wjpmr, 2022,8(4), 27 – 36.

SJIF Impact Factor: 5.922

WORLD JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.wjpmr.com

Research Article

ISSN 2455-3301

WJPMR

COGNITIVE IMPAIRMENTS IN CHRONIC FATIGUE SYNDROME PATIENTS: CHOICE REACTION TIME, ENCODING OF NEW INFORMATION, RESPONSE ORGANISATION AND SELECTIVE ATTENTION

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Article Received on 08/02/2022 **Article Revised on 01/03/2022** **Article Accepted on 22/03/2022**

ABSTRACT

Background: One of the features of Chronic Fatigue Syndrome (CFS) is the reporting of cognitive impairment. Prior research has confirmed this using cognitive performance test batteries. Psychomotor slowing and episodic memory impairments appear to be robust, but little is known about selective attention or the stages of processing leading to slower reaction times. The present study addressed these gaps in the literature. **Methods:** CFS patients were recruited from a health service clinic. Sixty-seven patients agreed to carry out cognitive tasks measuring aspects of focused attention and categoric search and the components (encoding and response organisation) of choice reaction time. They were compared with 126 healthy controls. As well as carrying out the performance tasks, the participants also completed symptom checklists and questionnaires measuring fatigue, mental health and cognitive failures. **Results:** The questionnaires revealed the typical profile of symptoms of CFS patients. With regards to the objective performance tasks, the CFS patients had significantly slower choice reaction times on both tasks. This is likely to be due to slower motor responses as neither of the measures of stimulus encoding or response organisation showed differences between the groups. There was also little evidence for the groups differing in aspects of selective attention. **Conclusions:** CFS patients report greater fatigue, more somatic symptoms, greater mental health issues and more cognitive difficulties. Objective testing revealed slower choice reaction times which probably reflect motor slowing. These measures can now be used to assess the efficacy of the management of CFS.

INTRODUCTION

Chronic Fatigue Syndrome (CFS), often referred to as Myalgic Encephalomyelitis/chronic fatigue syndrome (ME/CFS), is a chronic disease where the primary feature is severe and unexplained fatigue lasting for at least six months. CFS is commonly associated with reports of cognitive problems. A recent systematic review and meta-analysis[1] examined the neuropsychological profile described in the CFS literature. This showed impairments in visual-spatial immediate memory, slower reading speed and impaired episodic memory (storage, retrieval and recognition). Sustained attention was also impaired, but executive and instrumental functions showed little evidence of impairment.

Our laboratory has investigated cognitive impairments in CFS since the 1980s.[2,3,4] The early results showed that the most robust impairments were slower reaction time, impaired free recall, a reduced ability to sustain attention and greater distraction while naming colours. One of the problems with early research on CFS was the lack of a case definition. In the UK, this was largely resolved by the development of the Oxford Case Definition.[5] This was used in our later research.[6,7,8,9] This research confirmed the earlier findings and investigated larger samples. This allowed analyses to examine which characteristics of the patients were associated with the cognitive impairments. Generally, the impairments did not reflect psychopathology. Rather some impairments were related to the severity of the fatigue, disturbed sleep, and the slower reaction time reflected physical de-conditioning.

The first aim of the present study was to replicate slower choice reaction time in CFS patients. This was done using two tasks which were also developed to examine aspects of selective attention.[10] The first task involved focused attention, and the target (an A or a B) always appeared in the same location in the centre of the screen. The second task involved searching for the target in one of two possible locations. Both tasks measured mean reaction time over 320 trials, and it was predicted that the CFS patients would be slower than controls on both tasks. The tasks also measured the encoding of new information. If the target stimulus was the same as the previous trial (e.g., A – A), then reaction times were

quicker than if it alternated to the other stimulus (e.g., A – B). This difference between alternations and repeats is an indicator of the speed of encoding new information. Response organisation was also measured in the categoric search task by considering stimulus-response compatibility. The letter A was responded to with the left hand, whereas the letter B was responded to with the right hand. If an A was presented on the left of the screen or a B on the right, the stimulus and response were compatible. Incompatible combinations (i.e. the A on the right of the screen, the B on the left) led to slower reaction times. The difference between incompatible and compatible responses provides an indicator of response organisation.

