PSYCHOLOGICAL ADJUSTMENT FOLLOWING OPEN HEART SURGERY

by

Stephen Marshall Weiss

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I hereby recommend that this dissertation prepared under my direction by STEPHEN MARSHALL WEISS

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After inspection of the dissertation, the following members of the Final Examination Committee concur in its approval and recommend its acceptance:*

Robert W. Lawson — 9/30/64

Richard O. Gordon — 9/30/64

[illegible] — 9/30/64

[illegible] — 9/30/64

[illegible] — 10/1/64

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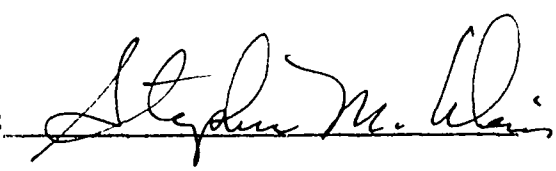
SIGNED: 

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PSYCHOLOGICAL ADJUSTMENT FOLLOWING

OPEN HEART SURGERY

Stephen Marshall Weiss, Ph. D.

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Director: Roland G. Tharp

This study was undertaken to assess the role of psychological factors in observed behavioral reactions following open heart surgery. Thirty open heart surgery candidates (experimental group) and twenty-four general major surgery patients (control group) were psychologically evaluated pre-operatively, immediately post-operatively and three to seven months after surgery. The results of this investigation indicated that 46.7% of the open heart surgery group experienced a significant post-operative reaction suggestive of an acute psychotic episode or an organic confusional state.

Statistical analysis of the data showed significant differences between the "reactor" and "non-reactor" patients in the open heart surgery group. On the basis of a multiple regression analysis, a prediction equation was developed based primarily on pre-operative psychological variables which was able to differentiate "reactors" from "non-reactors" with 100% accuracy. Results from Minnesota

Multiphasic Personality Inventory analyses successfully differentiated "reactor" from "non-reactor" groups on the basis of profile patterns. The "reactor" group indicated a diffuse, but statistically significantly higher, profile pattern.

The more deviant profiles noted for the "reactor" group were interpreted as the result of a diffuse but consistent stress reaction which was not reflected in the profiles of the "non-reactor" group.

Conclusions pointed to the importance of the psychological resources of the patient as determiners of behavior in such life-threatening stress situations as open heart surgery.

INTRODUCTION

The term "psychological stress" has been used to explain the behavioral phenomena noted in crisis situations. It has been conceived as a construct which deals with the interaction between environmental stress and the adjustive capabilities of the individual.

Although the need for systematic investigation of behavioral reactions to external stress is evident, the body of knowledge extant in this area is sparse. The difficulties of attempting anything more intensive than anecdotal note-taking and post-hoc inference in real-life crisis situations has left this vast arena of behavioral phenomena virtually untouched.

An attempt has been made to develop a hierarchy of stress experiences by Schwab and Pritchard (1949) who have delineated three general classes:

a. Mild stresses, the effects of which last from seconds to hours, e.g., annoying insects, public appearances before a large audience, missing a train, and other such minor occurrences in daily life;

b. Moderate stresses, the effects of which last from hours to days, e.g., a period of overwork, a gastric upset, a visit of an unwelcome guest, the temporary absence of a loved person;

c. Severe stresses, the effects of which last for weeks, months, or even years, e.g., prolonged separation

from one's family, death of a loved one, drastic financial losses, illnesses and surgical operations.

Only recently have behavioral scientists concerned themselves with investigating the psychological aspects of an example of the third type of stress experience: surgery (e.g., Janis, 1958; Doris Menzer, et al., 1957; Zukin and Weiner, 1960; Zwerling, et al., 1955; Giller, 1962; Coodley, 1961; Corman, et al., 1958; Moore, 1960; Price, et al., 1957; Hackett and Weisman, 1960; Meyer, 1958; Greenspan, et al., 1960; Scott, 1961). The considerable advantages of having potential access to the individual prior to the stress experience, having an accurate medical record of the nature of the experience plus having occasion to observe clinically and to examine the individual in a reasonably controlled environment subsequent to the stress experience make this an unique situation for the study of adjustive reactions to stress.

The above sequence of events may be divided into three major phases of psychological stress (Janis, 1954):

1. The threat phase, during which the person perceives signs of oncoming danger and/or receives communication of warning which are likely to arouse anticipatory fear (e.g., pre-operative state).

2. The danger impact phase during which a person perceives that physical danger is actually at hand and realizes that his chances of escaping intact depend partly upon the protective actions executed by himself or by other people who are in a position to help him (surgery).

3. The post impact victimization phase during which the person perceives the losses he has sustained and at the same time undergoes some severe deprivations which continue for a varying length of time after the acute danger has subsided (post-operative state).

Psychological Stress in General Surgery

Psychosomatic medicine has been concerned with the effects of psychogenic mechanisms on somatic illness. Ferraro (1948) criticized the neglect of these theorists to address themselves to the reverse process, i.e., "the process of soma influencing the psyche, the process of somatic stimuli determining psychologic reactions." Toward the investigation of this issue much research on the psychological effects of surgery has been directed.

Deutsch (1942) noted that patients awaiting major surgery would sometimes show a relatively low level of conscious fear whereas patients facing minor surgery would be much more apprehensive, indicative of wide individual differences in reaction to a given external danger. Sutherland and Orbach (1953) found a similar situation with poor prognosis cancer patients facing life-threatening surgery who were more concerned about the surgical incisions and upheaval in their daily routine than the possibility of dying.

Janis (1958) has delineated three stress groups in a discussion of pre-operative status influencing post-operative adjustments: (1) mild

anticipatory fear, (2) moderate anticipatory fear, and (3) high anticipatory fear. Both the low and high anticipatory fear groups were characterized by a marked post-operative emotional reaction in contrast to the moderate anticipatory fear group which was distinguished by a relative absence of emotional disturbance post-operatively. The relationship between pre-operative fear and post-operative adjustment, therefore, appeared as curvilinear.

Janis saw low pre-operative fear patients as tending to use the mechanism of denial, ignoring the realistic warnings of what might be expected in the recovery phase. Their response post-operatively was one of surprise and resentment regarding post-operative procedures, and they reacted in the light of their feelings of victimization. The high anticipatory fear group, on the other hand, gave overt expression to its emotional tension through occasional outbursts characterized by weeping, trembling, flushing, etc. These patients reported feeling continually nervous post-operatively in terms of apprehension, doubts as to the success of the surgery, loss of confidence in their ability to get well, etc.

Coodley (1961) and Greenspan (1960) agreed with observations of Janis that denial appeared to be one of the most common defense mechanisms apparent in both pre- and post-operative major surgery patients. Psychological regression was another mechanism commonly noted among major surgery patients (Coodley, 1961; Greenspan, 1960; Meyer, 1958).

The etiology and incidence of post-operative behavioral reactions have been subjects of much controversy in the literature over the last several years.

Several investigators have taken the position that post-operative behavioral reactions are a consequence of pre-operative psychiatric disorder.

Corman (1958), in a study of 43 major surgery patients, claimed that 36 of these patients (84%) had pre-operative psychiatric disorders. Of the total group, 40% experienced some sort of post-operative reaction, with 4 patients (9%) having "severe" post-operative reactions.[1]

Zwerling, et al. (1955), reported psychiatric disorders in 172 (86%) of 200 major surgery patients with 43 patients (21.5%) being classified as psychotic. Although it appears that both Corman and Zwerling are in agreement, the latter study gives no indication as to when the diagnoses were made and the criteria by which they were assessed. Further, no control groups were used to evaluate the psychiatric baseline used in these studies. It is this writer's opinion that the above figures are spuriously high; this high incidence was not obtained in any of the well-controlled studies, including those on cardiac surgery.

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[1] The case histories cited by Corman would not qualify as a "severe" reaction in the present investigation.

Scott (1961) asserted that personality and emotional adjustment were important in assessing post-operative reactions to major surgery: ". . . all individuals with excessive reations (sic) to stress of an operation have had signs of psychoneurosis prior to the procedure."

The manner in which persons handled previous difficult life situations was considered especially useful in predicting post-operative reactions by Menzer, et al. (1957). However, this group felt that the immediate post-operative reaction during recovery from anesthesia was most highly predictive of subsequent behavior patterns during the remainder of the hospital stay.

Other research has served to rule out several variables under consideration as potential predictors of behavior. Schneider, et al. (1950), in attempting to predict good vs. poor recovery from surgery found age, sex, education, financial and economic status and duration of illness did not discriminate on the above dimension.

Corman (1958) found no correlation between the incidence of post-operative behavioral disorder and age, sex, religion, kind of surgery or anesthetic used. Although cited above as claiming 84% of major surgery patients in his study suffered from a pre-existing psychiatric disorder, he was unable to predict which of these patients would have a post-operative behavioral reaction. "There was no significant predictable correlation between preoperative psychological assessment

and the incidence of postoperative behavioral disorders." Price, et al. (1957), concurred with this conclusion in their study in which, on the basis of psychiatric interviews, they concluded that no characteristic manner of psychological adaptation was evident in the assessment of post-operative behavioral reactions.

No pre-existing psychiatric disorders were noted by Rushton (1949) or Lindemann (1941) in their studies of post-operative behavioral reactions. Lindemann, however, was of the opinion that if an operation brought promised relief from symptoms, no post-operative behavioral reaction could be expected. Only in cases where surgery would be perceived as mutilative might a post-operative reaction take place.

Meyer (1958) disagreed with the above formulation in that whereas psychological post-operative reactions might be more common in mutilative and amputative surgery, they are perhaps more profound in successful surgery involving peptic ulcers, asthma, hypertension and cardiac conditions where the removal of symptoms in which the patient has great emotional investment is one of the major "benefits." It is the contention of the present investigator that the latter position is most valid with respect to open heart surgery.

Post-Operative Psychosis

Much controversy has also been generated regarding the issue of whether or not there is such a syndrome as a "post-operative psychosis." Although most researchers involved in psychological studies of surgery are aware of definite atypical post-operative behavioral reactions which cannot be explained entirely on a physiological basis, the idea of the post-operative psychosis as an unique entity has met much resistance.

Stengel (1958) concluded from a study of 80 major surgery patients who experienced a post-operative reaction that no evidence can be found for the entity post-operative psychosis. Rather, this syndrome manifested itself in a variety of the commonly diagnosed mental disorders, the particular type being determined by predisposing factors. Confusional states, related solely to the surgery itself, formed only a small percentage of the total group of post-operative reactions. The post-operative syndrome was also compared with "post-partum psychosis" in terms of similarity of types of reaction seen and the interval between the stressful event and the onset of psychiatric symptoms. Affective reactions (depression 36, manic 9, mixed state 1 = 46) appeared most frequently, accounting for 57.5% of the total, while confusional states were responsible for 26.2% of the reactions. Interestingly, schizophrenic reactions were noted in only 12 cases (15%)

with neurotic diagnoses accounting for only one case. (The low frequency of neuroticism was explained by the investigators as an artifact of the study in that neurotics were rarely admitted to the observation ward where this study was conducted.)

Stengel examined several other variables as potential etiological agents. Age was no more predictive of post-operative psychosis than of psychosis generally, i.e., patients become more prone to develop psychosis as they grow older. Sex was not predictive nor was "site of operation"; however, hysterectomies in gynecological surgery produced significantly more cases of psychosis in women ($p < .005$) than all other gynecological operations.

Findings by Lindemann (1941), Abeles (1938) and Robe (Abeles, 1938), in part, supported Stengel's conclusions in that these investigators found post-operative behavioral reactions more common in pelvic surgery than in any other type of surgery. However, surgery involving the eyes also produced a significant number of post-operative reactions. Therefore, it appears likely that " . . . the importance to the patient of the particular organ operated will affect the possibility of a postoperative psychosis occurring" (Abeles, 1938).

Abeles, in a study of 23 cases of post-operative psychosis, also investigated the influences of type of anesthesia, metabolic imbalances, food and vitamin deficiencies and fever with no conclusive findings.

Confusion has existed regarding differentiation of "post-operative psychosis" from that of "post-operative delirium." Hackett and Weisman (1960) contended that both were common psychiatric problems and that no absolute distinction could be made between them. Delirium generally was shortlived and was associated with high fever, drug withdrawal, acute head injury, etc. The indices of psychosis were far less evident, as the primary consideration was that symptoms occurred more or less independently of physiological factors. Whereas delirium was characterized by disturbed reality testing on a perceptual level and was accompanied by anxiety and agitation, psychotic reactions were involved with distortions at the conceptual and symbolic levels of reality testing.

Rarely is the evidence so clear-cut and apparent that the above distinctions can be readily discerned. The nosology of psychiatric diagnosis appears inadequate when attempting to classify post-operative behavioral reactions into specific illness categories. In the present investigation, the primary differentiation has been effected on the basis of severity of reaction, with persons evidencing grossly deviant, inappropriate or bizarre behavior being designated "reactors" with all others termed "non-reactors."

Psychological Factors in Cardiac Surgery

Cardiac surgery differs from all other forms of surgery on several dimensions.

The elective nature plus the serious hazards involved are an unusual combination in surgical practice. It involves repair of an organ which has had a long history of malfunction with concomitant restrictions on daily activities. The structural results of the surgery appear to bear little relationship to the functional consequences. Even the mythology which surrounds the heart and its functions unquestionably involves more affect and concern than any other part of the body (Meyer, et al., 1961).

Surgical teams have noted certain post-operative behavioral reactions among cardiac surgery patients which seem to appear with far greater frequency and severity in this group than in patients who have undergone other types of surgery. These reactions have variously been described by psychiatrists as "acute psychotic reactions," "confused states," "delerium," etc. However, only one of the two types of cardiac surgery, "closed" heart surgery (see footnote, page 20) has received intensive study (Fox, et al., 1954; Reiser and Bakst, 1959; Zaks, 1959, 1962; Butts and Wachtel, 1961; Priest, et al., 1957; Boshes and Zaks, 1960; Zaks, et al., 1960; Knox, 1963a, 1963b;

Meyer, et al., 1961; Matarazzo, et al., 1963; Kaplan, 1956; Dencker and Sandahl, 1962; Kovalev, 1961; Bliss, 1955).

