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PSYCHOLOGICAL TESTING OF CEREBRAL MALARIA PATIENTS

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The performance of nine patients with cerebral malaria on a battery of psychological tests, administered while they were ill and again when they recovered, was contrasted with the performance (while ill and recovered) of a matched group of nine patients with malaria alone. Results indicated that the cerebral malaria patients while ill suffered characteristic impairments in several aspects of cognition (*e.g.*, in recent memory, visual motor functioning and psychomotor speed) suggestive of organic dysfunctioning, which were not present in patients with malaria alone. Upon recovery, no measurable organic residual was found.

Falciparum malaria is a frequently encountered illness among U. S. troops in South Vietnam. A cerebral syndrome is a well recognized complication of this type of malaria and our experience with the clinical manifestations of cerebral malaria has been previously reported (2, 4). The clinical signs varied but were broadly divided into five groupings: disturbance of consciousness, acute organic mental syndrome, movement disorders, focal neurological signs and acute personality changes. Nineteen cases of cerebral malaria were diagnosed during a 10-month period at the 93rd Evacuation Hospital, Long Binh, South Vietnam, and nine of these served as subjects (*S*s) in this investigation.

The present study was designed to measure more precisely, by means of a psychological test battery, the effects of cerebral malaria on intellectual functioning. The tests selected were those found sensitive to intellectual change in previous research: the Wechsler Adult Intelligence Scale (WAIS) (15), the Wechsler Memory Scale (WMS) (14), the Bender Motor Gestalt Test (1, 7) and the Rorschach Test (11). Review of the medical and psychological literature revealed that cerebral malaria patients had never before been examined with such instruments. Testing seemed indicated to provide answers to three questions. 1) Despite the different clinical manifestations of the illness listed above, are there common impairments in intellectual functioning? 2) If there are common impairments, are they sufficiently distinct to be of clinical utility in differentiating cerebral from noncerebral malaria in borderline cases? 3) Is there any residual organic brain damage? Generally it has been stated that survivors of cerebral malaria are free of residual disability (6, 12), but actual measurement of intellectual functioning has not been made.

METHOD

SUBJECTS

Eighteen soldiers hospitalized at the 93rd Evacuation Hospital, Long Binh, South Vietnam, served as *S*s. Nine were independ-

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TABLE 1

Mean Values on Seven Matching Variables of Malaria and Cerebral Malaria Groups, with t tests Comparing the Means

Matching Variables	Malaria	Cerebral Malaria	*t*
Age	21.11	22.56	0.66
Military rank	3.56	3.89	0.60
FSIQ upon discharge	104.44	101.67	0.58
Years of schooling[a]	10.78	11.62	1.24
Days afebrile	3.22	3.22	0.00
Days to retest	6.56	8.33	1.37
Number of difficulties reported during youth[a]	7.44	1.75	4.55[b]

[a] Cerebral malaria group $N = 8$.

[b] Significant at <.001 level.

ently diagnosed[4] by the hospital neurologist (RBD) as cases of cerebral malaria (CM group), and the other nine comprised a matched group of patients with malaria alone (M group). The basis for the matching was similarity of temperature pattern, though subsequent analysis revealed that *S*s were well matched on several other parameters.

PROCEDURE

All *S*s were first tested approximately 3 days after their fever had remitted, *i.e.*, after 3 consecutive days of fever below 102°F. (They were not tested at the peak of their illness because of gross incapacitation and the possible confounding effects of high temperature on test performance.) At that time one of the psychology technicians administered the WAIS and the Bender Test, and the hospital psychologist (AJK) administered the WMS and the Rorschach. Initially the technicians were naive with respect to the purposes of the study, but about halfway through they inadvertently discovered that they were testing malaria and cerebral malaria patients. However, they did not know the direction of the anticipated results, so that conscious manipulation of data was not possible. The fact that one of the authors administered two of the test instruments while aware of *S*s' classification is clearly a flaw in design. This arrangement was unavoidable because he was the only psychologist in South Vietnam. (The consistent pattern of results from all four tests suggested that this flaw did not significantly alter the findings.)

