PSYCHOPHYSIOLOGICAL EFFECTS OF STRESS IN DIABETIC PATIENTS, ISCHAEMIC HEART DISEASE PATIENTS AND HEALTHY SUBJECTS.

by

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ABSTRACT

This thesis is concerned with the relationships between physiological changes and subjective and behavioural responses to stress. The effects of noise stress were examined under laboratory conditions, and retrospective studies of stress induced by life events were also carried out.

Changes in blood glucose levels were of particular significance under stressful conditions and interesting relationships were found between changes in blood glucose levels and performance at experimental tasks under stressful conditions. Performance and the experience of stress were shown to be affected by the experimental manipulations of blood glucose levels.

The effects of stressful conditions on diabetic subjects with impaired control of blood glucose levels were of particular interest. The poor control of blood glucose levels in the 'high glucose diabetics' was exaggerated when working under noise stress. Studies of life events demonstrated that diabetic subjects' experience of life events was associated with physiological disturbance of diabetic control. Diabetics' subjective experiences of stressful conditions were also examined and compared with the experiences of control subjects.

Previous research showed considerable evidence to suggest that stress was a promoting factor in ischaemic heart disease (IHD). Subjects with IHD and controls were included in the present research. Experiments similar to those with diabetic subjects were carried out. The IHD subjects had enhanced physiological responses to noise stress which were associated with significantly low levels of reported stress. Subjective experiences of stress were further examined with investigations of the degree of stress associated with life events by Myocardial infarction patients.

Differences in subjective experience of stress by patient groups and their controls were discussed in relation to the concept of alexithymia.

Experiments with healthy subjects were carried out in order to examine the mechanisms involved in the relationships found between glucose, performance and the perception and experience of stress. The effects of glucose preloading were shown to be primarily of physiological rather than of psychological origin,and a vagal-insulin model was proposed to account for the relationship between glucose preloading and performance efficiency. Experimenter effects were examined in the studies of healthy subjects and the implications of such effects discussed in relation to the results of the experiments with hospital subjects in this work and with reference to other psychophysiological research.

The experimental findings were evaluated and suggestions made for further research. In particular research directed towards the possibility of developing a more flexible, individual approach to diabetic management, taking account of unavoidable sources of stress, was outlined.

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PREFACE

My interest in the problems of diabetes developed from my involvement in work initiated by my supervisor, Tom Cox and his colleagues at Nottingham University. The original studies suggested that performance under stress was related to the level of blood glucose and that performance efficiency was affected by experimental manipulations of blood glucose levels. These data indicated that the effects of stress on performance efficiency of diabetic subjects might differ as a result of the diabetics' abnormally elevated blood glucose levels. Research on diabetic subjects described in the literature (particularly in the work of Vandenberg and his colleagues) supported my impression that studies of diabetic subjects working under stressful conditions would provide an interesting area for research with practical applications.

The insulin requiring diabetic males studied initially provided a relatively homogeneous experimental group in terms of treatment regimes if not in terms of degree of control of their diabetic condition. The results from the larger sample of diabetic subjects who participated in the later studies of life change could be divided according to the subjects' sex and treatment for the purpose of statistical analysis. The separate analyses of the different types of diabetic subject were possible due to the large population of diabetic subjects made available by Dr. Macfie in the outpatient clinic at the City Hospital.

My interest in patients with ischaemic heart disease (IHD) developed during the course of the studies of diabetic subjects. Num erous reports in the literature suggested that the response of heart disease patients to stressful situations would be different from that of healthy subjects. Furthermore there was evidence to suggest that IHD patients demonstrated abnormalities of glucose tolerance and a greater incidence of diabetes than healthy subjects.

The experimental study of IHD patients was more difficult to organise than the experimental work with diabetic subjects. A smaller number of IHD patients was available and the type of symptoms and form of treatment varied considerably within the population. The experimental group of the 32 males who participated in the laboratory study was a comparatively heterogeneous group with respect to both the presenting symptoms and the type of medical treatment. Although it would have been of great interest to have compared the responses of IHD patients treated with beta-blocking drugs with the responses of untreated IHD patients, it was not practically possible to obtain a large enough sample size within the limitations of the present research. Consequently, the results from the study of the IHD patients observed in the laboratory could only lead to tentative suggestions and pointers for further research rather than definitive conclusions. In the study of IHD patients' reported experiences of life change, the population of patients was more highly selected: each of these patients presented a history of myocardial infarction. The sample sizes obtained were, however, necessarily smaller than the samples of diabetic subjects studied.

No attempt was made during the course of this research in any way to alter the treatment regime of the patients studied. I was particularly interested in reaching some understanding of the manner in which such patients reacted to and coped with stressful conditions in their everyday lives. To have adjusted the treatment regimes would not only have created ethical problems but would also have changed the purpose of the studies.

Throughout this research I was concerned not only with the physiological changes shown and levels of performance efficiency obtained by the patients under stressful conditions but also with their subjective experiences. It soon became apparent that to observe physiological changes or subjective responses alone would have presented a misleading picture of stress reactions. Different modes of response were observed between the patient groups and between the patients and their controls. Differences in the degree of reported experience of stress were also observed between the sexes: these findings were supported by some evidence from other recent research. The differences in the subjective response to stress found in the groups studied, led to closer examination of the subjects' understanding of the concepts used in rating their experiences of stressful life events.

My visit to the Department of Psychology at the University of Stockholm provided an invaluable opportunity to discuss my research findings with Professor Mar ianne Frankenhaeuser and her colleagues and to clarify my ideas about the work. My interest in the concept of alexithymia was stimulated by discussions with Dr. Daisy Schalling and her associates at the Karolinska Hospital and discussion of my findings concerning IHD patients' responses to stress with Dr. Tores Theorell at the Serafima Hospital showed that the results were consistent with his own observations of comparable patients.

During the course of this research I have become increasingly interested in the possibility of improving methods of helping diabetic and IHD patients to adjust to their individual problems. Some ways in which such improvements, particularly of diabetic management, may be achieved have been suggested by the findings in this experimental work. I am at present planning clinical investigations of diabetic subjects to test some of the hypotheses that have arisen from the thesis.

Further research into 'alexithymic' responses may well point to a means of reducing the incidence of IHD. At this stage, however, my particular concern is to develop more adaptive strategies for maintaining diabetic control under stressful conditions.

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CHAPTER 2: METHODOLOGY

CHAPTER 1.

INTRODUCTION

The concept of stress is frequently used in many different contexts. Definitions vary considerably between those disciplines which employ the concept. Differences are also apparent within any one discipline. A global definition embracing every aspect of stress would be too complex for practical use and it is therefore necessary firstly to outline the major differences in approach to the concept and secondly to specify the way in which the term stress will be used in this thesis.