The main feature of the two tasks used here was to measure many different aspects of selective attention. There are two main dimensions of attention. One involves selecting stimuli with some characteristic feature such as location in space. This is known as filtering or focused attention. The other type of attention involves a categorical search. This is known as selective-set, categoric search, pigeon-holing or response set. Within these two different tasks, various measures of attention can be examined. Nineteen different measures of selective attention are described in the original paper describing the tasks used here.[10] These reflect the effects of different distractors on the response to the target stimulus. For example, funnel vision can be examined by examining the difference between near and far distractors, which are different from the target. Two other measures were added in later research[11], namely, the Eriksen effect, which examines near and far agreeing and disagreeing distractors, and the place repetition effect[12], where targets in the categoric search task are responded to more quickly if they occur in the same location as the previous target. There is relatively little literature on selective attention of CFS patients. There has been some research showing that CFS patients have a greater attentional bias towards health-threatening stimuli.[13] Research looking at visual selective attention shows little evidence of impairments in CFS patients.[14,15] Other research suggests that fatigue decreases externally directed attention which may underlie performance impairments.[16] One of the problems with the research on cognitive functioning in CFS is that different tasks are used to assess different functions. These tasks may differ in length and be performed at different times in the test batteries. An advantage of the tasks used here is that the multiple measures are obtained from two very similar choice reaction time tasks.[17]

MATERIALS AND METHODS

The study was carried out with the approval of the Local Regional Ethical Committee and the informed consent of the participants.

Questionnaires measuring physical and mental health

Prior to attending the laboratory session, physical symptoms were assessed using a symptom checklist[18], the somatic symptoms from the Profile of Fatigue Related Symptoms[19], and the Cohen -Hoberman Index of physical symptoms.[20] Mental health was assessed by measuring mood in the last week[21], state anxiety[22], the Centre for the Epidemiology of Depression Scale [CES-D][23], Beck's Depression Inventory [BDI][24], Emotional Distress from the Profile of Fatigue Related Symptoms[19], and the Perceived Stress Scale.[25] Cognitive difficulty was measured using the Cognitive Difficulties scale from the Profile of Fatigue Related Symptoms[19] and the Cognitive failures Questionnaire.[26]

Performance Tests

The computer tasks were performed using an IBM compatible computer. Responses were measured using a Cologic response box connected to a timer card allowing measurement of reaction times to the nearest millisecond. The box was designed to offer all the keys required to complete the task. Two choice reaction time tasks were used to measure the speed of response, encoding of new information, response organisation and aspects of attention. Both tests assess vulnerability to distraction over a sustained period of time under several conditions. The focused attention task presented three stimuli, each preceded by a cross. The central item was the stimulus to be responded to and was either an A or a B. The stimuli on either side of the central character could also be A's or B's or blanks and *'s. The participant's task was to respond accurately and quickly to the central character. Effects of distraction were measured by the similarity and spatial position of the distractors to the target stimulus. The categoric search task presented two stimuli, one of which was a target and the other a distractor. Targets were either A or B and appeared either in the middle of the screen (2.04 degrees) or towards the edge of the screen (5.21 degrees). The participant was required to search for stimuli in addition to identifying them. Stimuli were preceded by crosses in the location of the stimuli to be presented. Both tests began with a 10-trial practice session with feedback and lasted for five sets of 64 trials with rest intervals between each set of a length determined by the participant.

Participants

Patients were referred by their General Practitioners to a Chronic Fatigue clinic set up for NHS referrals based on an illness of more than six months duration. The catchment area for the clinic included Glamorgan, Dyfed and Gwent and provided a cohort of 109 patients. Patients were asked to bring with them a completed medical questionnaire and a record of their temperature, taken twice daily for the period of time before attending the clinic. Blood and urine samples were also taken at the clinic. Patients returned to the clinic for more blood samples two and six months after their first visit. Patients attending the clinic received the medical and psychiatric

assessment of a detailed nature, and of these, 91 patients formed a medical database and 100 patients a psychiatric database. During their visit to the clinic, patients were invited to participate in the Chronic Fatigue study being carried out at the University. Sixty-seven patients from the clinic agreed to fully participate in the research programme and underwent a series of computerised tests and questionnaires.

RESULTS

Medical Database (N=91)

One hundred and nine people attended a National Health Service clinic at the University Hospital in Cardiff. Of these, 31 were males, whose ages ranged from 12 to 63 with a mean age of 40.69; and 76 were females whose ages ranged from 17 to 72 with and mean age of 42.81. A sample of these patients for whom complete data were available comprise a database of 91 subjects from whom the following results were obtained.