The findings of most investigators on the study of incidence of post-operative behavioral reactions in closed heart surgery have been surprisingly consistent. Fox, Rizzo and Gifford (1954) studied 32 patients who underwent mitral commissurotomy. They reported six patients (18.7%) as having "obvious emotional disturbances." Several other cases with less severe psychologic disturbances were also discussed by these authors. Bliss, Rumel and Branch (1955) found similar results upon analysis of hospital records of 37 mitral commissurotomy patients. Six patients (16.2%) evidenced some form of serious disturbance (4 cases of schizophrenia, 2 confusional states) while six other patients showed lesser forms of disturbances (anxiety, depression); sufficient, however, to merit comment by both physicians and nurses. Kaplan (1956) noted three patients (16.7%) of a total of 18 post-commissurotomy patients as having manifested some degree of psychotic behavior, in addition to several other cases which encompassed a variety of less severe psychologic disorders. Kovalev (1961) examined 57 mitral commissurotomy patients with nine cases (15.8%) of post-operative psychosis noted. Several other cases of milder disorders were also described. Welti (1958) evaluated 27 patients who underwent mitral commissurotomy, finding 6 cases (22.2%) of post-operative "delirium" plus 9 additional cases suffering from "neurotic-like" symptoms (e.g., apprehensiveness, restlessness, headaches, etc.).

The marked unanimity noted above is not shared by all. Among the dissenters are Meyer, Blacher, and Brown (1961) who found not one single instance of post-operative psychosis in his study of 24 closed heart surgery patients. Knox (1963b) reported an incidence of only 4.4% post-operative reactions (4 out of 90 patients). Dencker and Sandahl (1963), reporting on 61 mitral surgery patients, found three patients (4.9%) who had major mental disorders post-operatively. An unique finding here was the high frequency (6%) of the total group having been hospitalized for mental disorder at some time prior to surgery.

The considerable difference between the latter two studies and the former series was tentatively explained by Knox (1963b) as the high incidence of post-operative psychosis in earlier studies being attributed to less efficient (hence, more traumatic) surgical techniques. The earlier reports were undertaken at a time when valvotomy was a new innovation and many thoracic surgeons and anesthetists were less familiar with the techniques now commonly and expertly employed. On account of this, mitral commissurotomy was often a more prolonged and hence more traumatic procedure.

Dencker and Sandahl, however, were of the opinion that a high incidence of pre-operative psychiatric disturbance is the source of the customary high figures on post-operative psychosis. In their study, six per cent of the total group at some time pre-operatively had been

hospitalized in a mental institution; their psychiatric status prior to surgery did not change post-operatively. Only three patients had no pre-operative psychiatric indications who subsequently developed post-operative psychoses. Matarazzo, Bristow and Reaume (1963), however, found no pre-operative personality differences between mitral commissurotomy patients and control groups (coronary artery and general medical groups).

Irrespective of the above differences, however, are the statistics cited by Knox (1963b) that only one case in 1500 develops post-operative psychosis after general major surgery. Therefore, from this one may assume that the incidence of post-operative behavioral reactions of the types described above occur far more frequently in closed heart surgery (mitral commissurotomy) than in general major surgery.

There has been comparatively little agreement among investigators as to the possible etiologic agents involved in post-operative behavioral reactions. As in the studies previously reviewed involving psychological factors in major surgery, several have attempted to relate these reactions to pre-operative factors. Kovalev believed the appearance of post-operative "psychosis" to be directly associated with a reactivation of the rheumatic process. Dencker and Sandahl, as mentioned above, were of the opinion that post-operative psychosis

occurred primarily in patients who were disturbed prior to surgery. Priest, et al. (1957), on the basis of psychological examination stated that persons with severe mitral stenosis requiring surgery showed perceptual dysfunction pre-operatively as well as post-operatively (as compared with patients undergoing other forms of heart surgery). This condition was attributed to organic change in the course of rheumatic heart disease, e.g., long standing reduced cardiac output resulting from intrinsic cardiac lesions and causing chronic mild hypoxia.

The theory that persons suffering from cardiac conditions per se have chronically elevated anxiety levels has led several investigators of the Chicago group (Priest, et al., 1956; Zaks, 1959, 1962; Boshes and Zaks, 1960) to consider the increase in anxiety level generated by the imminence of mitral commissurotomy an overwhelming threat to the integrity of the individual which in severe cases has led to post-operative behavioral reactions.

One major difference between general major surgery candidates and cardiac surgery patients is that the major surgery patients hope they will be told they do not need surgery whereas the cardiac patients hope they will be accepted for surgery. However, as all surgery is associated with fear of death and dread of mutilation, the cardiac patient who is accepted for surgery has highly intensified ambivalent feelings regarding his dubious fortune; the result is a greatly increased anxiety

level with consequent enlistment of emergency defense mechanisms (e.g., belligerence, immobilization, denial, etc.) (Reiser and Bakst, 1959).

All investigators, however, are willing to concede that psychological factors do play an important role in post-operative behavioral reactions and the observed result is in all likelihood a product of some combination of the interplay of psychologic and organic factors. Even Welti (1958), who proposed electrolyte imbalance (low serum sodium) as a major cause of post-operative "delirium" gave cognizance to the significant role of psychological factors in extreme stress situations. The relative emphasis as to which is most important, however, is an unresolved and much disputed issue.

The chronicity of heart disease forces those so afflicted to make many adjustments in their daily living patterns. The nature of these adjustments and the degree to which they restrict or inhibit appears to be as much a function of pre-morbid personality variables as of the organic disease itself. As Briggs and Bellomo (1959) have noted, the rewards of chronic heart disease can be such that a patient would refuse rehabilitation because the gratifications received from the illness might be such that he could not afford to be cured. The authors describe these people as emotionally immature, relying on their heart disease to escape the responsibilities of life. Reiser and Bakst (1959)

concur: " . . . Those in whom the heart disease has led to increased dependency, ego restriction and the avoidance of mature responsibilities may then be loathe to give up the illness and face a normal life with its implied independence. "

The prospect of cardiac surgery offers just this opportunity to chronically ill persons. However, the many psychological ramifications of undergoing heart surgery and its multiplicity of meanings to the patient are just beginning to be realized. For example, Knox (1963b) has noted that the appearance of new symptoms after surgery in each instance were of such a nature as to insure continual avoidance of activity and responsibility (i.e., as in pre-operative state). Priest, et al. (1957), felt that psychogenic symptoms might account for some of the reported failures of surgery to relieve symptoms. Psychogenic symptoms may closely approximate organic cardiac symptoms; repair of the organ, however, would not influence psychologic makeup, i.e., surgery would not relieve psychogenic symptoms.

Butts and Wachtel (1961) reported on three cases of mitral commissurotomy who showed the classic indicators of adaptation to chronic illness. Restoration of health was perceived by them as a threat to their life adjustment of dependency and helplessness. They were able to adjust to their new found health only after a program of intensive psychotherapy.

The psychological importance associated with chronicity is further emphasized by the findings of Matarazzo, et al. (1963), that mitral commisurotomy patients who had post-operative behavioral reactions had a longer history of illness (6.9 years) as compared with 3.6 years for the "non-reactors."

A rather unusual work which bears inclusion here is an auto-biographical account of (closed) heart surgery by a psychoanalytically-oriented psychologist (Lawton, 1956). Although not meant to be a scientific treatise, some insight is achieved into the subjective world of the patient about to undergo the type of stress to which this present investigation is addressed.

> In my confused postoperative days, I would rouse myself in a panic from a nightmare, look down and notice arms next to my body that weren't mine.
>
> My difficulty in recognizing who or where I was, was an after effect of the operation.
>
> . . . The conviction grew that air was coming in via nose and mouth but escaping through the hole in my windpipe before reaching the lungs. Unless the hole was plugged up I would choke to death. Also, I felt it represented a direct channel to my heart . . . it was up to me to keep me alive, I felt, and that meant sitting propped up in bed with my finger against the adhesive tape (which sealed the tracheotomy tube) to prevent any leakage of air . . . I refused further needles. They were trying to trick me: "Fall asleep and you'll never reawake."

The above comments were a sample of recollections of the first ten post-operative days. Confusion, delusional ideation,

paranoid intrusions, and feelings of depersonalization were some of the more blatant psychiatric symptoms noted. The author's wife, also a psychologist, commented: "I was quite unprepared for George in his obviously confused state. His eyes had a peculiar glaring look . . . During those ten post-op days of mental confusion . . . he seemed to regress . . . and he became a demanding, commanding child, completely different from his easygoing reasonable self."

The author relates that the greatest suffering of the entire experience was his post-operative behavioral reaction and his being totally unprepared for this circumstance.

Both the author and his wife stressed the need for greater recognition of the role of psychological factors with respect to pre-operative preparedness and post-operative psychiatric treatment.

There appears to be little doubt that the psychological aspects of cardiac disease and surgery are multi-dimensional, with many areas yet to be explored.

Psychological Studies of Open Heart Surgery

"Open heart" surgery, because of its recent inception and the relatively few medical centers routinely performing this surgery,

has received as yet relatively little attention with regard to post-operative psychological phenomena.[2]

Although many studies of the neurological and biochemical response to open heart surgery have been published in recent years, these have not related these issues to the incidence of post-operative behavior anomalies. Whereas considerable psychologic and psychiatric research is presently being conducted in this area, little has been published as of this writing.

In a report of psychiatric findings on open heart surgery patients, Blachly (1964) found that 57% of 139 cases experienced psychotic reactions. These reactions were noted to have occurred several days after surgery, often during the period when metabolic changes induced by surgery were returning to normal levels.

Age, sex, duration of pre-operative illness and operative procedure were felt to play some role in the incidence, development, and duration of post-operative psychosis. No clear relationship was noted between post-operative psychiatric disturbance and intelligence,

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[2]The most significant difference between "open" and "closed" heart surgery is the cardio-pulmonary bypass procedure which is utilized in open heart surgery. The machine which is used in this procedure, the "pump-oxygenator," assumes the functions of the heart and lungs through maintaining the circulation of oxygenated blood throughout the rest of the body. The heart action is usually arrested during the procedure and is resumed only through electric stimulation.

pre-operative psychiatric disturbance, cerebrovascular accidents, presence or duration of cardiac arrest or post-operative pneumonitis.

Statement of Purpose

The purpose of the present investigation is to examine intensively the post-operative behavioral reaction noted in "open heart" surgery using several quantitative psychological measures. An attempt will be made to isolate those psychological factors (if any) which may be predictive of a post-operative reaction in the pre-operative phases as well as an analysis of the psychological sequelae (if any) resulting from a post-operative reaction (as determined by examination three to seven months following surgery). A control group of general major surgery patients will provide a "surgery base-line" with regard to the effect of surgery, per se, on the various psychological dimensions.

PROCEDURE

All of the data described herein was collected on the thoracic and general surgery wards of the University of Oregon Medical School Hospital from December 1962 through December 1963. The follow-up phase of this study was completed in April 1964. This research was one of several concurrent studies conducted by an interdisciplinary team representing psychology, psychiatry, and neurology.

Selection of Patients

The experimental design involved two groups: (1) open heart surgery patients and (2) general major surgery patients.

The open heart surgery group (OHS) was composed of patients subjected to cardio-pulmonary bypass during corrective cardiac surgery (see Table 1). The selection of patients was accomplished by serial order from the open heart surgery schedule and by the various age and cultural criteria described below. Although a total of 46 patients agreed to participate in the study, only 30 patients completed all the requirements for inclusion of their data in the final results (8 patient deaths, 1 patient failed to complete follow-up questionnaires, 7 patients did not complete the pre-operative psychological evaluation for various reasons).

TABLE 1. --Open Heart Surgery Group

Patient	Age	Sex	Illness	Operation
1	56	F	Aortic stenosis	Aortic valve replacement
2	32	M	Mitral insufficiency	Mitral valve replacement
3	42	M	Aortic stenosis	Aortic valve replacement
4	29	M	Atrial septal defect	Repair
5	55	F	Pulmonary stenosis	Repair
6	38	M	Aortic stenosis	Aortic valve replacement
7	20	F	Atrial septal defect	Repair
8	56	F	Mitral stenosis	Mitral valve replacement
9	50	M	Aortic stenosis	Aortic valve replacement
10	21	F	Aortic stenosis	Aortic valve replacement
11	57	M	Aortic stenosis	Aortic valve replacement
12	31	F	Aneurysm of aortic arch	Aortic graft (repair)
13	51	F	Aortic stenosis	Aortic valve replacement
14	43	F	Aortic stenosis	Aortic valve replacement
15	42	M	Aortic and mitral stenosis	Aortic and mitral valve replacement
16	17	F	Aortic stenosis	Aortic valve replacement
17	38	M	Aortic and mitral insufficiency	Aortic valve replacement; mitral repair
18	38	F	Mitral insufficiency	Mitral valve replacement
19	41	M	Aortic stenosis	Aortic valve replacement
20	43	F	Aortic and mitral stenosis	Aortic and mitral valve replacement
21	53	F	Aortic stenosis and insufficiency	Aortic valve replacement
22	49	M	Aortic and mitral stenosis	Aortic and mitral valve replacement
23	21	F	Subaortic stenosis	Repair
24	53	M	Aortic insufficiency	Aortic valve replacement
25	34	M	Aortic insufficiency	Aortic valve replacement
26	37	F	Aortic and mitral stenosis	Aortic and mitral valve replacement
27	28	M	Aortic stenosis	Aortic valve replacement
28	45	M	Aortic stenosis	Aortic valve replacement
29	51	F	Aortic and mitral stenosis	Aortic valve replacement and mitral repair
30	56	M	Mitral stenosis	Mitral valve replacement

The general major surgery group (GMS) was composed of patients who (1) had undergone general anesthesia for their surgery and (2) had what the surgeons considered "major surgery" (see Table 2). An attempt was made to select a representative group of major surgery cases (e.g., abdominal, thoracic, gynecologic surgery) although eligible cases were difficult to find. Whereas few problems were encountered in securing the cooperation of the open heart surgery patients, only approximately one out of four of the general major surgery cases was willing (and able) to complete the necessary forms. Severe, debilitating illnessess, unscheduled admissions and emergency surgery accounted for approximately 50% of the potentially eligible patients; in addition, 25% of the potentially eligible patients did not desire to participate in the study.

A total of 30 GMS patients completed the pre-operative and post-operative psychological evaluations; 24 patients (80%) responded to the follow-up questionnaires.

It is quite apparent from the above statements that many factors were operating in the final selection of the membership of the two groups which were beyond the investigator's control.

Criteria for admission to either group involved:

1. U. S. born;
2. Between ages 16-60;

TABLE 2.--General Major Surgery Group.