1. Models of Stress

Cox (1978) has described three main types of definition which have been applied to the concept of stress. Stress may be defined in terms of the response a person makes, this response-based approach is typically used in the field of medicine. Stress may alternatively represent the stimulus characteristics of the environment external to the person. The stimulus-based approach is common in ergonomics. The third approach described is the psychological approach which takes account of both stimulus and response and regards stress in terms of the process of arriving at a response to a stimulus.

The first two approaches see stress from something like a Behaviourist point of view, as part of a stimulus-response mechanism. They differ in terms of what they label as 'stress', the stimulus or the response and as a result they differ in their approach to the study of stress. However both stimulus and response-based approaches tend to ignore the importance of intervening psychological processes such as perception and cognition. The way in which the stimulus is perceived and appraised (e.g. whether or not it is seen as threatening) plays an important role in determining which response, from the range of possible responses, is actually made. Such factors may account for many of the individual differences in response to stressful conditions. Many stress researchers (e.g. Sells, 1970; Lazarus, 1966 and 1976;) have argued that explanations purely in terms of stimulus-response type mechanism are inadequate in that they appear unable to account for the diversity and complexity of observed human behaviour.

The psychological approach to the problem of stress research accepts that stress is a highly individual phenomenon and emphasises the importance of perceptual processes. It has been variously suggested (McGrath, 1970; Sells, 1970; Lazarus, 1976; Cox, 1975 and 1978;) that stress arises as a result of imbalance between the person's perceptions of demands and his perception of his ability and need to cope. Cox and Mackay (1976) pointed out that although the psychological approach to stress is most clearly appropriate with regard to psychologically or psychosocially generated stress, it is also applicable to physical stresses such as muscular exercise. Muscular fatigue caused by physical exertion in sporting activities may be accompanied by a feeling of satisfaction and pleasure while muscular fatigue induced through work may be an unpleasant experience. It has also been demonstrated (Selye, 1950; Kagan and Levi, 1971; Levi, 1974;) that susceptibility to infection may be altered by psychological factors. A person's susceptibility to the 'common cold' may depend upon his degree of satisfaction with his work. Finally the psychological approach recognises not only the role of psychological factors in determining somatic responses but also the importance of bodily responses in affecting psychological states (e.g. Schachter and Singer, 1962).
The psychological approach to stress is better able to cater for the wide range of situations considered to be stressful without including objectively similar situations which, subjectively, are not reported to be stressful. It is also more flexible in the sense that it is able

to accept a wider range of psychological and physiological reactions as valid responses to stressful circumstances.

This approach to stress research has been developed by Cox (1975) and Mackay and Cox (1976) into a transactional model of stress. The transaction referred to is that between the person and the environment and implies an active, adaptive process rather than the passive, reactive type of process implied in the stimulus- or response-based models. The model is concerned with the balance or imbalance between four main aspects of the individual and the environment. These consist of the external environmental resources, the external environmental demands, the persons capability and his internal needs and wants. Stress is defined in terms of the person's transaction with his physical and psychosocial environment with emphasis on the importance of perceptual-cognitive processes in the experience of stress. The model describes the way in which the individual actively assesses his situation and attempts to balance his perceptions of the demands on him, his ability to cope and the consequences of coping or failing to cope. Stress arises when a balance cannot be achieved.

This model was designed to account for stress in general (Cox, 1975) and has been specifically applied to the study of stress reactions in the work environment (Cox and Mackay, 1976).

1.1. The Concept of Stress in this Thesis

It will be apparent in the present work that the use of the concept of stress has developed from the rather narrowly defined stimulus-based type approach in laboratory experiments using noise as a stressor, through to the more flexible psychological approach taking account of individual differences in the perception of and responses to stressful life events. A broad definition of stress can, however, be applied throughout the work reported in this thesis. Stress is viewed as a demand which stretches available resources. As the experiments progressed, greater consideration was given to both the quantitative and qualitative differences in perception of demand and attention was paid specifically to the measurement of subjective as well as objecttive responses to such demand.

1.2 Noise as a Form of Stress

The laboratory experiments examined the psychophysiological effects of white noise on different groups of individuals.

Noise is one potential source of stress from the physical environment which commonly affects individuals living and working in modern industrial areas. It is also a very practical form of stress for laboratory use; easily produced and regulated in a quantifiable way. Natural occurrence of noise stress in the environment may produce a great variety of responses from different individuals because of the different psychological meaning that it holds. The sound of someone else's infant crying at night, for example, may well produce a reaction in others which is different from the response of the parents themselves. A Parliamentary committee chaired by Wilson (1963) summarised the problem of noise annoyance as follows:

> 'The annoyance due to noise may perhaps be thought of essentially as the resentment that we feel at an intrusion into the physical privacy which we have for the moment marked as our own, or into our thoughts or emotions. From another point of view the annoyance may be ascribed to the 'information' which sounds may carry from the source to the recipient. The physical energy in the noise of a creaking door, a crying baby, or a distant party may be very small and if distributed in the form of random noise would probably be quite unnoticed. But it may convey manifold suggestions of alarm, neglect, sadness, loneliness; and so in some people it has an emotional effect out of all proportion to its physical intensity.'

Experimental white noise is devoid of such psychological meaning and the specific effects of noise intensity can therefore be studied more precisely in the laboratory. The physiological and behavioural effects of the noise itself can be measured in a controlled setting. Noise stress of this type has been found to produce a particular kind of reaction with little variation between individuals (Cox and colleagues, 1973; Simpson and colleagues, 1974).

1.3 Life Events as a Form of Stress

The study of naturally occurring life stress provided a direct contrast to the study of experimentally produced noise stress. The research progressed from experimentation with a simulated form of physical stress to sampling peoples' real life experiences of psychosocial stress. Although in the study of life events it was not possible to exercise the same precise control there was the advantage of studying responses to the experiences of naturally occurring stressors.

Both sources of stress, noise and life events present demands on the person subjected to such experiences. It was possible to observe and measure an individual's ability to perform an experimental task under different levels of noise. It was also possible to observe and measure an individual's ability to adjust to psychosocial stressors causing different degrees of upset. Subjective experiences of, and physiological reactions to noise and to life change were measured.

In summary; both noise and life change may be seen as potential forms of stress in that they both make demands which the individual is required to cope with in some way. How the individual reacts will depend on his perception of the stress and on his motivation and ability to cope with it.

2. Psychophysiological Response to Stress - Previous Research

The sympathetic-adrenal meduallary system was the first neuroendocrine system to be investigated in relation to the psychological (behavioural) response to 'stress'. Early this century Walter Cannon reasoned that the sympathetic-adrenal medullary system would be activated by emotional stimuli. His argument was based on the knowledge that the adrenal medulla is linked to the sympathetic nervous system and that many of the physiological changes observed to accompany emotional arousal such as heart rate increases and pupil dilation, are signs of sympathetic nervous system activity. Cannon and his colleagues (Cannon and de la Paz, 1911; Cannon, Shohl and Wright, 1911;) performed a series of experiments with cats, exposing them to emotional stimuli such as barking dogs, while normal cats showed glycosuria, this was not found with adrenalectomised animals. These results suggested adrenalin induced elevations of blood glucose levels which exceeded the renal threshold. (Review; Cannon, 1929).

