reported as having normal memory by examination.

In a limited manner, previous studies examining short-term memory of people with FM without stimulus competition have reported mild cognitive deficits based on mean score[5,20]. However, mean scores at times do not provide a good overall view of group performance. They are not the best estimate of group performance when diminished performance in a small proportion of the sample inflates the deficit visible by mean performance.

Taken together, these findings help to dispel poorly supported impressions that FM patients are overstating cognitive problems[2]. When appropriate cognitive tests are administered, FM patients with memory problems display measurable and substantial psychometric-based evidence of impairment; indeed, more than a comparative group presenting with memory problems. Rather than being at odds with FM patients' complaints, the findings complement self-reports and show that FM patients' appreciation of failing memory has a legitimate basis[20]. Cognitively, FM patients are not broadly impaired across cognitive tests. Instead, they are selectively impaired, and when measures focus on "real-life" memory skills, there is a high degree of correlation between how FM patients assess their memory skills and objective measurement[21]. While this research helps to bridge the gap between perception and cognitive findings in a large percentage of cases, much remains to be learned to fully understand memory complaints in patients with FM. Ultimately, test considerations are unlikely to account for all discrepancies between self- and data-appraised functioning.

The cognitive tests employed in this study draw on a number of different facets of cognitive skill. This study focused on stimulus competition as an encompassing variable influencing the processing of information in one set of scales (ACT, Letter-Number-Sequencing, and PASAT) and largely absent as a source of influence in the other set of scales (Digit Span, Logical memory, and Paired Associates). However, measures such as the PASAT and LNS also differ on separate distinguishable skills that could affect performance. For example, performance on the PASAT depends on the fidelity of adding ability, sustained attention, processing speed, and executive skills. It would be important in designing future studies of FM to separate the effects of these different skills.

A common element in recent surveys of test usage among neuropsychologists is the rare usage of NC measures encoded with distraction[22,23]. In 2 recent surveys, not a single NC measure containing this attribute was listed in the top 50 measures popularly employed by neuropsychologists in the US[22,23]. The Auditory Consonant Trigram was not ranked in the top 50 in either survey. In both surveys, the WMS-III was the measure most widely used by neuropsychologists to assess memory functioning. Unfortunately, it is also a measure that tracks cognitive skills in FM that are largely working adequately.

The study results convey an important message for neuropsychologists as well as consumers of their reports. Test outcomes can just as easily be determined by the choice of tests used to evaluate memory as by attributes of the test subject. Assessment measures encoded free of stimulus competition are inadequate to fully assess cognitive problems in FM patients. In the majority of cases, they essentially test the strengths of patients with FM and are the wrong tests for documenting cognitive impairment. It is easy to imagine examining memory under non-taxing conditions (single-channel information devoid of stimulus competition) and underestimating the true level of deficit in patients with FM[24]. As test results show, there is no general limitation in short-term memory capacity of the majority of patients with FM when priority is given to testing without stimulus competition. It is likely that many patients with memory complaints, not only those with FM, may test abnormally using neurocognitive measures that include a source of stimulus competition. It is only by employing measures that assess more representative obstacles to remembering that we can hope to fully address the basis of cognitive complaints of patients with fibromyalgia.

REFERENCES

1. Dickson B, Eccleston C, Crombez G. Attentional functioning in fibromyalgia, rheumatoid arthritis and musculoskeletal pain patients. Arthritis Rheum 2002;6:639-44.
2. Grace GM, Nielson WR, Hopkins M, Berg MA. Concentration and memory deficits in patients with fibromyalgia syndrome. J Clin Exp Neuropsychol 1999;21:477-87.
3. Pincus T, Swearingen C, Callahan LF. A self-report Cognitive Symptoms Inventory to assess patients with rheumatic disease: results in eosinophilia-myalgia syndrome, fibromyalgia, rheumatoid arthritis, and other rheumatic diseases [abstract]. Arthritis Rheum 1996;39 Suppl:S261.
4. Katz RS, Heard AR, Mills M, Leavitt F. The prevalence and clinical impact of reported cognitive difficulties (Fibrofog) in rheumatic patients with and without fibromyalgia. J Clin Rheumatol 2004;10:53-8.
5. Landros NI, Stiles TC, Sletvold H. Memory functioning in patients with primary fibromyalgia and major depression and health controls. J Psychosom Res 1997;42:297-306.
6. Cicerone KD, Azulay J. Diagnostic utility of attention measures in postconcussion syndrome. Clin Neuropsychol 2002;16:280-9.
7. Carbotte RM, Denburg SD, Denburg JA. Cognitive deficit associated with rheumatic diseases. Neuropsychological perspectives. Arthritis Rheum 1995;38:1363-74.
8. Mulligan NW. The role of attention during encoding in implicit and explicit memory. J Exp Psychol 1998;24:27-47.
9. Klinberg T. Concurrent performance on two working memory tasks: Potential mechanism of interference. Cerebral Cortex 1998;8:593-601.
10. Wolfe F, Smythe HA, Yunus MB, et al. The American College of Rheumatology 1990 criteria for the classification of fibromyalgia: report of the Multicenter Criteria Committee. Arthritis Rheum 1990;33:160-72.
11. Wechsler D. Wechsler Memory Scale III. Administration and scoring manual. San Antonio, TX: The Psychological Corporation; 1997.
12. Wechsler D. Wechsler Adult Intelligence Scale. 3rd ed. San Antonio, TX: The Psychological Corporation; 1997.
13. Stuss DT, Stethem LL, Pelchat G. Three tests of attention and rapid information processing. An extension. Clin Neuropsychol

1988;2:246-50.
14. Brittain JL, La Marche JA, Reeder KP, Roth DL, Boll TJ. Effects of age and IQ on Paced Auditory Serial Addition Task (PASAT) performance. Clin Neuropsychol 1991;5:163-75.
15. Gronwall DM. Paced Auditory Serial Addition Task: a measure of recovery from concussion. Percept Mot Skills 1977;44:367-73.
16. Beck AT, Steer RA, Brown GK. Beck Depression Inventory – 2nd edition (BDI-II) manual. San Antonio, TX: Harcourt Brace & Co.; 1996.
17. Vercoulen IH, Bazelmans E, Swanink CM, Fennis JF, Van der Meer IW. Evaluating neuropsychological impairment in chronic fatigue syndrome. J Clin Exp Neuropsychol 1998;20:144-56.
18. Fleming K, Goldberg TE, Gold JM, Weinberger DR. Verbal working memory dysfunction in schizophrenia: use of a Brown-Peterson paradigm. Psychiatry Res 1995;56:155-61.
19. Kawas C, Resnick S, Morrison A, et al. A prospective study of estrogen replacement therapy and the risk of developing Alzheimer's disease. Neurology 1997;48:1517-21.
20. Park DC, Glass JM, Minear M, Crofford LJ. Cognitive functioning in fibromyalgia patients. Arthritis Rheum 2001;44:2125-33.
21. Bennett-Levy J, Polkey CE, Powell GE. Self report of memory skills after temporal lobectomy: the effect of clinical variables. Cortex 1980;16:543-57.
22. Camara WJ, Nathan JS, Puente AE. Psychological test usage: Implications in professional psychology. Prof Psychol Res Pract 2000;31:141-54.
23. Lees-Haley PR, Smith HH. Forensic neuropsychological test usage: An empirical survey. Arch Clin Neuropsychol 1996;11:45-51.
24. Mateer CA, Mapou RL. Understanding, evaluating and managing attention disorders following traumatic brain injury. J Head Trauma Rehabil 1996;11:1-16.