Patient	Age	Sex	Operation
1	48	F	Cholecystectomy
2	38	M	Colectomy
3	57	M	Resection of aortic aneurysm and "Y" graft
4	53	M	Exploratory thoracotomy
5	58	M	Renal thrombosed arteriotomy and vein patch graft
6	60	M	Perineal biopsy of prostrate and perineal prostatectomy
7	42	F	Cholecystoplasty
8	45	F	Cervical polypectomy-post repair
9	37	F	Cholecystectomy
10	34	F	Mitral commissurotomy
11	33	M	Mitral commissurotomy
12	52	F	Mitral commissurotomy
13	33	F	Mitral commissurotomy
14	25	F	Mitral commissurotomy
15	55	F	Posterior colporraphy
16	51	F	Mitral commissurotomy
17	48	M	Thoracotomy-excision of pericardial cyst
18	42	F	Abdominal hysterectomy and bilateral oopherectomy
19	24	F	Closure of patent ductus arteriosis
20	31	F	Cystocele-trachelectomy
21	48	M	Vagotomy and finney pyloroplasty
22	52	F	Cholecystectomy
23	21	F	Dilation and curettage plus conization
24	40	F	Colostomy revision and repair of incisional hernia

3. No prior history of psychiatric disorder and/or psychiatric hospitalization.

Patients were matched for age (see Table 3). The age limits of sixteen to sixty were selected on the basis of (1) clincial observation indicating that persons under 16 showed no post-operative behavioral disturbance and (2) the issues under consideration being confounded by possible arteriosclerotic changes in the post-operative period in persons over sixty.

The distribution by sex was heavily weighted in favor of females in the general surgery group (see Table 3). The distribution closely conformed to the eligible patient population in that there are few male counterparts to the gynecological surgery patients who comprised a considerable proportion of the total female surgical patient group (see Brodman, et al., 1953; Boake, 1958). Diseases considered to be primarily psychosomatic (e.g., ulcers) were restricted from the group.

Although admittedly there are several unique features in open heart surgery which are not duplicated in general major surgery (e.g., length of surgery, recovery room tenure, amount of blood transfused, length of post-operative hospitalization) in addition to the more obvious differences (cardio-pulmonary bypass, chronicity of illness), the control group nevertheless served as a "surgery baseline" in assessing the psychological effect of surgery per se, on the various dimensions under

TABLE 3. --Age and Sex Distribution of Open Heart and Major Surgery Patients.

	Pre-operative		Follow-up[a]	
	OHS	GMS	OHS	GMS
		Age		
Mean age	40.53	40.83	40.93	42.83
Mean age males	41.41	46.82	42.33	49.38
Mean age females	39.53	37.37	39.53	39.56
		Age Distribution		
16-30 years	7	7	6	3
31-45 years	13	11	13	10
46-60 years	12	12	11	11
		Sex		
Males	17	11	15	8
Females	15	19	15	16

[a]Results based on follow-up subjects only.

consideration. As most psychological test variables have been validated on "normal" non-medically hospitalized patients, it was necessary to control for "deviant" test performance which might possibly be attributed to the stress experience of surgery per se.

All patients were asked if they wished to participate in a voluntary program designed to asses the changes which take place in peoples' lives as a result of surgery. All procedures were carefully explained with the assurance that all materials obtained would be used in strictest confidence.

Patients were evaluated during three periods:

1. Pre-operatively;
2. Post-operatively;
3. Three to seven months post-surgically (follow-up).

The pre-operative and post-operative sessions were held on the surgical wards of the University Hospital. The follow-up materials were mailed to the patients with a covering letter explaining explicit instructions as to how the forms were to be completed (see Appendix A).

The latter procedure was adopted when it became clear that most of the open heart surgery patients lived at too great a distance for either the patient to return to the hospital or for the examiner to visit the patient at his home. The alternative of accepting only local patients (e.g., within a radius of 200 miles from the hospital) for the study would have grossly diminished the size of the sample.

All patients were evaluated two to five days prior to surgery. The brief latency between examination and surgery was made necessary by the hospital admissions policy of admitting most patients no more than three days prior to surgery.

Selection of Psychological Instruments

The psychological instruments employed in Periods 1 and 3 were:

1. The Minnesota Multiphasic Personality Inventory;
2. The Cornell Medical Index;
3. The Taylor Manifest Anxiety Scale;
4. A modified version of the Wechsler Memory Scale (subtests I, II, III, Va and Vb). This scale was not administered during period 3.

The Minnesota Multiphasic Personality Inventory (MMPI)

The Minnesota Multiphasic Personality Inventory (MMPI) is a 566-item personality schedule designed to elicit personality characteristics along continua reflecting psychiatric diagnostic nosology (e.g., hysteria, depression, hypochondriasis, psychopathy, paranoia, psychasthenia, schizophrenia, and mania).

In addition to the nine traditional scales of the MMPI cited above, the Social Introversion (Drake, 1946), Ego Strength (Barron, 1953), and Dependency (Navran, 1954) scales were scored as additional

variables for the evaluation of post-operative behavioral reactions. For 14 out of the 108 protocols, however, the short form of the MMPI was administered due to time considerations. As the additional scales (including the Taylor Manifest Anxiety Scale) were only approximately 70% complete on the short form, a reliability coefficient was computed on the regular protocols to ascertain the relationship between the first 70% and the remaining 30% of the scales in question. The Social Introversion scale, 64% complete, yielded a reliability coefficient of .82; the Dependency scale, 77% complete, had an r of .81; the Taylor Manifest Anxiety score, 74% complete, indicated a correlation of .75. All the above are within the test-retest reliability limitations for the individual scales. Ego Strength, however, with 70% of the form completed, yielded a correlation coefficient of only .43. This scale, therefore, was not used with the 14 protocols in question. The scores for the 14 protocols on the other three scales (Si, Dy and TMAS) were interpolated (using the figures cited above) for the purpose of obtaining a prorated score to be used in the statistical analyses of the data.

Several studies have utilized all or part of the MMPI in personality evaluations of various illnesses (including valvular heart disease) as well as major surgery. Wiener (1952) studied several groups of acutely and chronically ill patients, using the MMPI in an attempt to clarify the role psychological factors played in the assessment

of various physical illnesses. Findings indicated that the group with valvular heart disease had many symptoms of emotional disturbance that were primarily neurotic in character. The mean profile in this group indicated hysteria and depression scores to be highest among the various illness groups, with hypochrondriasis second only to the ulcer group.

Giller (1962) found Barron's Ego Strength Scale (Es) highly predictive of speed of recovery from major surgery ($P < .05$). Zukin and Weiner (1960) using the MMPI with chronic duodenal ulcer patients reported the degree of emotional disturbance manifested pre-operatively to be negatively correlated with success of surgery (i.e., MMPI profile indicating moderate or severe neuroticism was predictive of unfavorable result from the operation). On the other hand, Schneider, et al. (1950), did not find the MMPI to differentiate good from poor recovery following surgery.

Heiskell, Rhodes and Thayer (1959) concluded that the degree of profile deviation on the MMPI was more closely correlated with severity of symptoms rather than specific disease entity. Therefore, personality patterns were related to degree of emotional stress as indicated by severity of illness.

In the present study, the MMPI, as well as the other psychological measures, was used to evaluate relative psychological adjustment

as compared with the control group and relative changes which occurred between the pre-operative and follow-up sessions (these changes presumably due to the effects of surgery).

The Cornell Medical Index

The Cornell Medical Index is a 195-item questionnaire devoted to various physical and emotional symptoms (see Brodman, et al., 1952, 1953). The format employs the traditional "review of systems" medical history approach, i.e., eyes and ears, respiratory system, cardiovascular system, digestive tract, musculoskeletal system, etc.; a general medical information section, including frequency of illness, fatigability and miscellaneous illness, as well as a series of 57 questions pertaining to moods and feelings ("psychiatric" items).

Several investigators have found the CMI useful in differentiating medical patients from psychiatric patients as well as being helpful in the more traditional medical diagnostic functions. Matarazzo, Matarazzo and Saslow (1961), using the total number of positive responses, were able to successfully identify psychiatric patients as having consistently higher scores than medical patients. Further, they found the number of "psychiatric" items endorsed was highly correlated with the number of "physical" symptoms ($r = .59$). The hypothesis suggested by the above involves the concept of total illness, i.e., the state of health or illness is a condition of the total organism rather than of one or more isolated systems.

Bard and Waxenberg (1957) attempted to predict psychogenic post-operative invalidism on the basis of pre-operative CMI scores. Using an independently judged group of psychogenic post-operative "invalids," the authors were only able to predict with 60% to 65% accuracy, using the critical score of 30 or more positive replies suggested by Brodman, et al. (1952), and others. They concluded that the usefulness of the CMI was limited in predicting psychogenic post-operative invalidism.

Knox (1963a), in a study involving closed heart surgery patients, found that by employing a critical score of 30 or more positive responses for the total score and ten or more positive responses for the psychiatric section, statistically significant differences between "normal psychological reaction" and "psychiatrically disturbed" post-operative patients were obtained. In predicting post-operative psychiatric disturbance on the basis of pre-operative scores, only the psychiatric section was found to be of limited value. A score of ten on this section indicated psychiatric disturbance may be anticipated; there was, however, a 20% misclassification both ways (false positives and false negatives).

The Taylor Manifest Anxiety Scale

The Taylor Manifest Anxiety Scale is a 50-item questionnaire derived from selected MMPI items which was designed to elicit both psychological and physiological symptoms of anxiety (see Taylor, 1953).

Research conducted with this scale has substantiated its usefulness in differentiating psychiatric from medical patient groups (Matarazzo, Guze, and Matarazzo, 1955). Taylor (1953) obtained test retest reliability coefficients of .89 (three weeks) to .82 (five months). She also found highly significant differences between "normals" (median score = 13; n = 1971) and psychiatric patients (median score = 34; n = 103).

The Wechsler Memory Scale (Modified)

The modified Wechsler Memory Scale was administered during the pre-operative examination for the purpose of serving as a "mental status baseline" (see Appendix B). In this manner any pre-operative deficiencies in the areas measured by this instrument (biographical and current information, simple orientation, immediate memory, mental control) were considered when evaluating post-operative response to this scale.

Post-Operative Procedures

The first two weeks post-operatively comprised Period 2 in the design of this study. During this period, all patients were subjected to a brief (five minutes) mental status examination every other day (e.g., days 2, 4, 6 . . . 12, 14, or days 1, 3, 5, . . . 11, 13). Although a more thorough evaluation would have been highly desirable,

it was ascertained through a preliminary survey that anything more elaborate was too taxing to the patient. To compensate in part for the brevity of this examination, the attending physician's and nurses' notes were carefully scrutinized, with any information concerning the patient's mental status being duly recorded as part of the patient's post-operative record. The nurses were instructed by the experimenter to include examples wherever possible of any deviant behavior noted.

Most other pre-post surgery studies cited involved post-operative examinations two or more weeks after the operation. As these post-operative reactions were only rarely present after two weeks post surgery, in many instances only casual observational and anecdotal evidence was used for the crucial "reactor/non-reactor" dichotomy. One of the interesting aspects of the present investigation was the series of brief examinations conducted with each patient beginning on post-operative day 1 or day 2. In this manner, a more accurate perspective, based on standardized stimuli, was obtained of the patient's reactions during this crucial period.

The data collected in this manner was independently judged by three psychologists including the examiner. The basic decisions involved were: (1) Did the patient show any difference between pre-operative and post-operative performance, and (2) If so, of what magnitude was the difference noted? As the primary objective in this section of the study was to separate those persons who had a "normal" recovery from surgery

from those who displayed a well-defined post-operative behavioral reaction, it was necessary to establish a category system based on type of post-operative behavior noted. Performance was rated on a three-point scale:

1. Normal recovery from surgery--this included incidents of mild confusion which would be consistent with the considerable fatigue and heavy medication noted post-operatively.

2. Severe confusion--this category was constructed for those patients who indicated lowered performance on simple rote memory and immediate recall tasks with loss of orientation for time and/or place (as compared with pre-operative performance). These patients suffered at times from illusions, but general social responsiveness was appropriate.

3. Bizarre, inappropriate behavior--this category was characterized by generally lowered or grossly uneven performance in all areas, including loss of orientation in at least two of the three spheres (time, place, person). This behavioral category included the presence of bizarre, inappropriate ideation and behavior suggestive of psychosis (e.g., hallucinations, delusions, severely regressed behavior).

A distinction between categories 2 and 3 was necessitated by the observation that quantitatively similar scores tended to obscure the considerable differences in qualitative performance. These qualitative differences suggested the presence of two distinct entities, each of which might have unique etiologic and prognostic correlates. The severely confused individual was unable, for example, to remember his age, birthday, the day's date or place, and communicated this to the examiner. The patient exhibiting bizarre, inappropriate ideation

would give the date as May 26, 1938, his birthdate as June 24, 1946, his age as 43 years and his present location as Massachusetts General Hospital in Oswego.

Patients evidencing Category 2 and 3 reactions were considered together as the "reactor" group. Although it was hoped that patients in categories 2 and 3 could be separated into two groups in a special analysis to determine if any significant differences existed between them, the paucity of category 2 patients (a total of four patients) made this statistically infeasible.

RESULTS

The data obtained on all patients are presented in Tables 4 and 5 in summary form. Initial analysis of the data was accomplished through the use of a product moment correlation computer program for the IBM 7072. As all pre-operative and post-operative variables were correlated with each other for both groups, the data are too voluminous (17,556 correlations) to present here. Excerpts of relevant correlation matrices will be presented where appropriate.

As can be seen from inspection of the figures in Table 5, there are significant differences between the open heart surgery group and the general major surgery group in those variables related to the surgery itself (e.g., length of surgery, post-operative hospitalization). Although this makes valid comparisons somewhat tenuous, the general major surgery group was incorporated to determine the effect of surgery per se on the psychological measures used. As noted in Table 4, there appears to be a relatively high degree of stability on most measures in the general major surgery group, as judged by the means and test-retest reliability coefficients of the variables under consideration. (Exceptions to this are Ma and Pt, which have low reliability coefficients in both groups.) These

TABLE 4.--Mean Scores and Reliability Coefficients on Psychological Measures for Open Heart Surgery and General Major Surgery Groups.

