Analysis of neuropsychological functioning in patients with chronic fatigue syndrome

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Abstract
Memory impairment dominates the cognitive complaints of patients with chronic fatigue syndrome (CFS). Twenty CFS patients were available for studies with a clinical and experimental battery composed of memory and cognitive tests. The results on objective testing indicated that the CFS patients had some mild memory impairment, but only on tasks requiring conceptually driven encoding and retrieval processes. There were no associations between the nature of the precipitating illness, self ratings of fatigue, physical findings, or laboratory determination and objective memory performance or self report of memory functioning. These generally negative results indicate that memory impairment in CFS patients is typically mild and involves memory processes that participate in conceptualising information.

(J Neurol Neurosurg Psychiatry 1993;56:684-689)

Medical professionals are frequently required to assess and manage patients who complain of chronic fatigue. When associated with pain, sore throat, feverishness, tender lymph nodes, decreased concentration, memory problems, and depressed mood in the absence of a discernible cause, the symptom complex is termed the chronic fatigue syndrome (CFS).1 The lack of uniform physical or laboratory abnormalities in patients with CFS dictates that the diagnosis is one of exclusion, and that treatment is empirical.2,3 In addition, there is a striking overall similarity between CFS and the condition long known as neurasthenia.4,4

Depression is a prominent feature in many patients with CFS. While in some it predatesthe illness and may contribute to this syndrome’s immune, somatic, and cognitive features,5-13 in others, the depressive symptoms may represent reactions to the debilitating illness and/or be a co-morbid expression of constitutional factors that ultimately make people susceptible to delayed recovery from infections or other acutely stressful events.7,9,13 This combination of factors has fueled an unresolved debate as to whether CFS is the reflection of an underlying psychiatric disturbance or, instead, is the result of an ongoing disorder with an infectious or immune origin.14-18 Regardless of the outcome of this debate, qualitative and quantitative characterisation of the clinical features of CFS would permit better patient classification and management.

Among the least studied features of CFS are the common complaints of deficits in memory, cognition, and mood.14 The goals of the present study were to characterise the dimensions of these neuropsychological problems and to determine the degree to which they correlate with other clinical and laboratory measures.

In a pilot study, we administered retrospective and current period surveys to 54 patients who met Center for Disease Control criteria for CFS and who were participating in ongoing research studies at the National Institutes of Health. These patients underwent medical and laboratory evaluations and completed self rating forms regarding mood and cognitive functions.20 The results showed that CFS patients report many symptoms that are characteristic of depression, and that the prevalence and severity of depressive complaints reflect the degree of overall illness and its cognitive features, especially those regarding memory, an observation made in an earlier controlled therapeutic trial in patients such as these.2 We extended these earlier observations by a detailed assessment of cognitive complaints in CFS patients and by analysis of their relationship with depressive complaints and severity of illness. Our results indicated that complaints of memory impairment dominate the current and past reports of patients with CFS. Moreover, the severity levels of cognitive and mood problems recalled during the worst period of illness correlated highly with the current cognitive and mood levels. For both the current and past periods, the level of depression correlated directly with the number and severity of memory complaints. Importantly, neither the current or recalled complaints of cognitive and mood problems could be predicted on the basis of any other clinical or laboratory data accrued.

We, therefore, decided to examine CFS patients with a battery of cognitive and memory tests to determine whether objective memory and cognitive deficits could be demonstrated in the light of the survey results.

Methods
SUBJECTS
The first 20 of the survey respondents who subsequently travelled to the NIH for further biological studies were neuropsychologically
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MEASURES
A set of measures was chosen that would evaluate objectively the cognitive complaints of CFS patients based on the pilot survey study. While we focused on memory measures, tests of planning, reaction time and intellectual capacity were also included in the battery. Two "Tower" planning tasks were selected because they represent different difficulty levels in planning. Thus, this battery not only measures those domains of cognition noted by CFS patients to be taxing, but also includes measures known to be sensitive to "subcortical dementia" such as time perception, response speed, and planning. The following battery of tests and scales was administered over a total of eight hours on two consecutive days of study. A more detailed description of these tests, except where noted, is available in Lezak.

All patients and controls demonstrated excellent effort and motivation during the evaluation. All of the patients remarked that the examination was tiring for them. Some patients complained of debilitating fatigue only on the day following the completion of the evaluation.

GENERAL INTELLECTUAL PERFORMANCE
1. Wechsler adult intelligence scale revised
This is a standard intelligence test composed of 11 subtests assessing verbal and non-verbal abilities. Both scale and subtest scores are reported.