In 1914 he formulated an 'Emergency Function' theory of adrenomedullary activity based on the findings from these investigations. The theory developed from the view that the physiological effects of adrenalin were adaptive by way of increasing the efficiency of the organism in coping with fear, rage or pain.

The pioneering work of von Euler (1946) and Holtz and his colleagues (1947) demonstrated the presence of nor-adrenalin in the body. The role of nor-adrenalin as a secondary adrenalmedullary hormone and the chemical transmitter for adrenergic nerves was shortly afterwards established and was reviewed by von Euler (1956). Several lines of research followed which showed that adrenalin and nor-adrenalin may be selectively released in response to different types of stressor and may have different effects. This apparent selectivity reflects differing types of response. (For review see Mason, 1968(c)).

It is now clear that the release of both catecholamines, adrenalin and nor-adrenalin is responsive to psychological influences. It has been variously shown that catecholamine levels reflect psychological reactions associated with everyday demands and activities. The work of Frankenhaeuser and her colleagues provides much evidence of catecholamine secretion in response to a variety of psychosocial conditions. (For example: Frankenhaeuser and Post, 1962; Frankenhaeuser, Sterky and Jarpe, 1962; Frankenhaeuser and Patkai, 1964;

Lundberg and Frankenhaeuser, 1976).

Attention has only more recently been focused on the role of the pituitary-adrenal cortical system and the influence of psychological factors on its activity. Although Uno in 1922 reported an increase in pituitary weight in rats after a six hour period of 'general excitement', it was not until Selye's work, reported in 1936, that this topic attracted serious consideration. The early work relied upon relatively indirect and non-specific measures of adrenal cortical activity. However, in the 1950's more specific and reliable methods became available for the measurement of the 17-hydroxycorticosteroids (17-OHCS) in blood or urine. (Nelson and Samuels, 1952;) and there is now a massive body of data on the factors influencing adrenal cortical activity.

There is some evidence to suggest that the two neuro-endocrine systems, the pituitary-adrenal cortical and the sympathetic-adrenal medullary, are activated in response to different types of psychological stimulation. Selye (1936) described how the adrenal cortex may take over from the adrenal medulla when stress was prolonged. Gray (1971) stated that the glucocorticoids, with their ability to promote transformation of non-sugars into sugars and to increase glycogen deposition in the liver,

> 'continue the job started during the alarm stage (Selye) of providing the body with rapidly mobilised sources of energy. They also facilitate the reactions of the blood vessels to adrenalin and nor-adrenalin, further increasing the potentiality of strenuous action if a second danger is added to the background of continuing stress'.

However, Mason (1968b and c;) in his reviews of the pituitary-adrenal cortical and sympathetic-adrenal medullary systems, suggested that the central nervous system exerted a constant 'tonicity' on both endocrine systems and that both equally reflected environmental and psychological factors. Most of the results reported on 17-OHCS

(17-hydroxycorticosteroid) levels were, however, derived from studies of chronic situations, ones that extended over periods of weeks, months or years. By contrast most of the studies on catecholamine excretion had shown significant responses to much shorter periods of stress, measured in minutes or hours. Relatively few studies investigated the acitivity of both endocrine systems simultaneously. Curtis and his colleagues (1960), measured daily excretion of urinary adrenalin, noradrenalin and 17-OHCS in several patients manifesting symptoms of various psychiatric disorders. They found that patients with depressed states excreted noradrenalin preferentially in comparison with adrenalin or corticoids while adrenalin predominated in states of mixed affect. Slob, Wink and Radder (1973) examined the effects of 80dB noise on corticosteroid, adrenalin and noradrenalin excretion in male students. Noise exposure continued from 09.00 until 17.00 hr. and four hour urine samples were collected. The results appeared to show an increase in adrenalin and to a lesser extent, noradrenalin but no effect on corticosteroid excretion was traced. There are very few similar studies comparing the relative contributions of the adrenal medulla and the adrenal cortex under different stressful conditions and it is difficult to assess their relative importance.

Extensive research on the activity of neuroendocrine systems in stressful conditions has been conducted by Mason. Mason (1968a) expressed doubts about the wisdom of concentrating exclusively on the activity of one endocrine system. The evidence he made available suggested that endocrine regulation was likely to be an integrated function involving other neuro-endocrine systems apart from those affecting the adrenal glands. (Mason, 1968a; Mason, 1968b; Mason, 1968c).

Mason (1968a) drew attention to the five general areas where neural or neurohumoural links had been observed between endocrine glands and the central nervous system which suggested that psychological influences on endocrine activity might be important. The five areas were as follows:

(a) The hypothalamic-anterior pituitary neurohumoural linkage through the portal hypophyseal system. Mason suggested that this system could provide a pathway for neural or psychological influences on the anterior pituitary hormones, adrenocorticotropin, thyrotropin, the gonadotropins, growth hormone and prolactin. Some of these linkages, as Mason termed them, have been shown to be functionally important, particularly those involving tropic hormones, adrenocorticotropic hormone, (Mason, 1959; Mangili and colleagues, 1966; Fortier, 1966; Ganong, 1963; Harris, 1955;) thyrotropic hormone (Reichlin, 1966a; D'Angelo, 1963;) and the gonadotropic hormones (Donovan, 1966; Flerko, 1963; Harris and Campbell, 1966). Physiological evidence is also available for the neural influences affecting the secretion of prolactin (Everett, 1966; Meites and colleagues, 1963;) and growth hormone (Pecile and Muller, 1966; Reichlin, 1966b).

(b) The anterior hypothalamic-posterior pituitary neural system. This second area described by Mason involved the neurosecretion of antidiuretic hormone and oxytocin (Cross, 1966; Heller and Ginsburg, 1966; Sawyer, 1963 and Sawyer and Mills 1966).

(c) The posterior hypothalamic sympathetic-adrenal medullary system involving secretion of adrenalin and nor-adrenalin has already been considered earlier in this section and is a well established locus of psychological effects.

(d) A vagal-insulin system was thought by Selye (1950) to be a part of the parasympathetic system involved in the response to stress and was a possibility considered by Cannon (1963). However, the inability to measure insulin secretion hindered early work. Although radioimmunochemical assays of insulin are now possible, experimental studies of vagal stimulation are confounded by the secondary effects of the necessary surgical trauma on blood glucose. As a result little attention has been given to the study of association between psychological factors and vagal-insulin activity.

(e) A posterior-diencephalic neurohumoral system was suggested by the work of Farrell and his associates (Farrell, 1959; Mulrow, 1966). This system involved a hormone 'glomerulotropin' which can influence aldosterone secretion, as well as renal and pituitary activity. However, neither the significance nor even the existence of such a neuroendocrine system has been generally accepted.