	Pre-Operative		Follow-up		Test-Retest Reliability Coefficient	
	OHS	GMS	OHS	GMS	OHS	GMS
MMPI[a] L	52.2	53.7	51.8	52.3	.887	.620
F	51.9	52.0	51.2	51.6	.373	.758
K	57.1	58.8	60.0	59.8	.763	.786
Hs	62.8	61.7	58.2	61.1	.410	.635
D	59.1	62.4	57.6	62.0	.710	.725
Hy	64.1	63.3	61.3	62.8	.597	.707
Pd	56.7	59.3	58.8	58.1	.515	.719
Mf	52.5	51.2	51.5	49.5	.640	.822
Pa	54.3	54.5	54.5	54.7	.228	.596
Pt	55.3	56.2	56.5	56.6	.454	.473
Sc	54.6	53.7	56.4	56.4	-.185	.602
Ma	51.4	48.3	52.6	47.3	.713	.587
Si	52.8	56.6	51.0	56.6	.808	.828
Es	52.2	51.2	54.3	52.4	.482	.863
Dy	49.0	49.9	47.1	47.8	.816	.687
TMAS	16.20	16.42	13.40	14.67	.705	.699
CMI L-R	6.53	8.25	5.37	7.33	.644	.807
TOTAL	28.50	31.00	24.60	29.63	.707	.880

[a]MMPI scales expressed in "T scores."

TABLE 5.--Mean Values on Age and Surgery Variables for Open Heart Surgery and General Major Surgery Groups.

	OHS	GMS	Level of Significance
Age	40.90	42.79	NS
Length of surgery	7.13	3.76	P <.01
Bypass	1.91	-	-
Post-operative hospitalization	23.80	8.75	P <.01

correlations were computed for the purpose of comparing the "surgery baseline" (the general major surgery group) with the experimental group in terms of consistency of response. Therefore, only low test-retest reliability coefficients in the open heart surgery group which were not reflected in the control group should be considered as having proceeded from the unique experience of open heart surgery.

The open heart surgery group, on the other hand, had several other low test-retest reliability coefficients, which would indicate that something (presumably the surgery and its psychological concomitants) had happened in the interim between the two examinations which caused differences in test-retest performances. As outlined in the Procedure chapter, to evaluate critically this group, the open heart surgery group was dichotomized into "open heart reactor" and "open heart non-reactor" groups (see Table 6). Agreement among

TABLE 6.--Mean Scores on Psychological Measures for Open Heart "Reactor" (OHR) and Open Heart "Non-Reactor" (OHNR) Groups.

		Pre-Operative		Follow-up	
		OHR	OHNR	OHR	OHNR
MMPI[a]	L	49.64	54.38	48.71	54.44
	F	52.21	51.63	51.86	50.69
	K	58.36	56.00	61.00	59.19
	Hs	66.14	59.94	62.57	54.38
	D	61.07	57.44	60.50	55.06
	Hy	64.07	64.19	63.28	59.50
	Pd	58.07	55.50	58.00	59.44
	Mf	55.93	49.56	52.86	50.38
	Pa	57.14	51.19	53.57	55.38
	Pt	55.93	54.81	57.43	55.69
	Sc	54.64	54.56	57.86	55.19
	Ma	50.71	53.19	50.64	54.31
	Si	53.14	52.44	52.86	49.31
	Es	48.20	56.20	54.14	54.38
	Dy	48.79	49.25	47.78	46.56
TMAS		15.14	17.13	13.43	13.38
CMI					
L-R		6.57	6.50	5.36	5.38
TOTAL		27.57	29.31	26.07	23.31

[a]MMPI scales expressed in "T"-scores.

judges categorizing patients by reactions was extremely high (perfect agreement on all but two cases; a re-evaluation of the two patients in question placed one in the "reactor" group and one in the "non-reactor" group). Since only one case in the general major surgery group was adjudged to be eligible for the "reactor" category, no separate "reactor" category was constructed for this group.

As the sex distribution was skewed as a result of dichotomizing the open heart surgery group into "reactor" and "non-reactor" categories, a careful analysis of this data was undertaken, using the Chi-square test as a measure of statistical independence (see Table 7).

TABLE 7.--Sex Distribution in Open Heart "Reactor" (OHR) and Open Heart "Non-Reactor" (OHNR) Groups.

Sex	OHR	OHNR
Male	9	6
Female	5	10

$\chi^2 = 1.2052$ (not significant)

$\phi = .20$

Although no statistically significant difference was obtained on the sex variable ($\chi^2 = 1.2052$, with Yates correction), this may have been due in part to the small number of cases in each cell (see

Table 7). The suggested trend of more males having reactions (64.3% of OHR) than females has been corroborated by Blachly (1964) who noted that 64.6% (51 out of 79) of his "open heart reactor" group was male. This data should be considered suggestive if not definitive in attempting to isolate the factors contributing to post-operative behavior reactions.

Age, on the other hand, was found to be correlated moderately ($r = .460$; $P < .05$) with "reaction" (see Table 9). As can be observed from inspection of Tables 8, the differences between open heart

TABLE 8.--Mean Values on Age and Surgery Variables for Open Heart "Reactor" (OHR) and Open Heart "Non-Reactor" (OHNR) Groups.

	OHR	OHNR	Level of significance
Age	46.71	35.81	$P < .05$
Length of surgery	7.66	6.66	NS
Bypass	2.28	1.59	$P < .05$
Post-operative hospitalization	27.93	20.19	$P < .05$

"reactor" and "non-reactor" groups on variables which indirectly measured physical stress factors in surgery [such as time spent on the "heart-lung" machine ("bypass") and post-operative hospitalization] were of sufficient magnitude to be considered statistically

TABLE 9.--Point Biserial Correlations of Pre-Operative Experimental Variables with Post-Operative Behavioral Reaction in the Open Heart Surgery Group.

Pre-Operative Variables	Correlation	Level of Significance
Hs	(.352)	not significant
Mf	(.312)	not significant
Ba	(.357)	not significant
Es	(-.476)	$P < .05$
Length of surgery	(.342)	not significant
Bypass	(.394)	$P < .05$
Age	(.460)	$P < .05$
Post-operative hospitalization	(.446)	$P < .05$

significant ($P < .05$). Of greater significance to the objectives of this study, however, was the emergence of the Ego Strength scale as having a moderately inverse relationship with "reaction" ($\underline{r} = -.476$; $P < .05$).

As the age and Ego Strength variables were assessed pre-operatively, the possibility of constructing an equation that could predict post-operative behavioral reactions through a multiple regression analysis (using the linear discriminant function technique) was explored. This method was deemed most appropriate in that it would produce a weighted constant for each of the variables which would be commensurate with that proportion of the total variance accounted for by each variable in its relationship to "reaction."

Only 25 of the original 40 variables were used in this analysis. Those variables related to operative procedures or post-operative indices (e.g., length of surgery, bypass, post-operative hospitalization) were excluded, as only pre-operative measures were desired with respect to predicting a post-operative behavioral reaction prior to surgery. Further, several subtests of the Cornell Medical Index did not have a sufficient range of entries to prevent the computer program from handling them as dichotomous variables (the program for the linear discriminant function will only accept continuous variables) and so they also were omitted from the regression analysis.

The results of the multiple regression analysis are summarized in Tables 10 and 11.

It appears from inspection of the data presented in Table 10 that through use of the linear discriminant function, the 25 variables employed are capable of 100% discrimination between "reactor" and "non-reactor" patients. The highest score attained by the "non-reactor" group was 8.758, whereas the lowest score in the "reactor" group was 8.981, indicating no overlap between the two groups. As these data are based on information obtained several days prior to surgery, it appears that successful prediction of the post-operative behavioral reaction can be accomplished without recourse to factors directly related to the surgery per se (see Table 11 for regression weights).

Unfortunately, the computation of the precise relative importance of each variable in the predictor equation is unfeasible due to the involved statistical problems inherent in such an undertaking. A method of ranking the several most important contributors to the total variance was devised using the difference scores between means of the "reactor" and "non-reactor" groups (d_i). This procedure was necessary as the linear discriminant function analysis uses the difference between the means of the two groups (d_i) as the right hand member of the multiple regression equation rather than the usual $\Sigma x_i y$ found in basic multiple regression analyses. The basic goal of multiple regression analysis

TABLE 10.--Multiple Regression Analysis Values for Individual Patients in the Open Heart "Reactor" (OHR) and Open Heart "Non-Reactor" (OHNR) Groups.

OHR Patient Number[a]		OHNR Patient Number[a]	
1	9.54651050	26	8.75796810
11	9.43740600	28	8.68599620
3	9.40526580	19	8.59630070
5	9.36455860	30	8.59378450
13	9.36306900	29	8.57029810
9	9.33844860	24	8.53084930
8	9.25026900	27	8.47732460
4	9.23284590	21	8.44065300
2	9.22993230	15	8.39288780
14	9.17333020	25	8.37474130
10	9.15368060	16	8.32378420
12	9.14365970	20	8.28749150
7	8.99288510	22	8.28522510
6	8.98121560	23	8.22241030
		17	8.20818700
		18	8.16223310
F = 1.206; not significant		t = 13.1442; P < .01	

[a]OHR group = patients 1-14; OHNR group = patients 15-30.

TABLE 11.--Regression Weights for Each of 25 Variables Utilized in the Prediction Equation.

	Variable	Z
MMPI	L	-1.02185690
	F	1.76631660
	K	2.17063120
	Hs	-1.14269930
	D	1.63252150
	Hy	-0.04429272
	Pd	-1.10825640
	Mf	0.83659381
	Pa	-0.75647357
	Pt	-1.34113150
	So	-0.01394282
	MA	0.75288908
	Si	0.00255910
	Es	0.54594002
	Dy	1.09384100
CMI	Ears and Eyes	9.89053790
	Cardiovascular	3.72447870
	Habits	-2.37034290
	Inadequacy	1.93682350
	Anxiety	8.11799990
	Anger	-7.25126350
CMI	TOTAL	-0.53065382
	Psychiatric	1.80321740
TMAS		-1.82806540
Age		0.28619413

involves attempting to maximize the differences between groups; therefore, the most important variable is that which shows the greatest difference (d_i) between the means of the two groups--in this instance, Age. Although it is usually impossible to separate the remaining variables in terms of ranked importance, a major cluster of five MMPI scales emerged as being of much greater significance than the remaining 19 variables. Ego Strength, Paranoia, Hysteria, Hypochondriasis and Masculinity-Femininity were seen as equal significant contributors to the predictor equation.

With respect to the MMPI scales, the conclusion drawn from the data presented is that no one scale has major predictive attributes in itself, but that gross evaluation of the total profile is prognostic of post-operative behavioral reactions. To investigate the merits of this hypothesis, a profile configuration analysis of the total MMPI was undertaken.

Upon inspection of Figures 1-8, it is apparent that the differences between groups are subtle. Although the probability of the significance of obtaining any significant results from a series of "t" tests to determine the significance of the difference between means of "reactors" and "non-reactors" is not beyond chance expectations (i.e., one out of 20), there appears to be a consistent relationship between the pre-operative open heart "reactor"/"non-reactor"

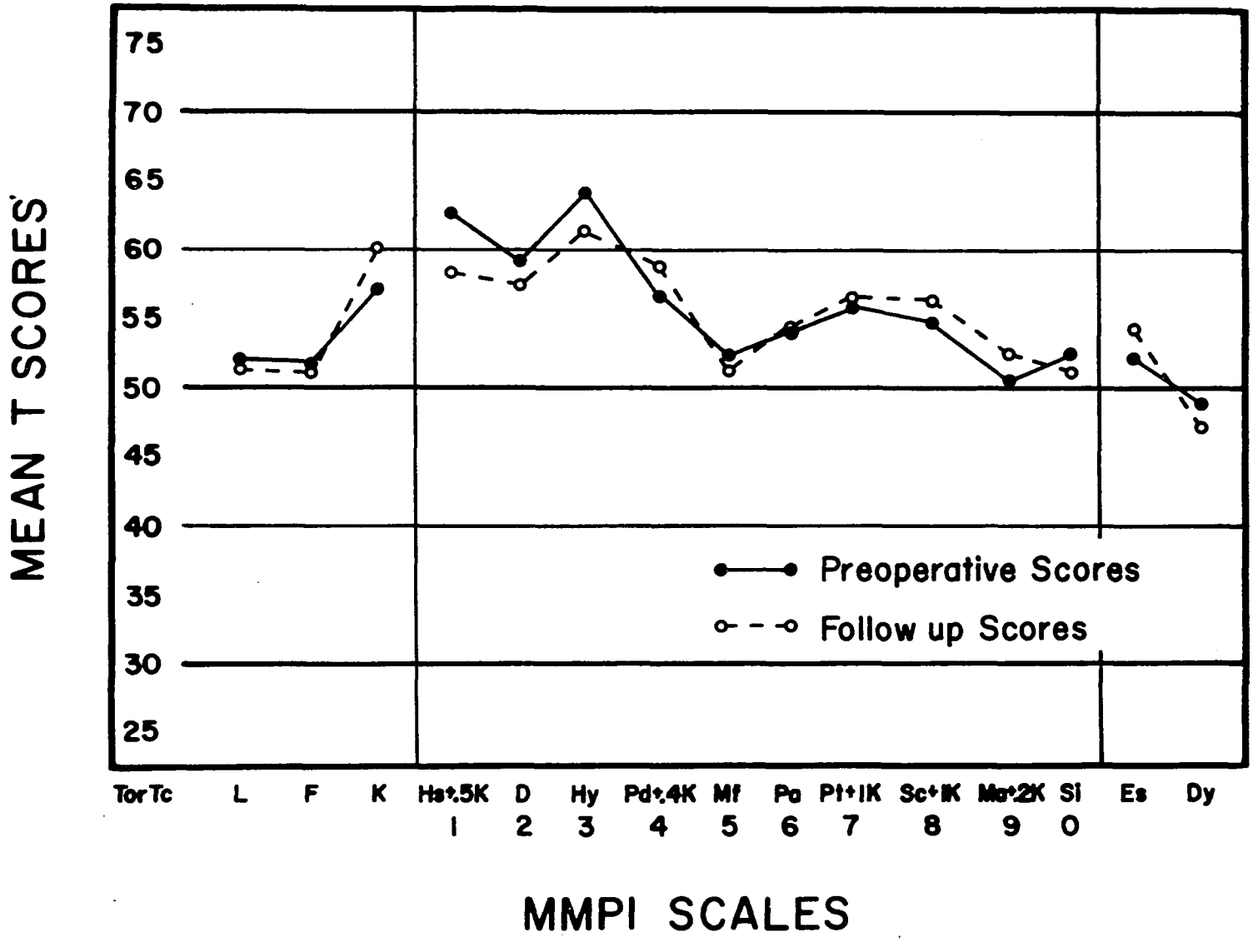

Fig. 1.--Mean MMPI Profiles of Open Heart Surgery Patients for Pre-Operative and Follow-up Periods.