All *S*s were reexamined with the same four instruments just prior to scheduled discharge from the hospital, approximately 7 days after initial testing. Thus each *S* was tested twice—once while ill and again when recovered. At various times during hospitalization, each *S* also received the Minnesota Multiphasic Personality Inventory (MMPI) and a medical-social questionnaire based on Wells and Ruesch (16).[5] These instruments were included to ascertain if the CM and M groups were matched with regard to several measures of personality and background.

RESULTS AND DISCUSSION

MATCHING PROCEDURE

Table 1 shows that there are no significant differences between the M and CM groups on six of the seven matching variables: age, rank, full scale IQ upon hospital discharge, years of schooling number of consecutive days afebrile (temperature below 102°F) when first examined, and number of days to retest. The fact that the M group reported significantly more disturbance during youth (*e.g.*, having been in many fights, having had trouble in school) can probably be understood as an attempt to exaggerate pathology, in order to increase the likelihood of being medically evacuated to the United States. (The patients with cerebral malaria were aware that their more serious condition would necessitate evacuation.)

This interest was also reflected in the contrasting MMPI scores (Table 2) of eight *S*s

[4] The diagnostic criteria utilized are described elsewhere (4).

[5] A copy of this questionnaire is available from the senior author on request.

TABLE 2

Mean MMPI Scores for Malaria and Cerebral Malaria Groups, with t Tests Comparing the Means

Scale	M	CM	t	Scale	M	CM	t
L	3.25	5.50	2.18[a]	Pa	10.62	7.62	1.20
F	9.50	2.62	2.89[a]	Pt	28.00	26.00	0.65
K	11.25	18.75	4.52[b]	Sc	28.62	25.88	0.73
Hs	12.62	14.75	1.29	Ma	24.38	18.88	4.70[b]
D	20.50	21.50	0.37	Si	27.75	23.75	0.76
Hy	17.38	21.75	1.95[c]	A	55.12	40.75	3.75[d]
Pd	27.00	23.25	1.34	R	45.62	52.88	2.09[c]
Mf	22.50	17.88	2.01[c]	Es	48.75	58.38	2.63[a]

[a] $p < .05$.
[b] $p < .001$.
[c] $p < .10$.
[d] $p < .01$.

in the CM group and eight *S*s in the M group. (One *S* in each group failed to complete the MMPI.) *S*s with cerebral malaria scored significantly higher on the L, K and Es scales ($p < .05$, $p < .001$ and $p < .05$, respectively), and suggestively higher on the Hy and R scales ($p < .10$). This pattern suggests that the CM group was trying to appear in the most socially acceptable light, to convey normality and freedom from symptoms and to indicate that their ego functioning was intact. The suggestive elevations on Hy and R imply some use of repressive defenses. In contrast, the malaria *S*s scored significantly higher on the F, Ma and A scales ($p < .05$, $p < .001$ and $p < .01$, respectively), and suggestively higher on Mf ($p < .10$). This pattern seems to represent an attempt to exaggerate emotional illness and psychological distress. (Masculine role identification and feelings of euphoria are emphasized, perhaps to deny the physical aspects of their illness.)

Thus, in terms of both the social history and personality inventory, the malaria group seemed to wish to appear impaired psychologically, whereas the CM group sought to affirm complete recovery. The effect of this situational variable on the questionnaire and personality test was interesting in itself, although our primary concern was that such motivations on the part of the M group not affect performance on the four test instruments. Our subjective impression was that the M group did not attempt to perform more poorly on the test battery. This impression was supported by the obtained results—the M group scored higher on almost every performance measure.

The groups did vary in two respects: amount of medication and amount of staff interest and attention. Although the additional medication that the CM group received was not of the type that would affect mental functioning, a more perfectly controlled experiment would require identical medication for both groups. This control was neither possible under field conditions nor in the best medical interest of the patients. The effect of greater staff interest in the cerebral malaria patients is difficult to quantify. It apparently did not enhance performance, since the CM group almost never performed at higher levels than the M group. Generally we feel that excellent matching was obtained, within the limitations of field experimentation.