TIMING AND REACTION TIME TASKS
1. Simple reaction time
Subjects were instructed to press the space bar on a computer keyboard as quickly as possible every time a stimulus appeared on a computer monitor. There were a total of 21 trials on this task.

2. Serial reaction time test
Subjects were instructed to press one of four keys that were spatially aligned with one of four positions on a computer monitor. Stimuli would appear at one of the four positions, one at a time, and subjects were to press the key that was underneath the position where the stimulus would appear as quickly as possible. There were seven blocks of 100 trials each. The first two blocks were composed of random presentations, the next four blocks were composed of 10 repetitions of a fixed sequence of 10 stimuli, and the last block was another random presentation. Familiarity with the task itself should be reflected by a slight decrease in reaction times (RT) across the first two blocks. The further expected decline in RT across blocks three to six indicates the procedural learning of the repeated sequence. The expected increase in RT on block seven (composed of random trials) compared with block six (the last repeated trial block) is an indication of visuomotor procedural learning (the difference score that we use subtracts the RT of block seven from block six). The RT for blocks one and two also represents a choice-RT measure independent of procedural learning.

3. Time wall
Subjects viewed a block falling from the top of a computer monitor at a steady velocity. Half way down the screen the block disappeared from view behind an opaque mask. Subjects had to press a key when they believed the block had reached the bottom of the screen. This task measures time perception based on encoding of the speed of a visual stimulus.

4. Time clock
Subjects saw a circle on a computer monitor and were asked to press a key once every second for 60 keypresses. After each keypress, the subject saw a clock hand move 1/60 of the distance around the circumference of the circle in a clockwise direction. This task measures elapsed time estimation when the target time interval (~1 second) is known.

PROBLEM SOLVING AND PLANNING
1. Tower of London
On this simple task of planning and procedural knowledge, subjects were shown a collection of three coloured discs placed upon a set of different sized pegs in a certain pattern defined as the initial state. They were then shown a card indicating the final state that the discs should be in. Subjects were then told to move the discs one at a time until they reached the final state. Only one disc could be moved at a time, there was a limit on how many discs could be placed on the pegs, and there was a time limit of two minutes by the end of which a move had to be made. If a violation of any of these rules was made, the subject was allowed to start over again. A total of three attempts per problem was allowed. Response times were recorded per move.

2. Tower of Hanoi
This is a more demanding task than the Tower of London but measures similar planning and procedural knowledge skills. Subjects were shown the graphic image of a collection of five discs placed upon a set of pegs on a computer screen. From this initial state, subjects were asked to use the numerical keys on the keyboard to shift discs to different pegs in order to reach a final state. Subjects had to solve the problem within two

Table 1 Subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>Controls (N = 17)</th>
<th>CFS patients (N = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>38.1 (8-9)</td>
<td>37.2 (9-0)</td>
</tr>
<tr>
<td>Education (years)</td>
<td>15-9 (2-7)</td>
<td>15-5 (2-2)</td>
</tr>
<tr>
<td>Handedness</td>
<td>100% Right Handed</td>
<td>100% Right Handed</td>
</tr>
<tr>
<td>Sex</td>
<td>9 Women/8 Men</td>
<td>12 Women/8 Men</td>
</tr>
</tbody>
</table>

(Mean and standard deviations are shown.)
minutes. The number correct out of nine problems was recorded. Each problem had a different initial state but a constant final state.

3. Twenty questions
Subjects had to identify the correct object from a set of 24 objects by asking questions. Two problems (each with a specific target object) are given with the type of question (for example, deductive) asked by the subject and whether the subject identified the object or not recorded by the test examiner. This test measures reasoning ability and question development (for example, divergent versus convergent).

MEMORY
1. Wechsler memory scale revised
This is a standardised test that includes several subtests which measure short term memory, verbal and non-verbal, immediate and delayed recall, mental control, and attention.

2. Experimental paired associate test
Subjects were asked to remember several types of paired items (either word word, word picture, picture word, or picture picture pairs); each pair was presented on a card. Subjects were next given a visual cued recall test using the first item in each pair, followed by a verbal free recall test and an incidental learning task which required subjects to indicate whether each item was presented originally as a picture or a word. This test evaluates structured versus free recall and incidental memory for a stimulus feature.