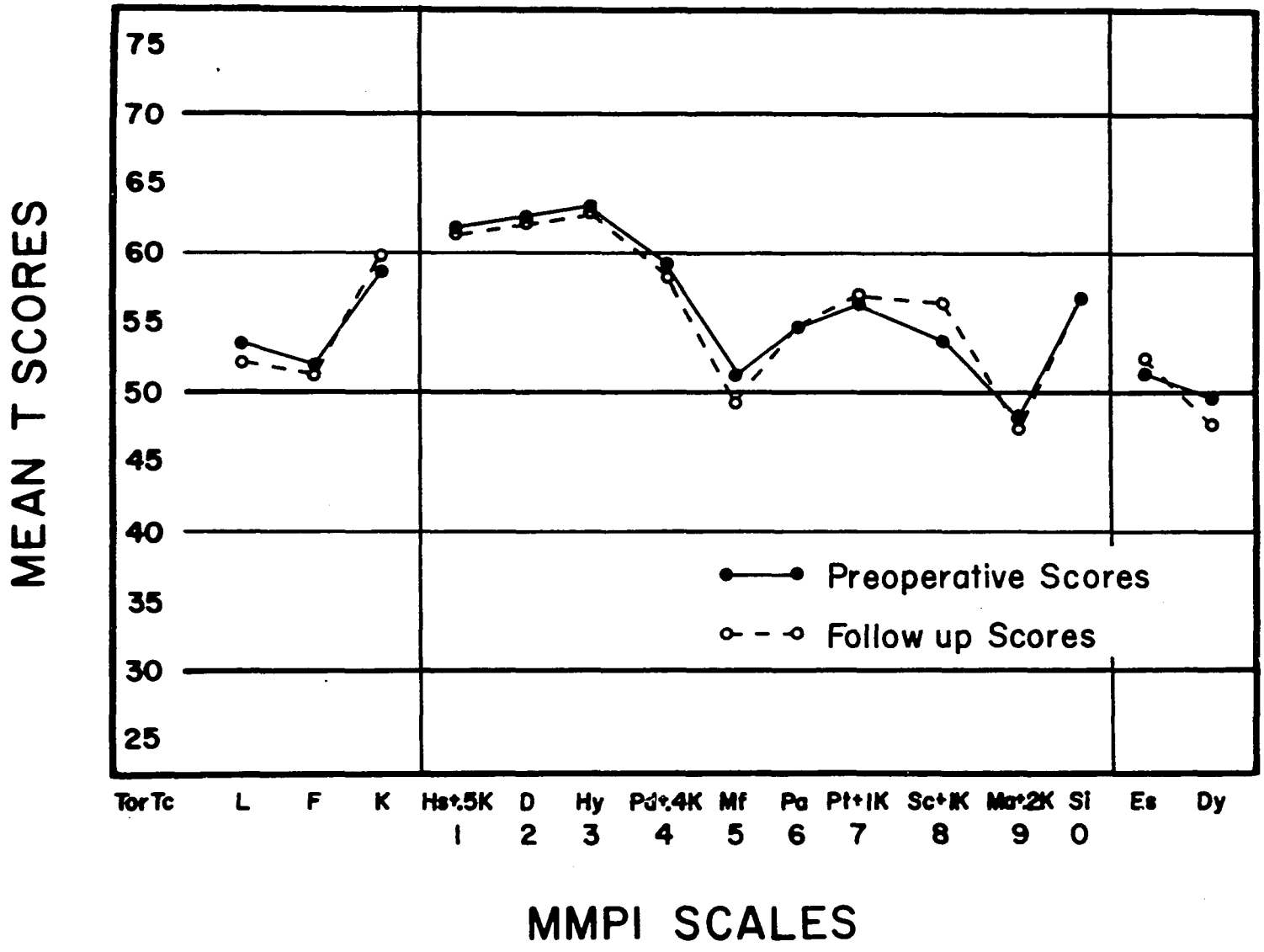

Fig. 2.--Mean MMPI Profiles of General Major Surgery Patients for Pre-Operative and Follow-up Periods.

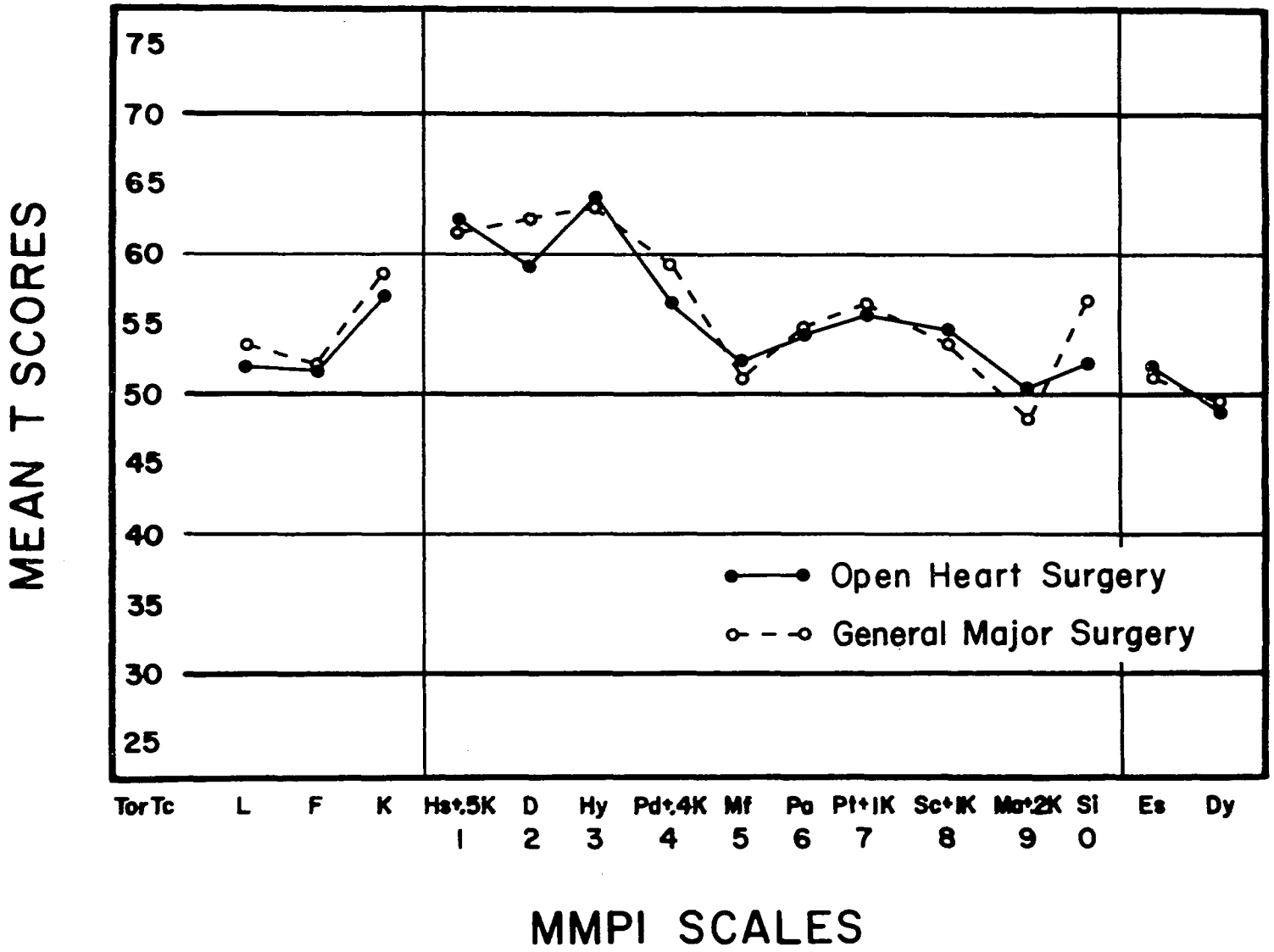

Fig. 3.--Mean Pre-Operative MMPI Profiles for Open Heart Surgery and General Major Surgery Groups.

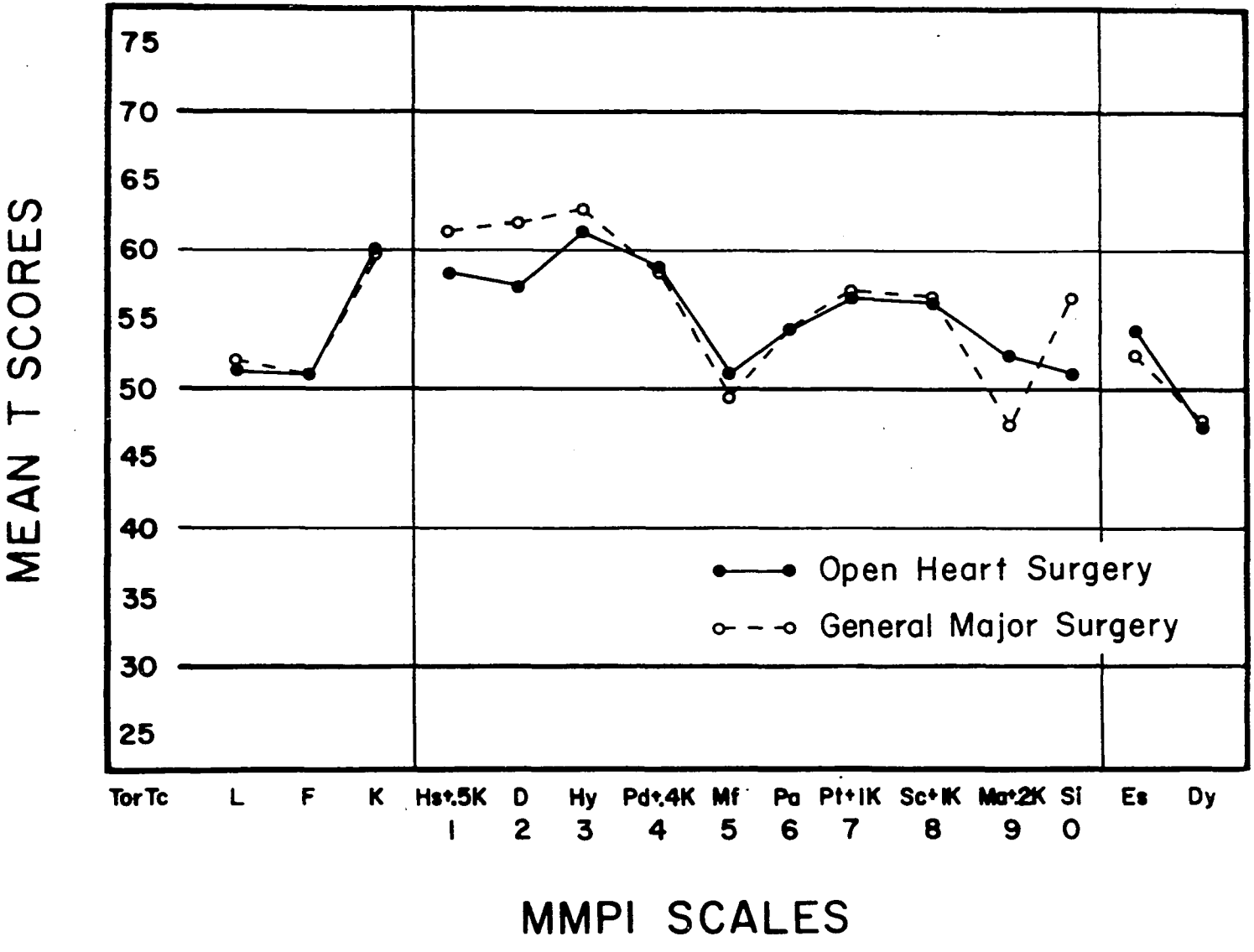

Fig. 4.--Mean Follow-up MMPI Profiles for Open Heart Surgery and General Major Surgery Groups.

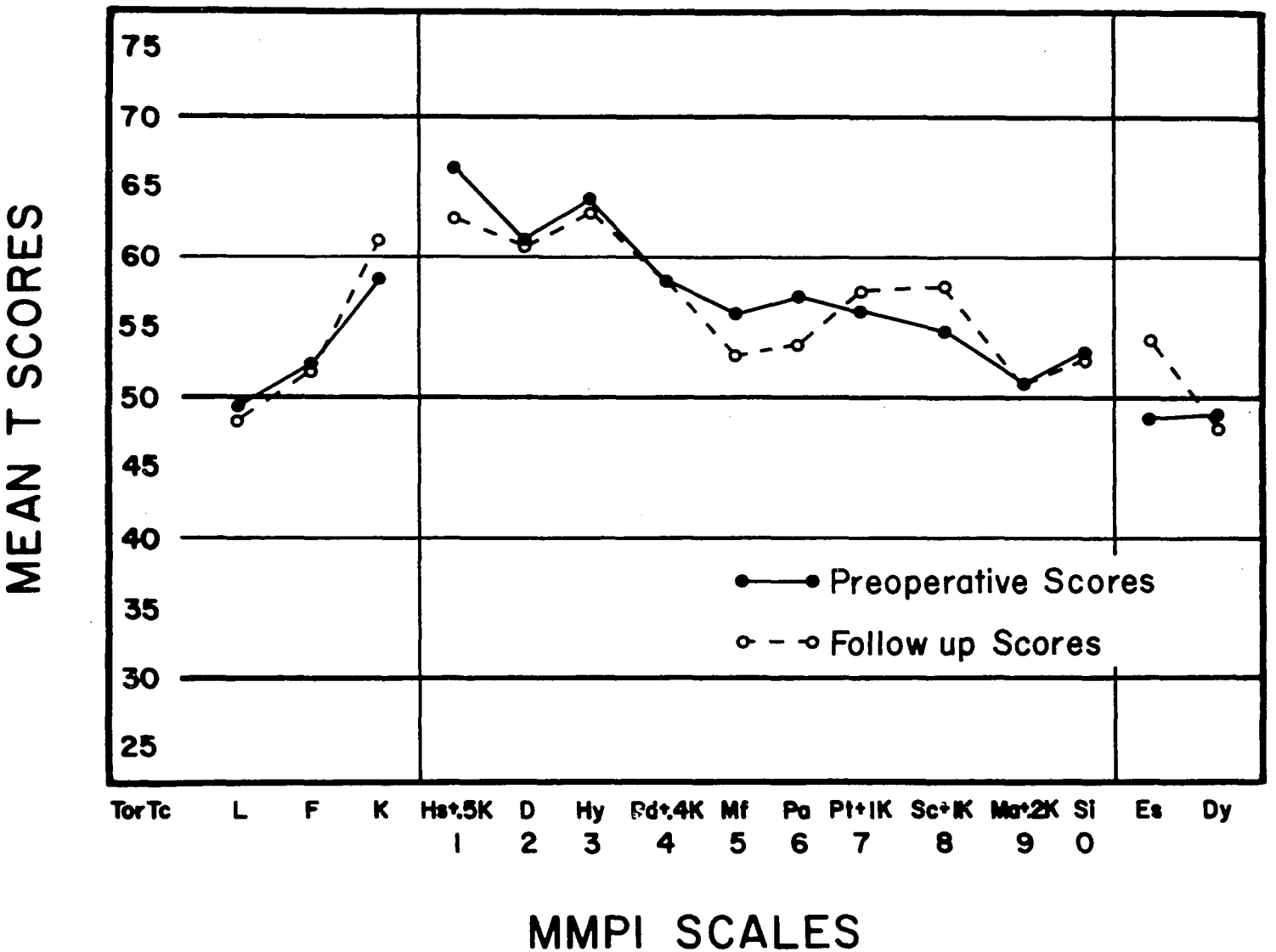

Fig. 5.--Mean MMPI Profiles of Open Heart "Reactor" Patients for Pre-Operative and Follow-up Periods.