WECHSLER ADULT INTELLIGENCE SCALE

With the exception of the similarities subtest, there were no significant effects of either condition (malaria *vs.* cerebral malaria) on degree of health (ill *vs.* recovered) on the six verbal subtests of the WAIS. A two-way fixed effects analysis of variance

TABLE 3

Mean Scores on WAIS Variables of Malaria and Cerebral Malaria Groups, while Ill and when Recovered, with F Ratios Comparing Performances

Variable	Group	Ill	Recovered	F_c M vs. CM	F_h Ill vs. Recovered	F_i
Information	M	9.00	9.56	0.28	0.70	0.01
	CM	9.33	10.00			
Comprehension	M	8.78	10.22	0.06	3.46[a]	0.06
	CM	8.78	9.89			
Arithmetic	M	9.89	11.00	0.54	2.48	0.28
	CM	8.56	10.78			
Similarities	M	8.56	10.44	0.38	5.70[b]	0.05
	CM	9.11	10.89			
Digit span	M	9.22	9.89	1.06	2.20	0.64
	CM	7.44	9.67			
Vocabulary	M	9.67	9.67	0.09	0.09	0.09
	CM	9.33	9.67			
Verbal IQ	M	96.33	101.78	0.17	4.50[b]	0.17
	CM	93.67	101.78			
Digit symbol	M	7.78	9.56	2.72	20.30[c]	0.98
	CM	6.44	9.22			
Picture completion	M	10.11	11.67	1.15	6.04[b]	0.10
	CM	9.11	11.11			
Blocks	M	9.56	10.33	0.36	4.41[b]	1.10
	CM	8.33	10.67			
Picture arrangement	M	10.56	11.44	3.82[a]	1.15	0.00
	CM	8.78	9.78			
Object assembly	M	9.22	13.00	2.96[a]	11.39[c]	1.01
	CM	8.55	10.67			
Performance IQ	M	96.11	107.44	3.14[a]	10.75[c]	0.07
	CM	88.44	101.78			
Full scale IQ	M	95.78	104.44	1.36	8.73[d]	0.10
	CM	90.89	101.67			

[a] $p < .10$.
[b] $p < .05$.
[c] $p < .001$.
[d] $p < .01$.

(5) performed for each of the verbal subtests separately revealed that only for the similarities subtest was there a significant overall finding—a difference in performance while ill as compared with performance when recovered ($F = 5.70$, $p < .05$). As indicated by an insignificant interaction ($F = .05$) and subsequent t tests,[6] this difference occurred in both groups and seems to represent a simple practice effect (Table 3). Overall verbal IQ was also significantly different while ill and when recovered ($F = 4.50$, $p < .05$). The insignificant interaction ($F = .17$) and subsequent significant t tests suggested that both groups improved through simple practice.

Following Wechsler (15, p. 217) some deficit in arithmetic, similarities and digit span was anticipated for the CM group while ill, but was not found. Our findings were more like those of Ladd (10), who noted no significant difference on any verbal subtest, between brain-damaged and neurotic patients. Another explanation for the absence of the anticipated findings was the very small sample size in the present study. As expected, information, comprehension and vocabulary were not affected by condition or degree of health.

In contrast to the verbal subtests, all

[6] Copies of all t test computations are available from the senior author upon request.

TABLE 4

Mean Scores on WMS Variables of Malaria and Cerebral Malaria Groups, while Ill and when Recovered, with F Ratios Comparing Performances

Variable	Group	Ill	Recovered	F_c M *vs.* CM	F_h Ill *vs.* Rec.	F_i
Information	M	5.22	5.44	0.03	0.45	0.03
	CM	5.22	5.33			
Orientation	M	4.33	4.78	2.13	8.51[a]	0.96
	CM	3.78	4.67			
Mental control	M	5.33	7.22	0.44	4.60[b]	0.14
	CM	5.11	6.44			
Logical memory	M	6.94	8.89	3.91[c]	6.53[b]	0.75
	CM	3.67	7.61			
Digits	M	10.44	10.78	0.61	3.14[c]	1.81
	CM	8.78	11.22			
Visual memory	M	6.56	9.67	0.24	8.61[a]	0.06
	CM	6.78	9.00			
Paired associates	M	16.44	19.33	3.80[c]	9.40[a]	0.29
	CM	13.61	17.72			
Memory quotient	M	86.78	104.22	3.33[c]	17.93[d]	0.32
	CM	75.44	98.22			