3. Hasher frequency monitoring task
Subjects were read a set of words that they were told to remember. Some of the words were repeated up to seven times. Following the presentation of this list, subjects were asked to recall as many of the items as they could from the original list. Then, subjects were read all the items from the original list and some items that were never presented before and asked to estimate how many times they had heard these words. This test evaluates sensitivity to frequency of presentation under implicit (free recall) and explicit (forced choice) conditions.

4. Story memory
Subjects were read two stories and asked to recall as much information as they could about each story following its presentation. The number of story idea units recalled were recorded.

5. Word fluency
Subjects were asked to generate words for 90 seconds that belonged to various categories (for example, animals, countries, things you can buy in supermarkets) or began with a specific letter (for example, F, A, S).

MOOD STATE AND PHYSICAL CONDITION
1. Beck depression inventory
This scale was completed by the subject who indicated the number and severity of symptoms associated with depression that they were currently experiencing. A score of 15 or higher is suggestive of at least a mild depression.

2. Somatisation scale
This questionnaire is completed by the subject who indicates whether he is currently experiencing unusual symptoms that are typically associated with somatisation.

3. Neurobehavioural rating scale
This scale is completed by the test examiner and indicates the severity of behavioural symptoms (for example, depressed effect) observed by the examiner during the test examination. The higher the score per behavioural symptom, the more severe the symptom appears to the examiner. There are 29 behavioural symptoms scored on this scale.

4. Fatigue scale
Subjects rated their fatigue on an unpublished analogue scale developed by the Center for Disease Control reflecting the degree of fatigue they were experiencing on the day of testing, the month before the testing, and the month before their illness.

These scales and questionnaires are used for screening purposes only. A psychiatric diagnosis requires a formal psychiatric interview which was not completed on any of the patients or controls in conjunction with this evaluation.

STATISTICAL ANALYSES
Analysis of variance was used for most between group comparisons. Posthoc evaluations used the Scheffé test. Regression analysis was used to determine the effects of age, education, and sex on specific measures. Pearson product moment correlations were computed to evaluate the relationship between performance on related cognitive measures. The error bars in the figures always refer to standard deviations.

Results
GENERAL INTELLECTUAL AND COGNITIVE FUNCTIONS
There were no significant between group differences in performance on tests of intelligence, reaction time, planning, time perception, or problem solving, with two exceptions. The CFS patients demonstrated greater variability than the controls in the timing of their tapping on the time clock task (F(1,33) = 4.62, p < 0.03) although the overall mean tapping times of the CFS patients and controls were similar. CFS patients solved more problems than did the controls on the Tower of London task (F(1,33) = 4.04, p < 0.05). On the other hand, CFS patients tended to make more errors in solving the Tower of London problems (F(1,30) = 7.38, p < 0.01). The essentially normal performance of CFS patients on these mea-
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Table 2 Wechsler memory scale-revised

<table>
<thead>
<tr>
<th>Subtests</th>
<th>Controls</th>
<th>CFS patients</th>
</tr>
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<tbody>
<tr>
<td>Information</td>
<td>13.94(0.25)</td>
<td>13.90(0.31)</td>
</tr>
<tr>
<td>Mental Control</td>
<td>5.44(0.73)</td>
<td>5.15(0.93)</td>
</tr>
<tr>
<td>Figural Memory</td>
<td>7.38(1.20)</td>
<td>6.79(1.08)</td>
</tr>
<tr>
<td>Logical Memory I</td>
<td>29.06(5.57)</td>
<td>26.95(6.92)</td>
</tr>
<tr>
<td>Logical Memory II</td>
<td>24.38(6.64)</td>
<td>20.50(8.10)</td>
</tr>
<tr>
<td>Visual Paired-Associates I</td>
<td>16.00(2.73)</td>
<td>14.85(3.05)</td>
</tr>
<tr>
<td>Visual Paired-Associates II</td>
<td>5.94(0.25)</td>
<td>5.70(0.66)</td>
</tr>
<tr>
<td>Verbal Paired-Associates I</td>
<td>20.75(3.53)</td>
<td>20.70(2.68)</td>
</tr>
<tr>
<td>Verbal Paired-Associates II</td>
<td>7.69(0.60)</td>
<td>7.70(0.57)</td>
</tr>
<tr>
<td>Visual Reproduction I</td>
<td>36.50(2.37)</td>
<td>34.00(3.51)*</td>
</tr>
<tr>
<td>Visual Reproduction II</td>
<td>33.13(5.73)</td>
<td>28.50(6.34)*</td>
</tr>
</tbody>
</table>

The only significant differences between groups occurred on the visual reproduction subtest. However, CFS patients generally performed slightly worse than controls on almost all subtests. (Means and standard deviations are shown.)