It is clear that there are many of these anatomical systems in which 'points of contact' exist for neural and psychological influences on endocrine secretion. However only two of these, the sympathetic-adrenal medullary and the pituitary-adrenal cortical systems have been extensively studied. To redress the balance Mason (1968a) argued for

> 'a broad, systematic survey of the extent to which the many endocrine systems are subjected to psychological influences.'

The work reported in this thesis did not concentrate on any one of the possible neuro-endocrine systems but aimed to achieve a more global picture of psychophysiological reactions associated with stressful conditions by considering the effects of stress in terms of regulation and response of blood glucose.

The concentration of glucose in the blood is of great physiological importance. Glucose is the main source of energy for the body tissue and the level of glucose in the blood is a measure of its availability to these tissues. Changes in the level of blood glucose may reflect the activity of many of the hormones mentioned earlier in this section such as adrenalin, insulin and growth hormone. In demanding or stressful situations, one of the major functions of adrenalin and the glucocorticoids is to increase or maintain energy resources by stimulating the mobilisation of glucose. Blood glucose changes may therefore be used as an integrated measure of the body's need to adapt to demands.

3. The Regulation of Blood Glucose Levels

Under normal circumstances the level of glucose in the blood is maintained within the fairly narrow range of 70 to 120 mg per 100ml. Following digestion and absorption of a carbohydrate meal the level of glucose in the blood rises considerably. Insulin is secreted from the pancreatic beta cells and prevents hyperglycaemia by promoting glucose storage in the liver. Insulin appears to act by facilitating the passage of glucose across the cell wall and also by accelerating the conversion of glucose into glucose-6-phosphate which is then converted to glucose-1-phosphate and stored in the form of glycogen.

Glucagon, secreted from the pancreatic alpha cells, acts as an insulin antagonist and guards against hypoglycaemia. Glucagon acts to increase blood glucose levels by stimulating the breakdown of glycogen in the liver which leads to the release of glucose into the blood stream.

Secretion of both insulin and glucagon appears to be controlled both locally and centrally. A raised glucose level in the blood supplying the pancreatic beta cells results in secretion of insulin. Similarly a lowered glucose level leads to glucagon secretion from the alpha cells. There is considerable evidence to suggest that blood glucose levels are also controlled centrally, (e.g. Mayer and Thomas, 1967; Shimazu and colleagues, 1966; Frohman and Bernadis, 1971; Bloom et al, 1974). Glucose sensitive cells in the hypothalamic areas may detect changes in blood glucose which are regulated through vagal mediation resulting in the release of insulin or glucagon.

Insulin is not essential for the uptake of glucose from the blood by the liver since it only increases the rate of phosphorylation. It is however essential for the transport of glucose into the muscle cell since it increases permeability of the muscle cell wall. Glucagon acts as a potent glycogenolytic agent in the liver but is unable to breakdown glycogen in the muscle cell.

Although at first insulin and adrenalin were thought to maintain the normal homeostatic control of blood glucose levels, recent research has demonstrated that it is glucagon rather than adrenalin which acts in opposition to insulin in the regulation of minute-to-minute fluctuations. However, adrenalin and other hormones such as growth hormone and the glucocorticoids do have an important role in the regulation of carbohydrate metabolism. Whereas glucagon is only effective in the liver, adrenalin is able to promote glycogenolysis in the muscle cells as well as in the liver. Adrenalin is also able to inhibit insulin secretion and in so doing, it stimulates glucagon secretion via a negative feedback system in operation between insulin and glucagon (Samols, Tyler and Marks, 1972). Insulin suppresses glucagon while glucagon stimulates insulin secretion. There is also some evidence (Samols, Tyler and Kajinuma, 1971; Bloom and Edwards, 1975;) that activity of the sympathetic nervous system may directly increase glucagon secretion and at the same time block its insulinotropic effect (Porte and colleagues, 1966; Bloom and Edwards, 1975) thereby permitting unhindered elevations of blood glucose levels.

The glucocorticoids contribute indirectly to raised blood glucose levels by promoting gluconeogenesis from amino-acids and by directly inhibiting the transport of glucose into the muscle cell. Growth hormone also plays a part in providing energy through lipid metabolism when glucose resources are low thereby sparing oxidation of carbohydrates.

3.1. Blood Glucose Regulation and Stress

Cannon and De la Paz (1911) in his experiments with cats showed indirectly that increases in adrenalin secretion were accompanied by increased blood glucose levels. Other work, since these early experiments, has produced contradictory and inconsistent findings in relating blood glucose changes and emotion (review by Bowman and Kasanin, 1929).

Selye (1950) in his classical treatise on stress paid considerable attention to the blood glucose changes characteristic of the General Adaptation Syndrome. An increase in blood glucose levels was the immediate response on exposure to stress. The magnitude of this increase depended primarily upon the adrenalin output from the adrenal glands and upon available hepatic glycogen reserves. Selye associated a second stage, the 'stage of resistance', with normal or slightly increased blood glucose levels. If the stress was prolonged then the blood glucose level fell to hypoglycaemic levels. Finally, in the 'stage of exhaustion', if no relief was available, death might result from severe hypoglycaemia. In considering the effects of nervous and emotional stimuli on carbohydrate metabolism, Selye suggested that they were

> 'most effective in causing sympathetic, adrenomedullary and parasympathetic stimulation. The former two tend to raise blood sugar through adrenergic gycogenolysis, while the latter causes hypoglycaemia, perhaps by stimulating insulin secretion. Depending upon conditions one or other of these effects prevails...'

Unfortunately Selye did not go into the conditions under which different effects are observed, in any detail. Cox (1978) suggested that the type of response was related to the severity of the stress and was determined by the relative degrees of sympathetic and parasympathetic nervous activity. Cox suggested that, under moderate stress, parasympathetic activity predominated leading to an overall fall in blood glucose levels. With severe or prolonged stress sympathetic nervous activity exceeded parasympathetic activity and elevations in blood glucose would be apparent.

The observation that both divisions of the autonomic nervous system are involved in stressful situations has not received too much attention but has been studied by Gellhorn (1953), Gellhorn and Lootbourrow, (1963). Gellhorn found that rats startled by sudden loud noise showed increases in blood glucose levels. After adrenodemedullation the blood glucose level did not merely fail to rise in response to noise; it was depressed. Therefore in these experiments with rats, noise appeared to produce two effects, one tending to raise and one to lower blood glucose. In normal rats, the former effect predominated and accounted for the observed rise. In rats in which both the adrenals had been removed and the vagi cut, little change in blood glucose levels was observed. Gellhorn suggested that emotional excitement commonly associated in the human with fear, anger and rage, may elicit both a sympathetic and parasympathetic discharge.