[a] $p < .01$.
[b] $p < .05$.
[c] $p < .10$.
[d] $p < .001$.

performance subtests individually, as well as overall performance IQ, did show significant effects of condition or degree of health. Of primary interest here were the differences between the M and CM groups, when both were ill. F values were suggestive ($p < .10$) of differences between the groups on picture arrangement, object assembly and performance IQ, and near suggestive on digit symbol. A series of one-tailed t tests showed that the direction of differences was consistently such that the CM group performance was inferior, yet the difference was significant only for the digit symbol subtest ($t = 1.91$, $p < .05$). When the groups recovered, the difference between groups was no longer significant ($t = .47$). (There were no significant differences between the groups when recovered on any subtest.)

The significant impairment of the CM group while ill on digit symbol is certainly consistent with the cognitive impairments of organic patients described by Wechsler (15), and also found by Ladd (10). That the effects are less marked for the other performance subtests in the present study is probably due to the small sample size. Certainly the direction of the obtained results suggests common impairment for cerebral malaria patients, and the fact that there are no significant differences when both groups have recovered suggests that there is no organic residual.

WECHSLER MEMORY SCALE

Table 4 shows that there were suggestive overall differences ($p < .10$) between the two groups on logical memory ($F = 3.91$), paired associates ($F = 3.80$) and overall memory quotient ($F = 3.33$). Subsequent one-tailed t tests showed that the direction of differences was such that the CM group performance was significantly inferior ($p < .025$) when both groups were ill ($t = 2.37$, $t = 2.18$ and $t = 2.25$, respectively). When both groups recovered, no significant differences between their performances emerged, for these or the other five measures.

The significant differences found between the groups while ill was consistent with the expected pattern of cerebral dysfunctioning described by Wechsler (14) and also noted in several more recent studies (3, 8, 9). The

TABLE 5

Mean Scores on Bender Gestalt Test Tachistoscopic and Copy Phases of Malaria and Cerebral Malaria Groups while Ill and when Recovered, when Scoring is Done by Experienced and Inexperienced Scorers Using the Hain Method

Scorer	Administration	Group	Ill	Recovered	F_c M *vs.* CM	F_h Ill *vs.* Recovered	F_i
Experienced	Tachistoscopic	M	10.11	3.78	15.32[a]	36.39[a]	0.61
		CM	15.78	7.56			
	Copy	M	5.56	4.33	0.82	3.70[b]	0.46
		CM	7.11	4.56			
Inexperienced	Tachistoscopic	M	10.33	4.00	4.79[c]	12.94[d]	0.74
		CM	12.22	8.33			
	Copy	M	6.00	5.44	0.38	1.94	0.70
		CM	7.44	5.22			

[a] $p < .001$.
[b] $p < .10$.
[c] $p < .05$.
[d] $p < .01$.

fact that mental control, digits and visual memory were not affected in a systematic way may again be due to the small sample size.

With the exception of the information subtest, all subtests showed a significant or suggestive difference in performance while ill as compared with performance when recovered. Subsequent t tests showed that this improvement was present in both groups and represented a simple practice effect.

The WMS results indicate that there is a common impairment in the memory functioning of the CM group as compared with the M group. Upon recovery there are no significant differences between groups, suggesting that there is no organic residual.

BENDER MOTOR GESTALT TEST

Seventy Bender Motor Gestalt Test protocols were scored blind by an experienced scorer (AJK), and also by an assistant unfamiliar with the test (inexperienced scorer). The method employed was that developed by Hain (7). (There were four protocols for each *S:* one from the 5-inch tachistoscopic presentation phase while ill, one from the copy phase while ill, and one from each phase obtained when *S* recovered. Two protocols were lost, leaving a total of 70 rather than 72.) The results of the scoring are presented in Table 5.