MEMORY FUNCTIONS

There were no between group differences on the digit span task, indicating that short term memory span was intact in the CFS group. There were also no between group differences in retrieval of category exemplars suggesting that at least some aspects of semantic memory search and retrieval were intact. CFS patients also demonstrated normal reaction times and visuomotor procedural learning on the serial reaction time task.

Despite normal functioning on these memory measures, CFS patients had a significantly lower score than controls on the general memory index of the Wechsler memory scale (F(1,34) = 5.05, p < 0.03) suggesting that some aspects of their current memory functioning were impaired. Specific subtest raw score comparisons (see table 2) revealed that the CFS patients were only impaired on the immediate (F(1,34) = 5.94, p < 0.02) and delayed (F(1,34) = 5.15, p < 0.02) visual reproduction subtests which requires the subject to reproduce complex geometric designs. Other subtests requiring attention and orientation, immediate and delayed verbal cued and free recall, and non-verbal recognition memory were all performed normally. On two measures of free and incidental recall (from the experimental paired associates and Hasher frequency tasks), CFS patient recall and judgment were similar to those of the controls. On the first of two experimental stories, the CFS patients recalled as many story idea units as did the controls. However, following the second story, patients recalled significantly fewer idea units than did controls (F(1,33) = 15.26, p < 0.0004). Furthermore, on the experimental paired associates test (see fig 1), CFS patients recalled fewer words in the cued retrieval condition than the controls (F(1,35) = 4.81, p < 0.03).

Thus, CFS patients appeared to have generally normal memory functioning, yet, paradoxically, they demonstrated specific difficulties in recalling information under conditions of greater semantic structure (for example, cued as opposed to free recall and recall of story propositions as opposed to isolated words) and in reproducing geometric designs. This is the opposite of the common finding in which normal subjects and patients with various types of central nervous system impairments are generally helped by increasing stimulus structure (as seen in story memory or cued recall tasks). Correlational analysis was not particularly helpful in identifying associations between other variables (for example, age, education, degree of fatigue, mood state) and these unusual memory deficits in the CFS patients although verbal IQ was significantly correlated with the number of propositions retrieved on story two (r = 0.46), suggesting that the general verbal skills of these patients were partially responsible for their poorer performance.

MOOD STATE AND EFFORT

There was no difference in the number of depressive symptoms reported by the CFS patients and controls on the Beck depression inventory. Scores from an examiner rating scale showed that about a quarter of the CFS patients demonstrated mild to moderately impaired attention and memory during the evaluation. As expected, CFS patients reported being significantly more fatigued on the day of testing than controls (F(1,30) = 46.37, p < 0.0001) and their fatigue on the testing day was compatible with their general level of fatigue throughout the illness. However, there were no differences between the level of pre-illness fatigue in the CFS patients and the current level of fatigue in the controls. Furthermore, there was no relationship between any of these fatigue measures and cognitive performance in the CFS group.

This series of tests demonstrated, then, that CFS patients have selective deficits in memory processing arising against a background of relatively normal cognitive functioning. Curiously, they had greater problems recalling material when the material or retrieval measure was the most structured. There was no relationship between performance on these specific memory measures and mood state, fatigue level, age, or education although verbal intelligence was correlated with story memory performance.
Nevertheless, with the Beck depression inventory, we were able to describe a film or television show reliably enough to assess the degree of memory impairment as reported by the CFS patients' caregivers. Such a decrease in cognitive effort, however, may cause memory deficit at present.

Both infections and concurrent symptoms of depression and fatigue may also predict memory complaints. Furthermore, the Beck depression inventory, when used in conjunction with the Beck depression scale, can predict the severity of the illness. A decrease in cognitive effort, however, may cause memory deficit at present. Nevertheless, with the Beck depression inventory, we were able to describe a film or television show reliably enough to assess the degree of memory impairment as reported by the CFS patients' caregivers. Such a decrease in cognitive effort, however, may cause memory deficit at present.
impairment in CFS patients, these symptoms cause considerable distress. With the background provided by this study and a recently completed parallel study of selective attention in CFS, in which patients were shown to have normal visual attentional processes but slowed response execution, we have developed a more focused testing protocol for continued prospective and objective measurement of neuropsychological complaints in CFS.

Neuropsychological functioning impairment in CFS is considerable distress. We have shown that normal visual attentional processes but slowed response execution, we have developed a more focused testing protocol for continued prospective and objective measurement of neuropsychological complaints in CFS.4