More recent studies in humans on the effects of noise on blood glucose levels would tend to support Gellhorn's suggestion that there are two mechanisms at work. Finkel and Poppen (1948) showed that blood glucose levels rose in response to very loud jet engine noise but fell back if the noise exposure was continued for two hours or more. Ashbel (1965) showed that there was a significant fall in the blood glucose levels of workers exposed to ultrasound and high frequency noise. Other similar studies in the literature reported either an increase or decrease in blood glucose levels in response to noise stress (Serra et al, 1964; Fecci et al, 1971). The effects of noise on several of the hormones involved in carbohydrate metabolism have been directly demonstrated. Various studies have shown increases in adrenalin (Levi, 1972; Frankenhaeuser and Lundberg, 1973; Lundberg and Frankenhaeuser, 1976; Hawell and Starlinger, 1967; Slob, Wink and Radder, 1973;) glucocorticoids, (Wink, 1971;) and glucagon (Bloom etal, 1973). Other studies have shown decreases in adrenocortical activity (Atherly and colleagues, 1970). No recent work on the insulin response to noise has shown any significant effects.

Difficulties arise in making comparisons between the different studies reported due to the problem of assessing the relative contributions of stimulus duration, frequency and intensity. The noise may be intermittent or continuous and this factor may also influence the results.

A programme of research was started in Nottingham in 1973, concerned primarily with the effects of noise stress and glucose preloading on blood glucose levels and performance on various psychomotor tasks. This work followed a study by Murrell (1971) who has shown that human skilled performance under monotonous conditions could be improved by the prior administration of glucose. Two papers (Cox, Simpson and Rothschild, 1973; Simpson, Cox and Rothschild, 1974;) have reported that the groups preloaded with glucose prior to the 'experimental' session (exposure to 80dB noise while working at a pursuit rotor task) showed a greater fall in blood glucose levels than the preloaded groups working under 50dB noise. Similar, but much less marked changes occurred in the non-preloaded groups. Without glucose preloading, noisy conditions (80dB) impaired performance at the task. Preloading with 18gms glucose reduced this impairment of performance in the noisy condition but was associated with impairment in the quiet condition (50dB). Although when working under noisy conditions (80dB) the high blood glucose levels produced by glucose preloading fell markedly, under quiet conditions they did not.

Simpson, Cox and Rothschild tentatively suggested that the blood glucose changes might be manifestations of the activation of the 'phylogenetically old "flight or fight" reaction to stress' (Selye, 1950), and that the blood glucose levels might be altered by changes in adrenal activity or insulin release. The improvement in performance under stress was accompanied by a reduction in the high blood glucose levels produced by pre-loading with glucose. It was assumed that the glucose removed from the blood was metabolised for the production of energy rather than for storage as glycogen. It was not clear, however, how the production of energy from carbohydrate metabolism resulted in improved performance. The authors suggested the possibility that glucose metabolism simply reduced a physical fatigue component. It was also not clear why the elevation of blood glucose levels under the non-stressful, quiet condition was associated with impairment in performance. It appeared that a fine balance existed between the level of glucose in the blood (or the change in blood glucose), the degree of noise stress, and the ability to maintain efficient performance.

The findings reported from these experiments stimulated questions which led to the present work with diabetics. For example: how do diabetics, with their abnormal control of glucose metabolism and unusually high blood glucose levels, respond to stressful conditions? Are changes in blood glucose levels associated with the efficiency of performance by diabetics in the same way that they appear to be in non-diabetic individuals?

There is much evidence to suggest that stress is closely linked with the onset of diabetes mellitus; much research has been done and much is still possible in that area. However, this thesis is concerned with the ways in which diabetics with their particular problems of blood glucose regulation respond to and cope with stress.

4. Diabetes Mellitus

Figures published in 1976 by the British Diabetic Association estimated that 3% of adults in this country suffered from some form of diabetes mellitus. It is a small but significant proportion of the population and the majority of those affected lead a relatively normal life. They are subject to the stresses and strains affecting the rest of the population and the manner in which they cope, both physiologically and behaviourally is of great interest in the area of psychophysiology outlined above.

4.1. The Pathogenesis of Diabetes Mellitus

Diabetes is the result of a deficiency of insulin function. Either insufficient insulin is produced by the pancreas or the insulin which is produced is being used ineffectively. This relative ineffectiveness of insulin may be due, either to hypersecretion or to hyperactivity of insulin antagonists such as the pituitary, adrenal medullary and thyroid hormones. It may also be due to the action of glucagon produced by the alpha cells of the pancreas itself. Antibodies which combine with and neutralise insulin may also be the cause of diabetes.

Insulin deficiency results in an inability to utilise glucose adequately. When utilisation and storage of glucose is inefficient, glucose accumulates in the blood until it passes the renal threshold (normally about 180mg.% but often higher in diabetics) and glycosuria results. An increased volume of urine is then required to remove the excess glucose and dehydration follows. When glucose is not available as a fuel, fat is used instead. However, complete combustion of fats requires the presence of reagents produced during combustion of glucose. In the absence of glucose metabolism, fat combustion is incomplete, toxic ketone bodies are produced which accumulate in the blood. If these collect in sufficient amounts, they can cause acidosis and eventually coma. This may be fatal.

Coma may result from hyperglycaemia or from hypoglycaemia. In hyperglycaemia, although the blood is rich in glucose, those body cells which require insulin in order to metabolise glucose adequately are starved as a result of insulin deficiency. The breakdown of fats which follows, produces ketone bodies. These may be responsible for coma or the glucose rich blood may cause the dehydration of brain cells which could also account for the coma. Hypoglycaemic coma in diabetics tends to result from overdoses of insulin or from insufficient carbohydrate intake. Glucose is not available to the brain cells and, in this case glucose starvation is responsible for the coma.

Hyperglycaemic coma is treated by the administration of insulin, however this treatment would be fatal for hypoglycaemic coma. In the case of hypoglycaemic coma, glucose may be given intravenously. One indicant of the appropriate course of action is the presence of ketone bodies on the breath of the hyperglycaemic person.

There are two very distinct forms of diabetes mellitus, juvenile and maturity onset, which present similar symptoms but may differ in terms of etiology. Juvenile or growth onset diabetes is invariably an insulin requiring form of the disease and consequently, is often referred to as 'insulin requiring diabetes'. Maturity onset diabetes is generally a milder form of the disorder. Juvenile diabetics tend to be underweight because of glucose wastage in glycosuria due to insulin insufficiency. Maturity onset diabetics tend more often to be overweight. This form of diabetes may be due to excessive carbohydrate intake for which normal resources of insulin are inadequate. With overweight patients it is often possible to reduce carbohydrate intake to a manageable level. In cases of maturity onset diabetics who are underweight there is insufficient insulin to cope even with a normal intake of carbohydrates. Hypoglycaemic drugs such as tolbutamide or chlorpropamide can be used to stimulate the pancreatic cells to secrete more insulin or to increase the effectiveness of the insulin that is already being produced.