We note that for both experienced and inexperienced scorers, there were significant differences between the CM and M groups for the tachistoscopic presentation phase ($F = 15.32$, $p < .001$ and $F = 4.79$, $p < .05$, respectively). Subsequent one-tailed t tests showed that Bender protocols, when scored by the experienced scorer, revealed marked differences between CM and M groups both while ill ($t = 3.37$, $p < .005$) and when recovered ($t = 2.25$, $p < .025$). For the inexperienced scorer the two groups were statistically distinguishable only when recovered ($t = 1.98$, $p < .05$). (This finding was unexpected and will be discussed below.) Table 5 and subsequent t tests also indicated that both groups showed significant improvement on retesting (for both scorers). For the copy phase, Table 5 and subsequent t tests showed that there were no significant effects on Bender Test performance of either condition or degree of health (for both scorers).

These results suggest that Hain's scoring system is quite effective in discriminating between the CM and M groups and in detecting improvement in both groups, at least for the tachistoscopic presentation.

(As might be expected, the method is more effective with a more experienced scorer.) The significantly higher scores of the CM group suggest that they perform much like the brain-damaged group in Hain's study. (The lack of discrimination for the copy phase may be due to the use of a tachistoscopic phase first; Hain's method was based on the use of a copy phase alone.)

The fact that the two groups were readily distinguished on the tachistoscopic phase *when recovered* suggested that residual organicity was present in the cerebral malaria patients. To investigate this possibility, eight judges made global ratings of the protocols obtained when both groups recovered.[7] (Also protocols obtained when both groups were ill were rated, the order of rating the two sets of protocols being randomized.) For each S, judges were given both the tachistoscopic and copy phase protocols. They were asked simply to give a global impression of the probability of organic dysfunctioning, on a four-point scale. Their ratings were then dichotomized into "organicity" (ratings of very probable and probable) and "no organicity" (ratings of possible and no organicity). It was hypothesized that if residual organicity were present, the judges would be able to discriminate successfully between the protocols of the CM and M groups. Tolor and Schulberg in their classical review have indicated that organically impaired groups can be discriminated from comparable nonorganic groups by the method of global ratings (13, p. 136).

The results of these ratings are presented in Table 6. They show that not one of the eight raters can discriminate to a statistically significant extent between the CM and M group protocols obtained when both groups recovered. Only two raters could distinguish

[7] Judges were obtained from the Psychology Service, Letterman General Hospital, San Francisco, and the authors gratefully acknowledge the assistance of the judges, and the Chief Psychologist, LTC Richard Cook.

TABLE 6

Number of Correct Judgements of Organicity from Bender Protocols by Experienced, Semiexperienced and Inexperienced Raters

p values represent the probability that the number of correct judgements is greater than expected by chance alone.

Experience	Rater	Protocol	Group I[a]	Protocol	Group II[b]
E	A	12	$p = .071$	10	$p = .408$
E	B	12	$p = .071$	12	$p = .120$
E	C	11	$p = .165$	11	$p = .241$
S-E	D	12	$p = .071$	08	$p = .408$
S-E	E	12	$p = .071$	07	$p = .241$
I	F	13	$p = .024$	11	$p = .241$
I	G	10	$p = .313$	10	$p = .408$
I	H	07	$p = .313$	12	$p = .120$

[a] $N = 17$; 8 CM patients and 9 M patients, while ill.

[b] $N = 18$; 9 CM patients and 9 M patients, when recovered.

the protocols at a level even approaching suggestive significance ($p = .120$). On the other hand, a majority of the raters were able to distinguish the protocols of the CM and M groups when both were ill. Rater F correctly identified 13 of the 17 protocols ($p = .024$) and raters A, B, D and E, 12 of 17 ($p = .071$). (It is of passing interest that level of experience did not seem to affect ratings strongly. The experienced raters had been using the Bender Test for more than 5 years, the semi-experienced 1 to 5 and the inexperienced had almost no acquaintance with it, yet it was one of the inexperienced raters who discriminated the two groups most accurately when both were ill.)