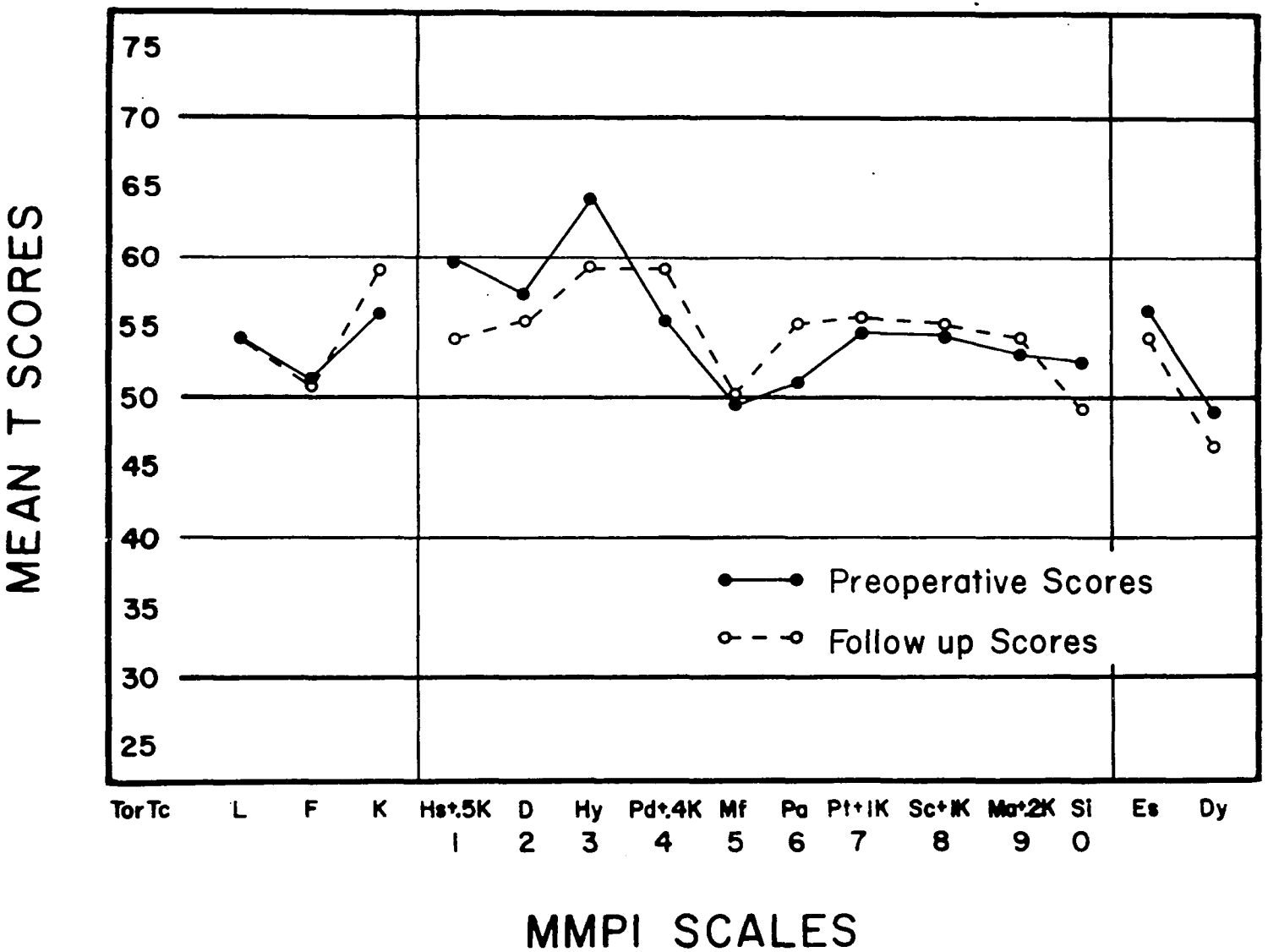

Fig. 6. --Mean MMPI Profiles of Open Heart "Non-Reactor" Patients for Pre-Operative and Follow-up Periods.

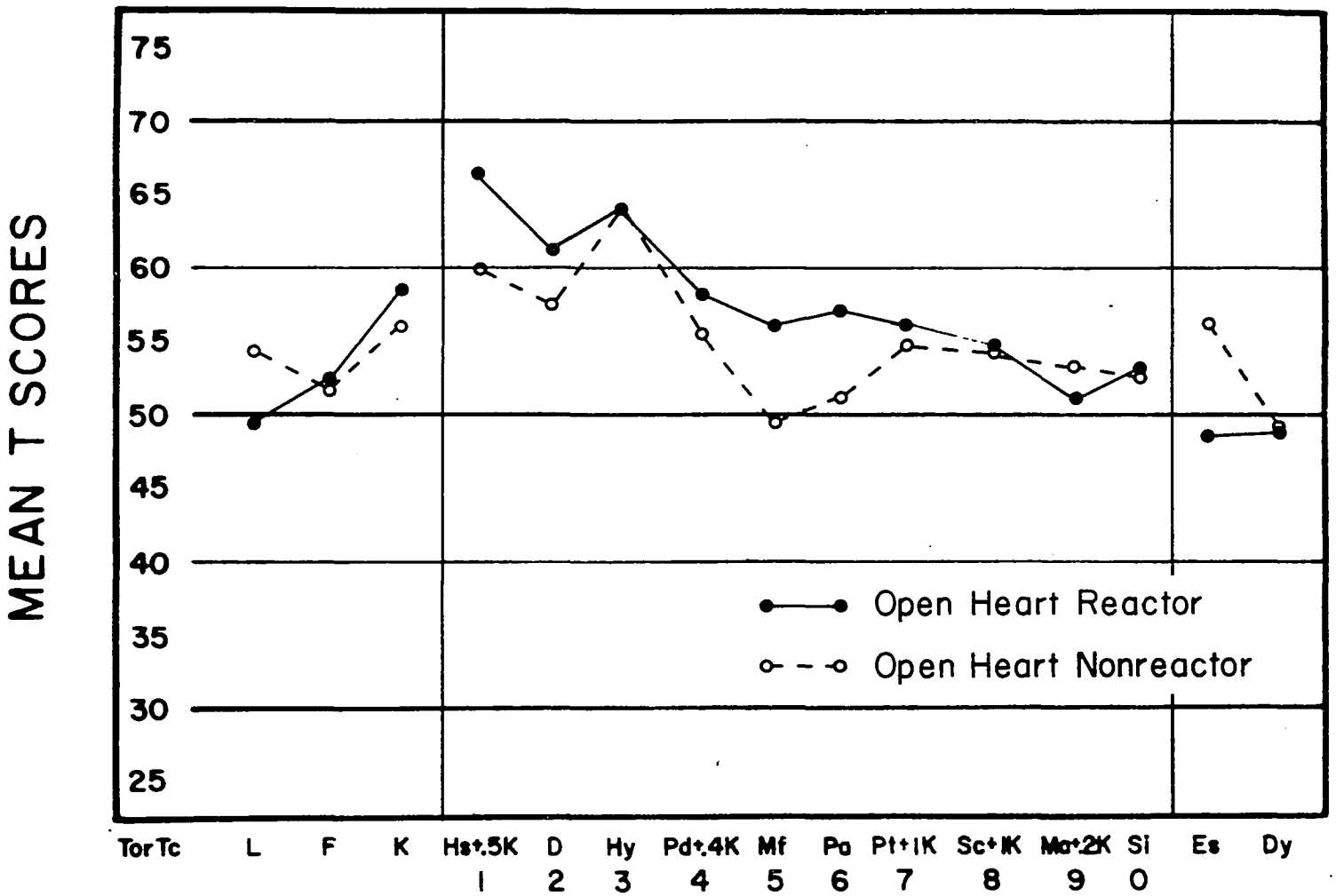

Fig. 7.--Mean Pre-Operative Profiles for Open Heart "Reactor" and "Non-Reactor" Groups.

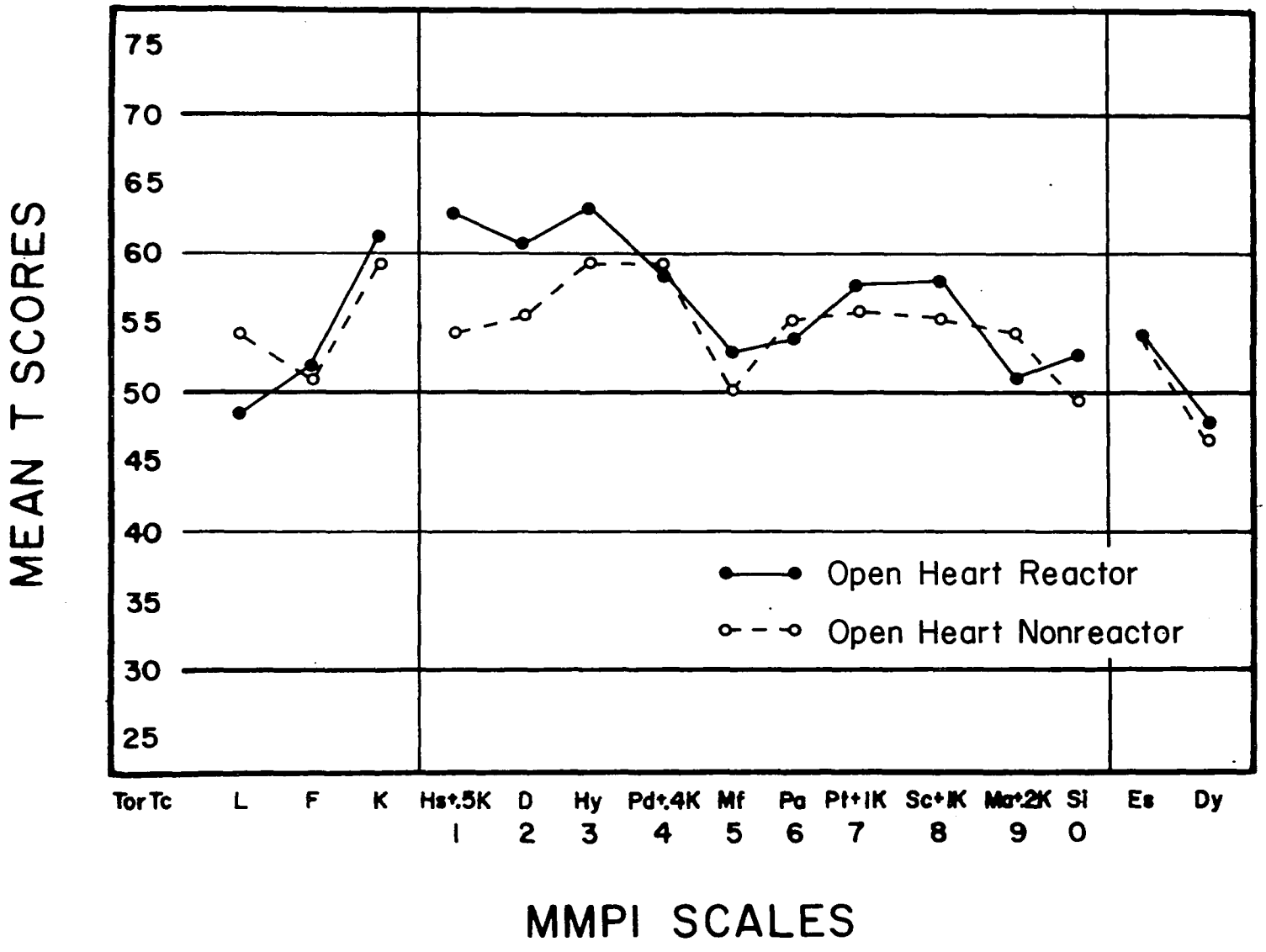

Fig. 8.--Mean Follow-up MMPI Profiles for Open Heart "Reactor" and Open Heart "Non-Reactor" Groups.

profiles (Figure 7) which suggests an analysis of the profile patterns themselves rather than individual subscales.

In accordance with the above observations, four analyses of the profile configurations were attempted (see Table 12).

TABLE 12.--MMPI Profile Configuration Analysis of Protocols from the Open Heart "Reactor" (OHR) and Open Heart "Non-Reactor" (OHNR) Groups.

Variable	χ^2	Level of Significance
	Pre-Operative	
Relative profile elevation	11.4556	P < .05
Two highest scales	9.4950	NS
Low scale	8.4800	NS
Highest pair of scales	5.5000	NS
	Follow-up	
Relative profile elevation	5.6017	NS
Two highest scales	9.0962	NS
Low scale	5.9232	NS
Highest pair of scales	1.1955	NS

[a]See Appendix A for detailed χ^2 analysis of the above variables.

"Elevation" was measured by the number of scales in each of five "T"-score categories. These categories were arranged in terms

of increasing psychopathologic deviation. As noted in Table 12, the open heart "reactor" group had a significantly higher number of elevated MMPI scores pre-operatively compared to the "non-reactor" group. As this observed difference is not reflected in the follow-up studies (see Table 12; Fig. 8), it must be assumed that a differential diffuse reaction to stress is responsible for the aforementioned pre-operative findings.

The diffuse nature of this difference is aptly illustrated by the lack of positive findings upon further discriminative analysis of the data (see Table 12). Attempts to isolate the two highest scales, the lowest scale and the highest pair of scales resulted in non-signifcant findings with both the pre-operative and the follow-up data.