4.2. The Role of Stress in the Etiology of Diabetes Mellitus

Diabetes has for a long time been described as an inherited metabolic disease but the mode of inheritance is still largely unknown. One reason for this may have been that the characteristic symptoms of glycosuria and hyperglycaemia have, in the past, been thought to be indicative of one single disease. More recently it has been accepted that diabetes is a global term embracing a range of disorders differing in etiology.

It is clear that if there is a hereditary component to the disease it is only partially responsible for its manifestation, or is the cause of only one form of diabetes. When one of a pair of identical twins is diabetic, the other twin will not necessarily develop the disease. Froesch (1971) put the chances at 70%, with the possibility of a child of diabetic parents under the age of 40 developing diabetes at approximately 50%. Bloom (1976) reported that only one in ten diabetic children had immediate relatives with diabetes. Factors other than hereditary factors may predispose a person to diabetes or may play a part in precipitating the disorder.

Over the past four decades, attention has focused on the role of stress in the etiology of diabetes. In non-diabetic people, a delay in the disposal of carbohydrates in the body may follow the experience of many forms of stress such as starvation, infection or emotional trauma and this delay may result in an undue elevation of blood glucose level. Hinkle and his colleagues (1950) observed that ketosis, characteristic of unregulated diabetes, can appear in non-diabetic individuals who have been exposed to stress. During a period of stress, previously non-diabetic individuals may manifest diabetic-like glucose tolerance curves in response to a carbohydrate load and increases in blood and urine ketones, similar to those of individuals with untreated diabetes. However, unlike the diabetic individual, the non-diabetic's blood glucose and ketone levels generally return to normal following the removal of the stress. The small proportion of patients whose blood glucose levels fail to revert to normal are usually referred to as prediabetic; the assumption being that some predisposition towards diabetes was already present and that the stress had precipitated the condition and made the symptoms apparent.

Heredity is thought to be one of the factors which may predispose an individual to diabetes. Danowski (1963) however cited some other important factors which may be implicated including obesity, injury to the pancreas, repeated pregnancies and the ageing process. Evans and Butterfield (1951) described how severe burning may precipitate diabetes. In the prediabetic individual, the reaction to stress may lead to exhaustion of already vulnerable pancreatic cells and hence to a permanent insulin deficiency and diabetes. Thus stress can be seen as a factor precipitating symptoms of an already dormant condition rather than as a direct causal factor. In populations of people subjected to prolonged stress such as in conditions of war or starvation, only a minority develop diabetes. If stress alone were a causal factor, a significantly greater number of people might be expected to develop diabetes.

Although there is insufficient evidence to support the idea that stress can, by itself, produce permanent diabetes in a previously non-diabetic person not already affected by some form of covert pre-diabetes, there is considerable evidence to suggest that stress precipitates the onset of diabetes in individuals predisposed to the disorder.

4.3. . Types of Diabetes and Response to Stress

Because there are at least two distinct groups of diabetics, it is possible that there are different patterns of physiological and psychological stress response present within the diabetic population. These may be due in part to the differences in glucose regulation. The extent of the differences may depend on the severity of the disorder. In juvenile-onset diabetes, where there is little or no endogenous insulin, the fragile homeostasis maintained by insulin administration, may easily be disrupted by the occurrence of stress. In maturity onset diabetes, however, homeostasis in the face of stress may be maintained to the same extent as the healthy condition particularly if the disorder is being effectively treated by diet alone. For this reason the work reported in the present thesis, for the most part, studied the different populations of diabetic separately. Insulin requiring diabetic males took part in the laboratory experiment. Insulin and tablet treated diabetics of both sexes participated in the life change studies but the groups were analysed separately and comparisons were made across the groups.

4.4. Personality Differences and Response to Stress

In addition to differences in stress response within the diabetic population due to the nature of the disorder, it would seem likely that there are also individual personality differences of the kind found in the general population. Such individual differences, however, have been minimised by several authors (e.g. Menninger, 1935; Lindberg, 1936; Dunbar, 1954;) who have postulated a 'diabetic personality' as a global factor which could be identified and was thought to be characteristic of individuals with the disorder. One assumption was that the rigorous demands made on the person in the management of the disorder might shape his or her whole attitude to 'life', and this might override normal variations in temperament. The diabetic population may thus be thought of as more homogeneous than the non-diabetic population. Attempts to define this 'diabetic personality' have been equivocal. Baker and Barcai (1970) in their review of studies in this area, stated that the literature still contained many conflicting and contradictory reports. There is little agreement and some authors (for example, Brown and Thompson, 1940; Kubany and colleagues, 1956;) have seriously questioned the existence of a typical diabetic personality. It is possible that the need to adhere to what may be a rather restrictive programme of treatment, particularly in the case of insulin-requiring diabetes mellitus, may encourage certain types of behaviour patterns. However, the assumption of a global definition of a 'diabetic personality' may conceal individual differences within the diabetic population which could have important implications for any one individual's control of his disorder.

Attention is paid to the differences in personality among the diabetics studied in this thesis. The personality dimensions, extraversion and neuroticism are considered in relation to both the diabetic's response to stressful situations and to his ability to manage his disorder.

4.5. Experimental Studies on the Role of Stress in the Control of Diabetes

Some diabetics experience frequent episodes of ketoacidosis and coma despite having conscientiously carried out a consistent routine. A study by Nabarro in 1965 reviewed 72 such cases and found that 15% of these people developed the ketosis following an emotional disturbance. However, he concluded that it was impossible to discover whether they had omitted to inject their insulin or whether, more interestingly, psychological factors had produced an intense resistance preventing the action of insulin. Other authors have, less cautiously, attributed such occurrences of ketosis to one or other but not to both of these causes.

There have been a number of experimental studies investigating stress induced ketosis. Amongst the earliest, were those of Hinkle and his colleagues (e.g. 1950; 1952a; 1952b;) who observed variation in the regulation of blood glucose levels with the experience of emotion. In 1952 Hinkle and Wolf reported a study of diabetic and non-diabetic subjects exposed to a stressful interview situation. Most of the subjects showed a transient fall in blood glucose level. This fall was usually accompanied by a rise in blood ketone concentration and by diuresis and increase in glycosuria. Hinkle and Wolf suggested that the fall in blood glucose level was due to increased uptake of glucose by the tissues. This appeared to result from an overall increase in metabolic activity.

In a small number of both diabetic and non-diabetic individuals, a slight rise in blood glucose levels occurred which was not accompanied by any significant change in blood ketone concentration. Relative oliguria and a decrease in glucose excretion was observed in these 'rare' cases. This type of physiological response was associated with signs of intense fear or anger in the individual. According to the authors there 'appears to be an emergency adaptive mechanism, reserved for acute and overwhelming situations'. They suggested that adrenalin may be responsible for the less common occurrence of rise in blood glucose associated with overt emotional reactions. However recent research (review Mason, 1968c) would suggest that increases in catecholamines would be expected in the majority of individuals exposed to a stressful interview situation. The data presented by Hinkle and Wolf suggested that the 'transient' fall in blood glucose levels was rapidly followed by a rise to at least the original level which may well have been due to adrenalin secretion. The rare occurrences of fear or anger may have been associated with a more extreme physiological reaction involving excessive catecholamine secretion or, perhaps, adrenal cortical activity, associated with enhanced glucose mobilisation.