Illness History

Medical assessments showed that 63 of 91 patients reported a viral event prior to their illness, whereas the remaining 28 reported a gradual onset. Twelve patients had suffered from severe depression prior to their illness onset.

Current Condition

Infection

In terms of any infectious serology, those screened for included Lyme disease, which was uniformly negative. Seventy-nine patients had Coxsackie titres measured with the following results: B1- 1, B2- 1, B3- 5, B4 - 14, B5- 0, B6- 0. Seventy-six patients had toxoplasma serology performed, 7 of whom were positive for IgC antibodies, 69 were negative. No IgM Toxoplasma antibodies were found. Blood screening showed individual abnormalities within the group, but no specific patterns of abnormality were found.

Work and disability

Of the clinical sample of 91, 40 had given up work due to illness, three were on sick leave, and seven had their employment threatened. Eight had a family history of the illness. Three patients arrived in a wheelchair (2 male, one female). Unlike some Chronic Fatigue samples, the spread of occupations (and thus Social-Occupational Classification) was quite large, including for the males: heating engineer, shorthand secretary, electrician, computer programmer, student, physics teacher, upholsterer, land surveyor, sales-assistant, landscape technician, medical student, warehouseman and unemployed; and for the females: teacher's aid, tax inspector, schoolgirl, housing benefit officer, nurse, teacher, civil servant, retail trade, childminder, social worker, accounts coordinator, personnel officer, ward receptionist, professional singer, hairdresser, riding instructor, restauranteur, probation officer, librarian, ex-student and housewife. There were only three nurses (2 unemployed) and six teachers (1 unemployed) - occupations most commonly associated with the illness. Four tax inspectors and two housing benefit officers attended the clinic, all of whom blamed stress at work for the exacerbation of their illness.

Diagnosis of organic disease

No defined organic disease was found in any of the 91 patients.

Psychiatric diagnoses (N=100)

Of the 109 patients attending the clinic, a sample of 100 was psychiatrically assessed with the following results. 97% of the Chronic Fatigue sample fulfilled the ICD-10 criteria for neurasthenia. All participants fulfilled at least one operational definition of the disorder according to ICD-10.

Immunology

Standard serological investigations were performed to estimate serum immunoglobulins (including IgG sub-classes), CRP, heterophile antibodies and virus serology against EBV VCA IgG/IgM, CMV, Coxsackie B viruses etc. Samples were also be examined for:

a) T cell subsets: cell numbers - CD2, CD3, CD19, CD16, CD8, CD4 and detailed study of CD8+T cells.

b) specific functional abnormalities in patients with EBV infection at the onset of fatigue.

No significant differences were found for any of these measures.

Medication

Of the sample attending the medical clinic (N=109), 15 were taking amitriptyline, and eight were taking 5HT uptake inhibitors. Ten patients had previously taken 5HT uptake inhibitors but had ceased. Four patients were taking thyroxine, and four were taking propranolol. All of those taking medication were female.

Laboratory Patient Sample

All those attending the clinic were invited for a laboratory testing session. They were aware that their participation was entirely voluntary. Of the 109 people attending the clinic, 67 took part in the study based at the University. The remaining 40 did not participate for several reasons: 11 lived too far away to visit the University, six refused to participate, 18 agreed to only fill in questionnaires (this included the 11 who lived too far away), one was too young (aged 12), and two were diagnosed as not having Chronic Fatigue. Thus, from the hospital sample, there was a proportion who attended the laboratory session ("attenders") and a proportion who did not attend ("non-attendees"). This section makes comparisons between the "attenders" and "non-attendees" and attempts to demonstrate that the patients attending the HPRU were not different from those who did not attend.

Attender/non-attender differences

The measures of medical and psychiatric assessments, physical symptoms, health-related behaviours and

activity showed very few significant differences between groups. The results would suggest, therefore, that the patients who attended the HPRU were representative of the Chronic Fatigue sample tested at the clinic.

Demographics: Laboratory Sample

Sixty-seven Chronic Fatigue patients attended the Health Psychology Research Unit for testing. There were 20 males and 47 females whose ages ranged from 17 to 63 in the case of males with a mean age of 39.65, and 17 and 73 in the case of females, with a mean age of 43.49. 59.1% of the Chronic Fatigue patients were married, 33.3% were single, 6.1% were divorcees, and 1.5% were widowed.