The type of open heart surgery was also considered in the analysis of the "reactor"/"non-reactor" groups (see Table 13). Although

TABLE 13.--Type of Open Heart Surgery as Related to Post-Operative Behavioral Reaction.

No. of Cases	Operation	Reaction %
18	Aortic valve replacement	9 (50%)
4	Mitral valve replacement	3 (75%)
3	Aortic and mitral valve replacement	2 (66%)
5	Open-heart repair	0 (0%)

the number of entries in each cell is sparse, the evidence suggests valve replacement to be more conducive to post-operative behavioral reactions as compared with open-heart repair (using cardio-pulmonary bypass in both instances). It also appears evident through inspection of Table 13 that no significant differences exist with respect to the location of the valve replaced. All of this data, however, remain suggestive due to the paucity of entries in each cell.

The variety of ways to evaluate the data has by no means been exhausted. Other variables by which one could hope to classify further the role and meaning of the post-operative behavioral reaction (i.e., incidence of rheumatic fever, chronicity of debilitating symptoms) were not included in the main analysis due to the lack of adequate criteria and general agreement among physicians for the classification of the above data. Although in every instance an attempt was made to gather this information, the accuracy of same is open to question (e.g., in several instances the physicians felt that rheumatic fever was the probable cause of the heart damage, although the patient gave no history of such illness). For the above reasons, the data were not evaluated with respect to these variables.

DISCUSSION

The role of psychological factors in medical phenomena is well documented in the literature on psychosomatic medicine. All previous studies have approached these issues primarily in terms of psychological factors playing a major role in the etiology of the organic illness. In the present study, there is little question as to the nature of the organic illness, its etiology, or the necessity for surgery. The physical ailment necessitates an adjustment to chronic illness and usually a severely reduced activity schedule, resulting in considerable dependence upon others in everyday living. The prospect of corrective surgery which will drastically alter living patterns with the ultimate goal of resuming daily activities and responsibilities adds to the consideration of factors involved in preparation for open heart surgery. The occurrence of atypical post-operative behavioral phenomena following surgery has posed the question as to whether these behaviors are in any way related to the ways in which a person may handle the psychological stress generated by the imminence of a life-threatening (and "life-changing") situation. Further reasons for undertaking this study were (1) to assess whether there were psychological factors contributing to the occurrence of these behavioral

phenomena, (2) were these psychological sequalae in any way permanently debilitating to the patient, and (3) was it possible to differentiate open heart surgery "reactors" from "non-reactors" on the basis of pre-operative psychological findings?

Although the results of this study may be discussed with respect to various theoretical positions dealing with psychological stress, certain caution must be observed in generalizing from this to other research findings. For example, the magnitude of response to stress measured in this investigation appears greater than most, as adjudged by the more profound reactions noted. Whereas post-operative behavioral reactions noted in general non-emergency major surgery is only 1:1500 (Knox, 1963b) in open heart surgery the figures are approximately 1:2. Length of surgery (7.13 hours for open heart versus 3.76 hours for general major surgery), post-operative hospitalization (23.8 days for open heart versus 8.75 days for general major surgery) are observations in this study which illustrate major differences in the population and treatment under consideration. Studies such as those by Janis (1958) primarily involve the more subtle nuances of behavior found in general major surgery rather than the "psychotic-like" states which characterize the majority of the "reactor" patients in the present study. Therefore, relatively speaking, the criteria used in the evaluation of the patient population in this study tended

toward molar rather than molecular behaviors and was generally concerned only with the more severe reactions (see criteria in Procedure chapter). Several patients whose mild reactions were considered directly related to the physiological strain of the surgery were not included in the "reactor" group.

Two other factors which suggest caution in the comparison of the results of this study with those of other research might also be included here. Most experimental studies of psychological reaction to surgery cited in previous chapters suffered from either (1) no control group to act as a baseline for the measures employed or (2) post hoc surveys which relied on retrospection and anecdotal evidence in assessing pre-operative status. The latter objection is unavoidable in most instances as the relative frequency of post-operative behavioral reactions in most types of surgery is 1:1500 (Knox, 1963b). With the exception of studies by Matarazzo (1963) and by Zaks (1959), the research data cited in earlier sections of this dissertation were not examined with respect to a surgery control group. Without this baseline, it is difficult to show meaningful relationships within a given study as well as between the studies of different investigators.

In the light of the above considerations, generalizations with respect to other theoretical positions must be made cautiously and with due consideration for differences in criteria used in the various studies.

Perhaps the most interesting result of the present study has been the emergence of psychological factors as being of considerable, if not primary, importance in assessing the incidence of post-operative behavioral reactions. Heretofore, situations of the type investigated in this study usually were considered the exclusive domain of physiologic research into various organ systems to account for the observed phenomena. Although the findings of the present study certainly do not preclude the possibility of organic agents playing some etiologic role in this phenomenon, the results clearly demonstrate the necessity of evaluating the functional resources of the individual in addition to the more traditional organic components.

Of particular significance in corroboration of the above were the comparatively low relationships found between such measures as length of surgery (.342), length of bypass (.394), post-operative hospitalization (.446), and post-operative behavioral reaction. These three factors above all others were considered to be of prime importance in the initial investigations of the post-operative behavioral phenomena. As these factors were more or less considered measures of organic stress, the significance placed upon them in these studies was certainly understandable. Their comparatively minor roles in the present study accentuates the importance of the psychological variables, particularly the variable of Ego Strength as defined by Barron (1953).

Although most psychological measures are imbued with some sensitivity to stress, the Ego Strength variable is perhaps the most direct measure of an individual's capacity to tolerate stress.

As discussed by Barron (1953), the originator of the scale, Ego Strength, although originally designed to predict improvement in psychotherapeutic treatment, was found also to be useful in measuring an individual's capacity for personal resourcefulness and providing some estimate of his adaptability. Included in the description of the ego strength concept are such terms as "feelings of personal adequacy and vitality, a strong sense of reality, emotional outgoingness, and spontaneity, intelligence, physiological stability and good health, permissive morality, " etc. (Barron, 1953). The measurement of such qualities would seem essential in any consideration of the individual's responsiveness to psychological stress. This interpretation appears admirably suited to the findings of the present investigation, i.e., a significant inverse relationship ($\underline{r} = -.476$; $p < .05$) between pre-operative assessment of Ego Strength and post-operative behavioral reaction.

On the basis of this finding, it can be assumed that the individual's reaction to surgery is based in large measure on his ability to respond effectively to overwhelming psychological stress, not to mention the additional burden of post-operative physiological

and biochemical chaos. If the Ego Strength scale is in fact a measure of the constructive forces of the personality, then the degree to which these elements are present will determine whether the individual can maintain his psychological homeostasis or whether he will suffer temporary disorganization.

These hypotheses are supported by Giller (1962) who found the Ego Strength scale to be highly predictive of recovery from surgery. Conceiving of ego strength in terms similar to those listed above, the need to maintain a clear "perceptual field," reality oriented to the situation at hand, was seen as paramount in dealing with the heavy demands made by surgery upon an individual's adaptive powers. The relationship between Ego Strength and post-operative hospitalization in the present study ($r = -.434$; $p < .05$) is congruent with the hypotheses advanced by Giller (1962).

A further confirmation of this issue is discussed by Janis (1958) who concluded that his "poor recovery" surgery groups did not maintain accurate perceptions and reality testing (for a variety of reasons) with the end result being surprise and a feeling of "victimization" regarding their surgery which greatly hampered their recovery.

This view finds support in the present study as cited above. Further, the proposition that those who do not maintain

accurate perception and reality testing recover more slowly is supported by the significant difference observed between the open heart "reactor" and "non-reactor" groups with respect to post-operative hospitalization (27.93 days versus 20.19 days; $p < .05$).

One non-significant relationship bears mention here: the low correlation ($r = -.154$) between post-operative behavioral reaction and anxiety (as measured by the Taylor Manifest Anxiety Scale). This lack of relationship is corroborated by an r of .025 with the Anxiety scale of the Cornell Medical Index. The importance of this lies in the fact that the concept of anxiety has heretofore been considered a major factor in the psychological investigations of medical problems (Zaks, 1959, 1962; Priest, et al., 1957; Boshes and Zaks, 1960). Though this is not meant to imply that anxiety does not exist or is not an important factor in all considerations of this nature, it clearly indicates that anxiety was in no way instrumental in differentiating "reactors" from "non-reactors."

Janis (1958) dealt with this issue in terms of there being a curvilinear relationship between "anticipatory fear" and "post-operative emotional disturbance," i.e., persons who display a moderate degree of anticipatory fear or anxiety will be less prone to develop a post-operative emotional disturbance than those who have either a very high or very low level of anticipatory fear. In

the present study, upon careful analysis of scatterplots of individual scores for each group, no evidence was found to support this hypothesis. This apparent discrepancy may be a result of the differences in criteria used in defining post-operative disturbance, as mentioned above. Anxiety may play a significant role in the more subtle, milder reactions, with the more pathological, disorganized behaviors resulting from a diffuse reaction to stress and being more closely related to such characteristics as discussed under the aegis of ego strength.

Although the above isolated findings were of significance, it was important to devise a method whereby the personality characteristics of the two groups could be evaluated on a multi-dimensional basis. As is well known to researchers and clinicians familiar with the MMPI, the individual diagnostic scales do not provide meaningful information about a person or group. Only through configuration analysis could an unified impression of the similarities and differences between the two groups be obtained.

On the basis of the pre-operative MMPI configural analysis, there appears a discernible difference between open heart "reactors" and open heart "non-reactors." This observation, however, does not take the form of any one scale or grouping of two or three scales; rather, it is the product of the entire configural pattern which indicates a significant difference ($P < .05$) between the two groups. As

this observed difference was not reflected in the follow-up MMPI analysis, the observed pre-operative difference must be considered a temporary reaction to considerable stress which is not present under non-stress (follow-up) conditions. Therefore, given the fact that open heart surgery is a "high-stress" condition, the more elevated MMPI configurations must be considered a reflection of the way in which the stress is perceived by this group, i.e., the objective stress causes a greater reaction (as measured by the elevated MMPI patterns) in those persons who subsequently have post-operative behavioral reactions. These findings are consistent with Janis' exposition on psychological stress in which he considers the individual's pre-operative capability to tolerate stress during the "threat phase" as being directly related to the quality of his reaction during the "post impact victimization" phase (see Introduction chapter).

Given the above set of propositions, it follows that one should be able to predict the occurrence of a post-operative behavioral reaction on the basis of pre-operative data which would be primarily psychological in nature. The above formulations are most definitely meaningful when the protocols are assessed in groups. However, the individual case cannot be handled through this form of analysis; "a predictor equation" would be the only way of assessing the potential of a given patient to have a post-operative behavioral reaction.

As noted in the previous chapter, the multiple regression analysis was totally successful in the determination of a predictor equation achieving 100% discrimination between the two groups (see Appendix C for a detailed discussion of how to implement this method). This was accomplished by using pre-operative variables which would ordinarily be available at least three to five days prior to surgery. The 25 variables used included 16 scales of psychopathology (MMPI), two CMI "organic" scales involving cardiovascular and eye-ear symptoms, several CMI "psychiatric" scales, plus age. (Sex could not involved as the computer program would not accept dichotomous variables.) As can be seen from the breakdown of variables, the overwhelming majority is basically psychological in nature.

The Cornell Medical Index served the dual purpose of assessing both organic and functional states of the individual. Due to various statistical considerations, only two "organic" scales (Eyes and Ears and Cardiovascular) had a sufficient number of positive responses to merit inclusion in the multiple regression analysis. Four of the seven "psychiatric" scales had sufficient entries to be included, which, in itself, is a clue to the comparative values noted in the organic/functional contributions.

The assumption by several of the investigators quoted in the first chapter of this dissertation (Scott, 1961; Zwerling, 1955; Corman, 1958) that patients who experience post-operative behavioral reactions are psychologically disturbed pre-operatively finds partial support in the results of this investigation. On the basis of pre-operative findings, it may be assumed that there is greater evidence of psychopathology among those patients who subsequently "react" than those who do not. However, as determined by the lack of significant differences in the follow-up studies, this appears to be only a temporary state ostensibly brought about by reaction to the objective stress conditions. Further investigation of this issue by psychological studies six months prior to surgery would test the validity of this assumption. However, irrespective of the lack of differences found under non-stress conditions, it must be assumed on the basis of differential reactivity to the stress situation that "reactors" are predisposed to react by virtue of their inabilities to deal effectively with "high-stress" situations.

One must agree, therefore, with Menzer (1957) that the manner in which the patient has handled previous difficult life situations should provide important clues to his effectiveness in dealing with life-threatening surgery.

The issues raised by Lindemann (1941) and Meyer (1958) with respect to the relationship of success of surgery to post-operative

reaction (see Introduction), although extremely important, cannot be dealt with successfully in the present research, primarily because of the nature of the surgery. If the operation was not successful, the patient died. Therefore, for the groups under consideration, this was not a differentiating characteristic. In addition to the above, patients might not know how successful their surgery was for some months because of the long convalescence. Therefore, the quality of their post-operative responses could only be based upon their expectations of what changes might be wrought in the future.

Meyer's contention that psychological behavioral reactions appear most often in successful operations involving removal of symptoms in which the patient has some emotional investment is most congruent with the present findings.

The open heart surgery candidates had in most cases made considerable psychological adjustment over the years to the incapacitating chronic aspects of their illnesses (e.g., Butts and Wachtel, 1961; Briggs and Bellomo, 1959). A few patients spontaneously commented on the positive side benefits of cardiac disease while awaiting surgery in the hospital. Some patients, on the other hand, were very anxious to have a successful operation, summarizing their remarks by stating they would rather die in surgery than have to continue living as helpless, dependent "cardiac cripples." Although all of the above were spontaneous comments

which were not elicited by the investigator, in all instances, these patients reacted as might have been expected; those whose comments indicated they were loathe to relinquish their comfortable niches of dependency (and control of their families through their illnesses) had post-operative behavioral reactions while those who were determined to resume normal lives had no difficulties post-operatively.

One might even hypothesize that this "reaction to health" may be, in fact, portrayed in the post-operative behavioral reaction itself, i.e., in the regressed behavior (incontinence, negativism, "baby talk," child-like petulance, etc.) which is characteristic of most post-operative disturbances (in addition to the more malignant psychopathological symptoms). It must be remembered, however, that these casual observations were based on only a small proportion of the total surgery population and in no way should be construed as definitive. They do suggest possible areas of inquiry for future research and are included here primarily on the basis of their heuristic merit.