The authors made no reference to the number of subjects employed in their studies and the data presented in graphical form generally represented observations of single case studies. The paper is a report of interesting clinical observations and not of rigorous experimental studies. The observations in this early study suggested that further research into the effects of stress on diabetic control would be valuable. However, the paucity of subjects indicates that the results described in the paper should be interpreted with great caution.

More recent studies by Vandenbergh and Sussman and their colleagues (1965; 1967;) showed similar findings with hypnotically induced emotion and with the experience and anticipation of electric shocks as sources of stress. They reported that diabetics under such conditions showed decreases in blood glucose levels. There was no subsequent glycosuria. Vandenberg and his associates (1967) discussed the possible reasons for a fall in blood glucose levels as follows:

> 'The decrease could not be explained by increasing urinary glucose excretion. It is conceivable that the conversion of fat and protein substrates to glucose, and/or the breakdown of liver glycogen to glucose, have diminished thereby decreasing the rate of glucose formation. It is more likely that an increase in peripheral tissue glucose utilisation has occurred. Emotional stress might produce a generalized increase in body metabolism or more specifically muscle glycolysis, thereby producing an increased rate of glucose disposal.'

In comparing the response of diabetic with that of non-diabetic subjects who showed no significant change in blood glucose levels the authors put forward two possible explanations for the different observations:

> 'It is conceivable and has previously been suggested that the patients with diabetes mellitus might have a defect in their sympathetic nervous system due to neuropathy, such that adrenalin and/or noradrenalin secretion might be impaired. (Sussman, Crout and Marble, 1963). It is more likely that in those patients receiving exogenous insulin for the treatment of their diabetes mellitus, even a minor degree of muscle movement or activity produces greater glucose utilisation than in subjects not receiving insulin therapy. Similar speculations have been advanced in the past with regard to the effect of exogenous insulin on carbohydrate utilisation (Peters and Van Slyke, 1946).'

One of the problems with Vandenberg's studies (and with that of Hinkle and Wolf) was that there was no measure of the psychological impact of the experimental conditions on the subjects. It had to be assumed that the 'stress periods' were indeed stressful to the patients and that the physiological changes observed were associated with the experience of stress.

Vandenberg and Sussman (1967) went on to study blood glucose changes under conditions of 'naturally' occurring examination stress in university students with insulin requiring diabetes mellitus. Here again there were significant decreases in blood glucose levels during the pre-exam and exam weeks compared with a control week. In this experiment some attempt was made to measure psychological reactions; each student rated daily changes in six different emotional categories. In five of the six students, the decreases in blood glucose levels correlated with ratings showing simultaneously increased anxiety levels.

The majority of studies of clinical populations use very small samples of patients and the experiments carried out by Vandenbergh, Sussman and their colleagues were no exception. Each of the studies reported above, used only six subjects and in the two earlier studies, different forms of diabetes were manifested within the samples of six, three of whom were male and three female. As with Hinkle and Wolf's experiment, the results should therefore be cautiously interpreted.

However these experiments do suggest that in stressful situations, diabetics are able to utilise more of their blood glucose than under non-stressful conditions. These findings may well be compatible with the results obtained in the Nottingham studies of the effects of noise and glucose preloading on blood glucose levels and performance already discussed in section 3.1 on blood glucose regulation and stress. (Cox and others, 1973; Simpson and others, 1974). It will be recalled that significant decreases in blood glucose levels were found when subjects worked at a psychomotor task under noisy (80dB) conditions and when the blood glucose was elevated by glucose preloading. This fall in blood glucose was accompanied by an attenuation of the impairment of performance under 80dB noise that was observed in subjects who were not preloaded with glucose.

Insulin requiring diabetics tend to have somewhat higher blood glucose levels than non-diabetics. When clinicians speak of 'good' control of diabetes they are using the term relatively; all control is poor in comparison with physiological control. In general, the aim of treatment is to stabilise the blood glucose to the extent that pre-prandial levels are within the range of 80 to 140 mg./100ml. In mild cases of tablet or diet controlled diabetes, the level after meals may not rise above these limits but in most cases, especially in cases of insulin requiring diabetes, the post-prandial level will rise to 200mg./100ml. or more and attempts to prevent this may lead to hypoglycaemia before the next meal. (In non-diabetic individuals, the blood glucose is generally maintained within the range of 70 to 120mg./100ml.). Thus greater reserves of glucose are present in the blood of diabetic individuals. How available these are to the body tissue, depends to some extent on the supply of sufficient insulin.

The laboratory experiments with diabetic subjects described later in this thesis were carried out along the lines of the Cox and Simpson studies with non-diabetics. It was predicted from the results of Vandenbergh's studies, that a fall in the blood glucose level of diabetics would occur under conditions of noise stress. The experiments were designed to test the hypothesis that a fall in blood glucose levels would be observed in diabetic subjects working in noisy conditions and would be accompanied by the improvement in performance on a psychomotor task similar to that used by Cox and Simpson. The third chapter is devoted to such laboratory experiments with diabetic subjects.

The results of this laboratory research and the studies of Nabarro, Hinkle, Vandenbergh and their colleagues suggested that a variety of stresses can disrupt the diabetic's control of blood glucose levels leading to a variety of responses, some apparently paradoxical, for example: decreases in the level of glucose in the blood or hyperglycaemia and possibly ketosis. The relationship between stress and physiological disruption of diabetic control has been examined in this thesis through retrospective studies of the effects of life events on the course of diabetes.

4.6. Studies of Life Events

In the 1950s, researchers at the University of Washington in Seattle constructed an inventory of life events which was an early edition of the Schedule of Recent Experiences (SRE). It was designed to record systematically the significant life changes reported by subjects during the years prior to developing illness. The idea that experience of excessive life change could lead to various forms of illness was based on a series of hypotheses derived from Selye's now classic work on stress and from developments on this work described by Levi and Kagan (e.g. Selye, 1971; Levi, 1974; Kagan, 1974). Every psychosocial change can act as a stressor in Selye's sense of the word. He states that in response to such an experience, and in accordance with the phylogenetically old adaptation pattern, the neuroendocrine system becomes activated, preparing the organism for physical activity such as fight or flight, even in situations where such reactions are clearly inappropriate. Stress reactions may lead to an 'increased rate of wear and tear' in the organism and if they recur frequently or with great intensity they may eventually in some unspecified manner lead to disease of one type or another in certain individuals. It was also hypothesised that desirable as well as undesirable events could lead to (Selye) stress: i.e. desirable events such as going on holiday would also lead to neuroendocrine activity preparing the organism for physical action. However, although all psychosocial events were assumed to produce qualitatively similar stress reactions, quantitative differences in the magnitude of response to different events were recognised. Several experiments have demonstrated that catecholamine output increases in situations which are novel to the subject (Frankenhaeuser and colleagues, 1968; Froberg and colleagues, 1971) and an increase has been shown to occur in response to many different life changes regardless of the quality of the change, (Froberg and colleagues, 1971; Levi, 1965).