Illness history

The laboratory sample (67 patients) showed an interesting range of precipitating factors, with 95.5% of patients reporting a potential causal factor for their illness. These factors (not mutually exclusive) ranged from influenza (41%), a sore throat (32%), glandular fever (27%), stomach upset (14%) and stress (41%). 29% reported another unspecified event. Only 18% of patients reported glandular fever as the only prior event, with 12% reporting influenza as the only event. Patients reported an average illness length of 62.75 months with an average diagnosis length of 24 months, and distributions are shown in Table 1.

Table 1: Illness and Diagnosis length for Chronic Fatigue patients (N=67).

	Mean (illness length)	sd.	N
No precipitatory event	73.33	34.98	3
Glandular fever (GF) only	34.09	26.35	11
Glandular fever and another event	43.33	34.98	6
Not GF, but one or more events	37.43	42.75	42
Influenza only	30.75	47.99	33
Influenza and another event	27.56	17.75	18
Not influenza, but one or more events	44.39	47.99	33

The current state of health

A self-assessment of the current state of their illness showed the following results:

Worse than at any stage of the illness:	6.1%
Bad:	24.2%
Bad with some recovery:	42.4%
Recovering with occasional relapses:	27.3%
Almost completely recovered:	0%

This indicates that most felt they were showing signs of recovery, few felt that they were at their worst, but none felt that they were almost well again. An analysis of variance looking at illness duration in terms of current severity (two-way, current severity as the dependent variable) showed no significant differences between groups (three groups; 'worse than..' and 'bad' collapsed together) ($F=0.51$; $df=2,60$; $p>0.05$).

Changes in their condition

Patients also reported detrimental effects from concentrating (84.8%), and stress (71.2%), and that alcohol made them feel worse (39.4%). 69.7% of patients reported that complete rest led to an improvement in their condition, 42.4% reported that sleep led to an improvement, but 15.2% of patients said that nothing helped their condition.

Additionally, comparing between pre and post-illness onset, Chronic Fatigue sufferers reported that the quality of their sleep was worse (43.9%), or much worse (36.4%) than before their illness, with only 19.7% of the group reporting their sleep quality was unchanged or better than before onset. 54.7% of sufferers reported their intake of alcohol to have moderately or significantly decreased since onset, with only 6.3% reporting an increase in alcohol intake. Similarly, 42.9% of sufferers reported a decrease in their smoking behaviour, with 7.1% having stopped completely. 28.6% of sufferers report an increase in their smoking.

Participants were asked if there were times during the day when they regularly felt better or worse:

felt worse in the mornings	31.8%
felt worse in the afternoons	7.6%
felt worse in the evenings	6.1%

No regular pattern of fluctuation across the day 54.5%

Activities which made patients feel worse included exercise - 60.6%; reading - 33.3%; shopping -69.7%; walking 68.2%; car journeys - 47%; and talking - 43.9%.

Current symptoms

Results from the symptom checklist are shown in Table 2.

Table 2: Current symptoms of Chronic Fatigue sample.

	Yes
Physical weakness (50% more than before you were ill)	86.4%
Excessive Fatigue (50% more than before you were ill)	97.0%
Legs feeling heavy	81.8%
Muscle pain in back, arms or legs	89.4%
Pain in chest	39.4%
Painful joints	63.6%
Nausea	48.5%
Indigestion	25.8%
Bloated stomach	40.9%
Sore throat	47%
Headache	66.7%
Earache	24.2%
Sore eyes	56.1%
Sensitive to noise	65.2%
Sensitive to light	63.6%
Feeling hot/cold	77.3%
Sweating	45.5%
Shivering	45.5%
Swollen glands	42.4%
Racing heart	31.8%
Insomnia	45.5%
Depression	39.4%
Anxiety/Panic feelings	31.8%
Loss of concentration	89.4%
Loss of memory	80.3%
Allergies	30.3%

Controls: Demographic characteristics

One hundred and twenty-six members of the general population were recruited to take part in the study as controls for a Chronic Fatigue sample. They were recruited from an advertisement in the local press and selected to participate on the basis of age and occupational status. Of the 126 general population participants, there were 43 males and 83 females. The males ranged in age from 21 to 66 years with a mean age of 39.14 (S.D.=13.53), and the females from 21 to 79 years with a mean age of 40.48 (S.D.=13.02). 50.8% of the general population participants were married, 32.5% were single, 15.9% were divorcees, and 0.8% were widowed.