The psychological studies of closed heart surgery have provided a suitable baseline on several dimensions with respect to the present research. Incidence of post-operative behavioral reactions on closed heart surgery patients was much lower (4-18.7%) than for open heart surgery (46.7%). Due to the more radical procedures

employed in open heart surgery, the increased psychological stress associated with the relatively high (20%) mortality rate, plus the considerable physiological adjustment necessitated by the introduction of the cardiopulmonary bypass procedure undoubtedly contributed considerably to the high incidence of post-operative behavioral disturbances.

As discussed above, the highly significant role attributed to anxiety in post-operative behavioral reactions in studies of closed heart surgery was not borne out by the results of this investigation. Rather, a diffuse generalized stress reaction appears to be associated with the behavioral phenomenon which bears no relationship to the formal conceptualization of anxiety as defined by the Taylor Manifest Anxiety Scale and the Anxiety Scale of the Cornell Medical Index The non-specific nature of this observed reaction suggests a less formal, albeit more inclusive definition of the psychological reaction to the perceived and imminent danger, i.e., a definition involving inadequate personal resources and lack of adaptability to cope with the present crisis (see discussion of ego strength), in addition to a subtle, but consistent psychopathological deviation in all areas of personality functioning (as measured by the MMPI).

As noted briefly in the previous discussion, the absence of long-term psychological effects (as measured by the MMPI) on those who experienced post-operative behavioral reactions is of considerable

interest. Even though these reactions appear to be of sufficient severity that one would expect some long-range differences, the follow-up MMPI protocols show no significant differences between the "reactor" and "non-reactor" groups. In terms of practical applications, the moral pressure to alleviate the occurrence of these reactions is somewhat reduced with respect to the long-range functional consequences of these reactions. However, future studies of the effects of post-operative behavioral reactions on the intellectual and perceptual areas of the individual may shed further light on this topic.

The emergence of psychological factors as being of primary prognostic importance in the evaluation of behavioral anomalies proceeding from open heart surgery once again affirms the interdependence of functional and organic factors in the assessment of disease. This statement has obvious far-reaching ramifications for further research. Continued exploration of this area (e.g., with respect to chronicity of illness, incidence of rheumatic fever, etc.) will capitalize upon and extend the findings of this initial investigation. Further, the success of this project will hopefully give impetus to investigation into other areas where assessment of psychological factors may bring more comprehensive understanding to selected phenomena in the field of medicine.

APPENDIX A

UNPUBLISHED FORMS

The following forms were designed for this study and are not available in published form.

The form letter was mailed to all patients involved in the follow-up period of this study as part of the packet of materials and instructions.

The two forms of the modified Wechsler Memory Scale were used in the pre-operative and post-operative periods, utilizing an alternating method of administration. One pre-operative and seven post-operative examinations utilized four copies of each form for each patient.

University of Oregon Medical School

3181 S.W. Sam Jackson Park Road • Portland, Oregon 97201
Area Code 503 Tel: 228-9181

DEPARTMENT OF MEDICAL PSYCHOLOGY

As you may remember, several months ago you participated in a psychological study while awaiting surgery at the University of Oregon Medical School. As we discussed at that time, I would be sending you a packet of materials similar to those taken prior to surgery, sometime after your discharge from the hospital.

To complete our records, I would greatly appreciate your completing and returning the enclosed forms within four days after you receive them, if at all possible. An addressed and stamped manila envelope is enclosed for your convenience.

Please read the test instructions carefully ; the same rules for taking these questionaires apply as when you were here at the Medical School Hospital:

(1) Answer the items with respect to how you feel now.

(2) Do not spend too much time on any one item - if you cannot answer it immediately, skip it and return to the skipped items when you've completed the rest of the questionaire.

(3) Please do not discuss any of the items with anyone while taking the test. We are interested solely in your opinion.

As I mentioned during our previous session, all information received from you is held in strictest confidence and under no circumstances is available to anyone without your written permission.

At this time I would like to sincerely thank you for your cooperation in this study. Should you have any questions concerning any phase of this project, please enclose them with the questionaires and I will be happy to answer them.

Sincerely yours,

Stephen M. Weiss
Fellow in Medical Psychology

SW:mt

Memory Scale Form I[1]

I. Personal and current information

Name _____

Date _____

1. Age _____
2. When born _____
3. President of the U.S. _____
4. Before him _____
5. Governor _____
6. Mayor _____

Score _____

Group _____
Pt. _____
Day _____

II. Orientation

Total score: _____

1. Year _____
2. Month _____
3. Day _____
4. Where now _____
5. City in _____

Score _____

III. Mental control

	Time	Errors	Score
1. 20 to 1 (30 sec.)	____	____	____
2. Alphabet (30 sec.)	____	____	____
3. Counting by 3's (45 sec.) (1, 4, 7, up to 40)	____	____	____

Score _____

V. Digits Forward (a)

4. 6439 ____ 7286 ____
5. 42731 ____ 75836 ____
6. 619473 ____ 392487 ____
7. 5917423 ____ 4179386 ____
8. 58192647 ____ 38295174 ____

Score _____

V. Digits backward (b)

3. 283 ____ 415 ____
4. 3279 ____ 4968 ____
5. 15286 ____ 61843 ____
6. 539418 ____ 724856 ____
7. 8129365 ____ 4739128 ____

Score _____

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[1]Reproduced from the Wechsler Memory Scale Form I. For research purposes only.

APPENDIX B

CHI-SQUARE CONTINGENCY TABLES FOR TABLE 9

(RESULTS CHAPTER)

Chi-Square Analyses - Relative Profile Elevation (MMPI)

Pre-Operative

	0-49	50-59	60-69	70-79	80+	Total
OHR	45 (44.3)	69 (70.9)	31 (36.9)	16 (12.6)	7 (3.3)	168
OHNR	50 (50.7)	83 (81.1)	48 (42.1)	11 (14.4)	0 (3.7)	192
	95	152	79	27	7	360

Parentheses indicate expected frequency.

$\chi^2 = 11.4556$ with 4 d/f; $P < .05$.

Follow-up

	0-49	50-59	60-69	70-79	80+	Total
OHR	43 (47.1)	66 (67.7)	44 (43)	10 (7.5)	5 (2.8)	168
OHNR	58 (53.9)	79 (77.3)	48 (49)	6 (8.5)	1 (3.2)	192
	101	145	92	16	6	360

Parentheses indicate expected frequency.

$\chi^2 = 5.6017$ with 4 d/f; $P < .30$ (not significant).

Chi-Square Analyses - Two Highest Scales (MMPI)

Pre-Operative

	Hs	D	Hy	Pd	Mf	Pa	Pt	Sc	Ma	Si	Es	Dy	Total
OHR	9 (6.5)	4 (4.7)	7 (7)	2 (2.8)	1 (.5)	1 (.9)	1 (.5)	1 (1.4)	1 (.5)	1 (1.4)	0 (1.4)	0 (.5)	28
OHNR	5 (7.5)	6 (5.3)	8 (8)	4 (3.2)	0 (.5)	1 (1.1)	0 (.5)	2 (1.6)	0 (.5)	2 (1.6)	3 (1.6)	1 (.5)	32
	14	10	15	6	1	2	1	3	1	3	3	1	60

Parentheses indicate expected frequency.

$\chi^2 = 9.495$ with 11 d/f; $P < .70$ (not significant).

Memory Scale Form II[1]

I. Personal and current information

Name _____

Date _____

1. Age _____
2. When born _____
3. President of the U. S. _____
4. Before him _____
5. Governor _____
6. Mayor _____

Score _____

Group _____
Pt. _____
Day _____

Total score _____

II. Orientation

1. Year _____
2. Month _____
3. Day _____
4. Where now _____
5. City in _____

Score _____

III. Mental control

	Time	Errors	Score
1. Alphabet (30 sec.)	_____	_____	_____
2. 20 to 1 (30 sec.)	_____	_____	_____
3. Counting by 4's (45 sec.) (1, 5, 9 up to 53)	_____	_____	_____

Score _____

V. Digits forward (a)

4. 2861 _____ 5394 _____
5. 74296 _____ 85164
6. 842751 _____ 729536 _____
7. 7482591 _____ 8396152 _____
8. 26958371 _____ 37294158 _____

Score _____

V. Digits backward (b)

3. 751 _____ 296 _____
4. 3582 _____ 9617 _____
5. 47186 _____ 39261 _____
6. 639158 _____ 481637 _____
7. 5492736 _____ 2519473 _____

Score _____

[1]Reproduced from the Wechsler Memory Scale Form II. For research purposes only.

Follow-up

	Hs	D	Hy	Pd	Mf	Pa	Pt	Sc	Ma	Si	Es	Dy	Total
OHR	4 (3.3)	5 (3.7)	9 (7)	4 (3.7)	0 (.5)	0 (1.4)	1 (1.9)	1 (.9)	1 (2.3)	1 (.9)	2 (1.9)	0 (.5)	28
OHNR	3 (3.7)	3 (4.3)	6 (8)	4 (4.3)	1 (.5)	3 (1.6)	3 (2.1)	1 (1.1)	4 (2.7)	1 (1.1)	2 (2.1)	1 (.5)	32
	7	8	15	8	1	3	4	2	5	2	4	1	60

Parentheses indicate expected frequency.

χ^2 = 9.0962 with 11 d/f; P < .70 (not significant).

Chi-Square Analyses - Lowest Pair of Scales (MMPI)

(Only those scales which had entries were included.)

Pre-Operative

	Hs	Pd	Mf	Pa	Sc	Ma	Si	Es	Dy	Total
OHR	0 (.5)	0 (.9)	1 (2.3)	0 (.5)	1 (.9)	1 (1.4)	3 (2.3)	4 (1.9)	4 (3.3)	14
OHNR	1 (.5)	2 (1.1)	4 (2.7)	1 (.5)	1 (1.1)	2 (1.6)	2 (2.7)	0 (2.1)	3 (3.7)	16
	1	2	5	1	2	3	5	4	7	30

Parentheses indicate expected frequency.

$\chi^2 = 8.48$ with 6 d/f; $P < .30$ (not significant).

Follow-up

	Hs	D	Pd	Mf	Pa	Ma	Si	Es	Dy	Total
OHR	0 (.9)	1 (1.4)	1 (.5)	2 (1.9)	1 (.9)	3 (1.9)	1 (1.9)	1 (.5)	4 (4.2)	14
OHNR	2 (1.1)	2 (1.6)	0 (.5)	2 (2.1)	1 (1.1)	1 (2.1)	3 (2.1)	0 (.5)	5 (4.8)	16
	2	3	1	4	2	4	4	1	9	30

Parentheses indicate expected frequency.

$\chi^2 = 5.9232$ with 8 d/f; $P < .70$ (not significant).

Chi-Square Analyses - Highest Pair of Scales (MMPI)

(Only those pairs with entries were included.)

Pre-Operative

	1-3 3-1	1-2 2-1	2-3 3-2	Total
OHR	5 (3.5)	2 (1.5)	0 (2)	7
OHNR	2 (3.5)	1 (1.5)	4 (2)	7
	7	3	4	14

Parentheses indicate expected frequency.

χ^2 = 5.50 with 2 d/f; P < .10 (not significant).

Follow-up

	1-3 3 1	2-3 3 2	2-4 4 2	3-4 4 3	Total
OHR	4 (4.5)	1 (.6)	1 (1.3)	3 (2.6)	9
OHNR	3 (2.5)	0 (.4)	1 (.7)	1 (1.4)	5
	7	1	2	4	14

Parentheses indicate expected frequency.

χ^2 = 1.1955 with 3 d/f; P < .80 (not significant).

APPENDIX C

METHOD FOR APPLYING THE PREDICTION EQUATION

To assist surgical teams in their efforts to evaluate fully the open heart surgery candidates, the following steps are offered as a means of pre-operatively assessing the probability of a given patient having a post-operative behavioral reaction.

Step 1. --The Minnesota Multiphasic Personality Inventory and the Cornell Medical Index should be administered and scored by a qualified psychologist or psychometrist. (The pre-operative examination took place 3-5 days prior to surgery in the present study.)

Step 2. --The scores obtained on the following scales should be converted to "T" scores (see Dahlstrom and Welsh, 1960): L, F, K, Hs, D, Hy, Pd, Mf, Pa, Pt, Sc, Ma, Si, Es, Dy. The scores of the Taylor Manifest Anxiety Scale, which is composed of MMPI items and can be scored from the MMPI, should remain in raw score form.

The following scales from the Cornell Medical Index should be scored and should remain in raw score form: A (ears and eyes), C (cardiovascular), L (habits), M (inadequacy), O (anxiety), and Q (anger). The total score and psychiatric scale total should also be included (again in raw scores). Age should be listed as of last birthday.

Step 3. --The products of the scores of the variables noted above and their corresponding regression weights should be summated.

Variable (a)			Regression weight (b)
MMPI	L	x	-1.02185690 = ab_1
	F	x	1.76631660 = ab_2
	K	x	2.17063120 = ab_3
	Hs	x	-1.14269930 = ab_4
	D	x	1.63252150 = ab_5
	Hy	x	-0.04429272 = ab_6
	Pd	x	-1.10825640 = ab_7
	Mf	x	0.83659381 = ab_8
	Pa	x	-0.75647357 = ab_9
	Pt	x	-1.34113150 = ab_{10}
	Sc	x	-0.01394282 = ab_{11}
	Ma	x	0.75288908 = ab_{12}
	Si	x	0.00255910 = ab_{13}
	Es	x	0.54594002 = ab_{14}
	Dy	x	1.09384100 = ab_{15}
CMI	Ears and eyes	x	9.89053790 = ab_{16}
	Cardiovascular	x	3.72447870 = ab_{17}
	Habits	x	-2.37034290 = ab_{18}
	Inadequacy	x	1.93682350 = ab_{19}
	Anxiety	x	8.11799990 = ab_{20}
	Anger	x	-7.25126350 = ab_{21}
CMI	Total	x	-0.53065382 = ab_{22}
	Psychiatric	x	1.80321740 = ab_{23}

Step 3--Continued

Variable (a)		Regression weight (b)
TMAS	x	-1.82806540 = ab_{24}
Age	x	0.28619413 = ab_{25}

Σab_{1-25} = Z value for a given patient

Step 4. --If the resultant Z value is greater than 8.9812156, the prediction will be that this patient will experience a post-operative behavioral reaction. If the Z value is less than 8.7579681, no reaction should result from surgery, on the basis of the prediction equation.

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