The fact that the raters cannot distinguish the protocols of the two groups when recovered supports the concept of the absence of residual organicity. The presence of a temporary organic brain syndrome is suggested by the consistent discrimination between the two groups when ill, by these same raters. The fact that the scoring method did distinguish between the performances of the two groups when healthy suggests that this method may tap an extremely subtle form of organic dysfunction-

TABLE 7

Mean Scores on Rorschach Variables of Malaria and Cerebral Malaria Groups, while Ill and when Recovered, with F Ratios Comparing Performances

Variable	Group	Ill	Recovered	F_c M *vs.* CM	F_h Ill *vs.* Recovered	F_i
R	M	9.78	10.00	3.87[a]	0.03	0.00
	CM	7.89	8.00			
W	M	7.78	7.56	8.61[b]	0.11	0.00
	CM	5.78	5.56			
D	M	1.89	2.22	0.01	0.23	0.01
	CM	2.00	2.22			
F	M	3.89	2.89	1.72	0.25	1.72
	CM	3.89	4.33			
ΣC	M	1.39	1.39	3.76[a]	0.07	0.05
	CM	0.83	0.67			
M + 1/R	M	.208	.262	2.24	0.06	0.50
	CM	.342	.314			
T/R	M	20.00	15.04	0.42	1.08	0.07
	CM	16.00	13.60			
TT/C	M	37.84	29.04	5.61[c]	4.72[a]	0.05
	CM	28.32	21.23			

[a] $p < .10$.
[b] $p < .01$.
[c] $p < .05$.

ing, which may not always be clinically significant.

RORSCHACH TEST

A series of eight F tests (Table 7) indicated that there were four significant or suggestive overall differences between the two groups on Rorschach variables presumed to be sensitive to organic dysfunctioning. The variables selected were based on the work of Reitan (11). Subsequent one-tailed t tests showed that the significant difference ($F = 5.61$, $p < .05$) between groups on mean total time per card (TT/C) and the suggestive differences between groups on total number of responses (R) and the weighted sum of the color responses (ΣC) were not related to significant or suggestive differences when both groups were ill or when recovered. Subsequent one-tailed t tests for the significant finding ($F = 8.61$, $p < .01$) regarding the number of whole responses (W) showed that the direction of differences was such that the CM group performance was significantly inferior only when the groups were ill ($t = 2.33$, $p < .05$).

This finding was consistent with one of Reitan's results—he found that W+1 was significantly lower in his brain-injured group, as compared with the controls. The fact that no other significant differences between groups were found in the present study may be due to our very small sample size ($N = 18$) as compared with his ($N = 192$). Another possible factor was the reluctance of all our *S*s to produce many Rorschach responses. This greatly reduced the number of scorable determinants.

Although we have only one significant finding for the Rorschach Test, that finding is consistent with a possible cognitive impairment in the CM group while ill, which is no longer present when they recover.

CONCLUSIONS

Our results showed common impairments in the intellectual functioning of cerebral malaria patients while ill, as compared with the performance of a matched group of malaria patients without cerebral involvement. These impairments were manifested in the areas of recent memory (particularly recall of paragraphs and paired associates), psychomotor speed, visual motor integration and visual organization. Impairments of this type may be conceptualized as reflecting cerebral dysfunctioning. The true extent of disability during the height of illness was not measured because extreme restlessness, obtundation or even coma made testing impossible until some recovery had begun.

The small number of *S*s in the present study prevents us from confidently stating cutting scores on various tests to determine definitively cerebral involvement in malaria cases. However, low scores on the following tests and measures, in the context of preservation of functioning on the other tasks of the test battery, is certainly suggestive of cerebral malaria: 1) WMS memory quotient, 2) WMS logical memory, 3) WMS paired associates, 4) WAIS digit symbol, 5) tachistoscopic phase of the Bender Test, scored with the Hain method, 6) clinical impression of impaired Bender Test performance and 7) number of whole responses on the Rorschach Test.

In addition, we feel that the present results provide substantial evidence of the absence of residual organicity in cerebral malaria. On every test and measure but two, the performance of the cerebral malaria patients when recovered is either indistinguishable from, or superior to, a group of matched malaria patients without cerebral involvement.

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