Group matching

The patients and controls did not differ significantly in terms of gender, age, occupational status, or pre-morbid intelligence (measured using the National Adult Reading Test).

Sleep

Chronic Fatigue sufferers reported that the current quality of their sleep was worse (43.9%), or much worse (36.4%) than before their illness onset, with only 19.7% of the population reporting their sleep quality unchanged or better than before the onset of their illness. Patients did not quantitatively differ from the Controls, but the reported quality of sleep was much worse for Patients ($F=60.26$; $df=1,102$; $p<0.01$; variances not assumed to be equal). Patients also reported more problems dropping-off to sleep ($F=6.23$; $=1,189$; $p<0.05$; variances assumed to be equal) and more problems awakening early ($F=7.06$; $df=1,106$; $p<0.01$; variances not assumed to be equal).

Physical symptoms

Comparisons between groups were made using three main measures: the symptom checklist, the Profile of Fatigue Related Symptoms, and the Cohen-Hoberman Index of Physical Symptoms:

Symptom checklist

Table 3 shows the symptoms of the patients and controls.

Table 3: Symptoms of General Population and Chronic Fatigue samples.

	Controls	Chronic Fatigue
	Yes	Yes
Physical weakness (50% more than before you were ill)	7.9%**	86.4%
Excessive Fatigue (50% more than before you were ill)	10.3%**	97%
Legs feeling heavy	4.8%**	81.8%
Muscle pain in back, arms or legs	27.8%**	89.4%
Pain in chest	2.4%**	39.4%
Painful joints	17.5%**	63.6%
Nausea	4.8%**	48.5%
Indigestion	11.9%*	25.8%
Bloated stomach	14.3%**	40.9%
Wind	12.7%**	45.5%
Sore throat	7.9%**	47%
Headache	11.9%**	66.7%
Earache	1.6%**	24.2%
Sore eyes	18.3%**	56.1%
Sensitive to noise	5.6%**	65.2%
Sensitive to light	11.1%**	63.6%
Feeling hot/cold	9.5%**	77.3%
Sweating	6.3%**	45.5%
Shivering	0.7%**	45.5%
Swollen glands	3.2%**	42.4%
Racing heart	4.8%**	31.8%
Insomnia	10.3%**	45.5%
Depression	10.3%**	39.4%
Anxiety/Panic feelings	9.5%**	31.8%
Loss of concentration	15.1%**	89.4%
Loss of memory	8.7%**	80.3%
Allergies	14.3%*	30.3%

(* $p < 0.05$; ** $p < 0.01$)

The Cohen-Hoberman Index of Physical Symptom scores are shown in Table 4.

Table 4: Cohen Hoberman physical symptoms scores.

	m	sd
Patients	24.37	7.77
Controls	6.39	5.84

A one-way analysis of variance between the Patient and Control groups shows significant differences between groups (F=259.08; df=1,96; p<0.01; variances not assumed to be equal). The results demonstrate again that the Patient group reported more symptoms than the Control group.

Profile of Fatigue Related Symptoms

The differences between the patients and controls in terms of somatic symptoms and fatigue are shown in Tables 5 and 6.

Table 5: Somatic symptoms.

	m	sd
Patients	49.67	17.99
Controls	23.43	8.79

A one-way analysis of variance for the Patient and Control groups showed significant differences between groups (F=121.34; df=1,79; p<0.01; variances not assumed to be equal). The results demonstrated that the Patients reported more somatic symptoms than the Controls.

Table 6: **Fatigue.**

	m	sd
Patients	62.97	12.36
Controls	22.75	11.24

A one-way analysis of variance shows significant differences between groups (F=506.47; df=1,187; p<0.01; variances assumed to be equal). The results show that the Patients reported significantly more fatigue than Controls.

Cognitive problems

These were measured using the cognitive difficulties scale of the Profile of Fatigue Related Symptoms and the Cognitive Failures Questionnaire. These results are shown in tables 7 and 8.

Table 7: Cognitive Difficulty.

Patients	49.86	12.1
Controls	23.58	10.58

A one-way analysis of variance between the Patient and Control groups showed significant differences between groups (F=239.64; df=1,115; p<0.01; variances assumed to be equal). The results demonstrate that the Patient group report significantly more cognitive difficulties than the Control group.

Table 8: Cognitive Failures.

Patients	60.77	17.13
Controls	38.35	13.04

A one-way analysis of variance for the Patient and Control groups shows significant differences between groups (F=81.16; df=1,96; p<0.01; variances not assumed to be equal). The results show that the Patient group reported significantly more cognitive failures than the Controls.

Mental Health

This was assessed using mood ratings, the State Anxiety Inventory, the CES-D scale, the Beck Depression Inventory, the Emotional Distress scale of the Profile of Fatigue Related States, and the Perceived Stress Scale.

Table 8 shows positive and negative mood scores in the last week for the two groups.

Table 8: **Positive and negative mood states.**

	Positive mood		**Negative mood**	
	m	**Sd**	**m**	**sd**
Patients	26.35	8.96	23.88	10.88
Controls	36.04	9.55	14.14	9.55

An analysis of variance (variances not assumed to be equal) for the positive mood score showed significant differences between groups (F=48.77; df=1,189; p<0.01). The analysis of variance for the negative mood score also showed a significant difference between groups (F=40.73; df=1,189; p<0.01). These results demonstrate that the Patients reported a more negative mood and a lower positive mood than the Controls.

Table 9 shows the state anxiety scores in the last week for the two groups.

Table 9: **State Anxiety scores.**

	mean	**sd**
Patients	41.02	9.79
Controls	30.99	8.16

A one-way analysis of variance showed significant differences between groups (F=10.72; df=1,188; p<0.01). This result showed that the Chronic Fatigue sample had higher state anxiety scores than the Control sample.

Table 10 shows the CES-D scores for the two groups.

Table 10: **CES-D scores.**

Patients	39.34	8.8
Controls	36.36	9.03

A one-way analysis of variance showed significant differences between groups (F=42.23: df=1,189; p<0.01). The Patients were significantly more depressed than the Controls using this measure.

Table 11 shows the Beck Depression Inventory scores for the two groups.

Table 11: Beck's Depression Inventory scores.

	m	**sd**
Patients	14.39	6.76
Controls	7.38	6.52

An analysis of variance between Patient and Control groups showed significant differences between groups (F=47.64; df=1,186; p<0.01; variances assumed to be equal). The Patients were significantly more depressed than the Controls using this measure.

Table 12 shows the Emotional Distress scores for the two groups.

Table 12: **Emotional Distress.**

	m	**sd**
Patients	46.23	18.56
Controls	32.52	15.75

A one-way analysis of variance between the Patient and Control groups showed significant differences between groups (F=28.73; df=1,189; p<0.01; variances assumed to be equal). The results show that the Chronic Fatigue patients reported more emotional distress than the general population sample.

Table 13 shows the Perceived Stress scores for the two groups.

Table 13: **Perceived Stress Scale.**

	m	**sd**
Patients	26.89	8.48
Controls	22.55	8.61

A one-way analysis of variance between the Patient and Control groups showed significant differences between groups (F=10.48; df=1,183; p<0.01; variances assumed to be equal). This result showed that the Chronic Fatigue sample perceived themselves to be under more stress than the general population sample.

Summary of differences in subjective reports between the Chronic Fatigue and Control samples

In terms of physical symptoms, the results indicated that the Chronic Fatigue patients are significantly different from the Control sample for Somatic Symptoms (PFRS), Fatigue-related Symptoms (PFRS) and also symptoms as

measured by the Cohen-Hoberman Index. In all cases, the Chronic Fatigue group reported more physical problems than the Control group.

For mood, the Chronic Fatigue group were significantly less positive and significantly more negative than the Control group. For state anxiety, Chronic Fatigue patients were found to be significantly more anxious than controls. With measures of depression, namely the CES-D and the BDI, Chronic Fatigue patients were found to be more depressed than the Control sample. Similarly, the Patients suffer more emotional distress and perceived stress than Controls. The Patients also reported more cognitive problems than the Controls.

In summary, these results confirm that the Chronic Fatigue sample report suffering from more physical problems and report more mental health and cognitive problems than the general population sample using the measures outlined above.

OBJECTIVE PERFORMANCE TESTS

Mean reaction times

Table 14 shows the mean reaction times (in msec) for the focused attention (FA) and categoric search (CS) tasks for the patients and controls.

Table 14: Mean reaction times for FA and CS tasks.

	mean RT FA		mean RT CS	
	m	**sd**	**m**	**sd**
Controls	476	75	611	82
Patients	567	129	697	130

The data were logarithmically transformed and submitted to two one-way analyses of variance. The results indicate that in both cases, there was a significant effect of group (for mean RT in BS; $F=33.81$; $df=1,182$; $p<0.01$: for mean RT in UD $F=28.18$; $df=1,182$; $p<0.01$), showing that in both tests, the Control group showed significantly faster reaction times than the Patient group. A one-way repeated-measures analysis of variance using both sets of reaction time for both groups showed a significant effect of group ($F=33.47$; $df=1,182$; $p<0.01$), a significant effect of task ($F=886.89$; $df=1,182$; $p<0.01$) but no interaction between task and group ($F=0.28$; $df=1,182$; $p>0.05$).

Encoding of new information

Tables 15 and 16 show the scores for the encoding of new information in the FA and CS tasks. These were calculated as the difference in msec between alternations (different stimuli to the previous trial) and repeats (the same stimulus as the previous trial

Table 15: **Encoding of new information in the FA task.**

	Alt-Rep RT	
	m	**sd**
Controls	12	29.0
Patients	3	52.0

Reaction time measures were logarithmically transformed before being submitted to an analysis of variance. The Alternation-Repeats RT analysis showed no significant differences between groups ($F=0.17$; $df=1,123$; $p>0.05$).

Table 16: **Encoding of new information in the CS task.**

	Alt-Rep RT (msec)	
	m	**sd**
Controls	2	31
Patients	-5	46

Again, all reaction time scores were logarithmically transformed before being submitted to analysis of variance. For Alternation-Repeats RT no significant differences between groups were found ($F=0.5$; $df= 1,97$; $p>0.05$).

Response Organisation

This was measured by examining stimulus-response compatibility in the CS task. When the letter A was presented on the left-hand side of the screen, the response was compatible in that it was made with the left hand. When it was presented on the right-hand side of the screen, it was incompatible with the hand of response. The opposite pattern applied to the letter B, which was responded to with the right hand. The difference between incompatible and compatible responses was analysed here. These results are shown in Table 17.

Table 17: S-R compatibility (msec).

	Mean CO	
	m	**sd**
Controls	10	10
Patients	8	35

The S-R compatibility analysis showed no significant differences between groups ($F=0.19$; $df=1,63$; $p>0.05$; variances not assumed to be equal).

Measures of selective attention

Ten measures of selective attention were derived from the FA data. None of these showed a significant difference between patients and controls. Eight measures were derived from the CS data, and there were no significant differences between patients and controls.

DISCUSSION

The present study compared a CFS sample with healthy controls. The CFS sample was selected based on the Oxford criteria for CFS, and a detailed clinical and laboratory profile was collected. The CFS sub-group who volunteered to carry out the laboratory tasks were representative of the sample attending the clinic. The

controls and CFS patients showed the usual differences on the questionnaire measures of symptoms, fatigue, mental health, and cognitive difficulty. This replication of the established CFS profile gives one more confidence in the novel measurements taken.

The objective performance measures confirmed the slower reaction times of the CFS group in the choice reaction time tasks. The CFS group did not differ in the speed of encoding of new information (Alternations-Repeats) or response organisation (S-R compatibility). This suggests that the differences may be at the motor stage and could reflect physical de-conditioning. There were also no differences in the selective attention measures. This conflicts with studies that have shown differences in distraction using the Stroop colour-word interference task. That task involves reading speed which may be the crucial reason why it shows a difference between CFS patients and controls.

CONCLUSIONS

The present study compared a group of CFS patients selected using the Oxford Criteria from a health service clinic with healthy controls. Subjective reports confirmed the usual differences between these groups in symptoms, fatigue, mental health and cognitive difficulty. Objective performance tests demonstrated greater psychomotor slowing in the CFS group. There were no differences between the groups in stimulus encoding, response organisation or selective attention. It is suggested that psychomotor slowing can be used as an indicator to evaluate the efficacy of different approaches to managing these patients.

Conflict of interest

The author declares no conflict of interest.

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