The SRE (Schedule of Recent Experiences) later developed and used by Holmes and Rahe in the 1960s (e.g. 1967) consisted of 43 possible life events (both desirable and undesirable) and their corresponding 'weights'. The weights, which represented the average responses of a large population, were meant to reflect the relative impact of each event on the individual and the degree of readjustment involved in coping with them. This work was the first systematic attempt to quantify the degree of stress experienced in life events and to demonstrate the effects of those events in terms of subsequent illness. However, Nelson (1974) in considering the importance of life events, noted that the life change scores obtained by Rahe and his colleagues (e.g. Rahe and Romo, 1974) tend to show only low correlations with illness incidence among young enlisted men in the Navy. Other variables, such as age, job speciality, work environment, illness history and job satisfaction correlate as highly as life change scores with dispensary visits aboard ship. Although this fact does not diminish the importance of determining the significance of life change events for future illness in a variety of populations and settings, it does suggest that improvements in measuring techniques and studies of possible intervening variables are required if the measure of life change is to be of prognostic significance.

The Holmes and Rahe questionnaire and a variety of similar documents have recently been widely used in the study of predisposing factors in specific types of psychosomatic disorder. This approach has been used extensively and has produced many interesting findings in the study of ischaemic heart disease. This work will be referred to later in this chapter.

4.7. The Effects of Life Events on the Diabetic Condition

Although a causal relationship between life events and illness onset has not been proved the association between life events and neuroendocrine activity has been variously demonstrated (e.g. Selye, 1950; Simon and others, 1961; Froberg and others, 1971). It is probable that experience of life events has important implications for the management of diabetes, given the effects of neuroendocrine activity on blood glucose regulation. The SRE has been used mainly in attempts to elucidate the precipitating factors in psychosomatic disorder rather than in studies of the course of disease. However, if psychosocial stress is an important variable affecting diabetic control, research in this area may well be of value.

One study which has used the SRE with diabetic patients is that of Grant, Kyle, Teichman and Mendles (1974). Their findings suggested a relationship between the occurrence of life change and aggravation of the diabetic state. 'Undesirable' events were mainly responsible for this relationship. However no differences in the influence of life events on the diabetic's physical condition were found between juvenile-and maturity-onset types, or between male and female diabetics. No comparisons were made with non-diabetic subjects.

In the investigations of life change in this thesis a questionnaire, used by Theorell and his colleagues (e.g. Lundberg, Theorell and Lind, 1975) in their studies of life change in myocardial infarction patients, was used to study diabetic and control populations. Theorell developed the use of two forms of questionnaire; one measuring how 'upsetting' each event was, the other measuring the amount of 'adjustment' required. In this way they thought it possible to achieve a more precise picture of the relative impact of each event on a person's life. The questionnaires were used in the present studies to examine the way in which potentially stressful life events were perceived by different groups of diabetic and non-diabetic individuals and to relate the experience of life events to the physiological control of the diabetic condition. This work is described and discussed in Chapter Four.

4.8 The Perception of Concepts used in Describing Stressful Experiences and the Coping Process

The research by Theorell (Lundberg, Theorell and Lind, 1975) assumed that the concepts of 'upsetting' and 'adjustment' were understood and were being used in the same way by different populations. However, if different populations of people were responding to stressful events in different ways it was clearly possible that they not only differed in their perception of these events in terms of upsetting and adjustment ratings, but that they also perceived these phenomena differently. Variations in the perception and use of these concepts may have implications for the interpretation of differences in response to life change questionnaires.

Some attempt is made in the present thesis to assess the meanings of the two terms through the use of a semantic differential technique and to compare their use by the different populations studied.

This approach, developed and used with the diabetic populations, was applied also to the study of patients with ischaemic heart disease because stress has been even more strongly implicated in the etiology and course of that condition. Interest in the way that people with ischaemic heart disease perceive and respond, both physiologically and behaviourally, developed into a secondary line of research which is reported in Chapter Five of this thesis.

5. ISCHAEMIC HEART DISEASE

5.1. The Etiology of Ischaemic Heart Disease

There is now a widely held view that ischaemic heart disease (IHD) is the result of a discrepancy between supply and demand in the blood flow to the heart. Atherosclerosis is generally thought to be the cause of diminished supply of blood, and this may lead to infarction in the heart muscle. Most research has concentrated on locating risk factors which may be causal in atherosclerosis. A high serum cholesterol level has been shown to contribute to this condition and much attention has been focused on determining the causes of elevated serum cholesterol levels. Many physical 'risk factors' in atherosclerosis have been studied and found to correlate to some degree with clinical manifestations of IHD (ischaemic heart disease). These risk factors include cigarette smoking, diet rich in fats or refined sugar, obesity and physical inactivity (for review see Friedman, 1969). However, a description of these causal factors in atherosclerosis would not completely account for the etiology of IHD. Baroldi (1969) noted that in many cases of myocardial infarction (MI) there was no atherosclerosis and Raab (1969) referred to studies which suggested that between 50 and 55%

of cases of clinically diagnosed infarctions showed no evidence of thrombosis or other coronary occlusion. Furthermore, Groen, (1976) stated that many people sustained a considerable degree of atherosclerosis without developing any of the clinical manifestations of IHD. He suggested that most middle aged women in our culture would present such a picture. In the light of these observations it may be more productive to study factors directly related to the manifestations of IHD, than to concentrate on the search for predisposing factors in atherosclerosis which may or may not be present in people sustaining angina, MI (myocardial infarction) or sudden death from heart disease.

Clinical experience and epidemiological and sociological surveys have all contributed useful information about such factors in relation to IHD itself. These sources of information have shown that IHD is related to such variables as age, sex, culture and urbanisation. The incidence of IHD increases with age. The early development of the disease is more common in males than females. IHD is typically a disease of Western society and is less common in 'underdeveloped' countries. Within Western society, IHD is more prevalent in urban than in rural areas.

Groen (1976), in considering the various risk factors some of which are mentioned above, summarised the findings:

> 'it appears that most of the risk factors which have been shown to play a role in the multifactorial causation of IHD are related to both the social structure and ways of 'Western' society in general and to certain personality and situational characteristics which make these 'Western' psychosocial behaviour patterns more risky for some individuals than for others'.

Clearly it is necessary to look beyond specific factors which have been found to correlate to a greater or lesser extent with IHD in order to elucidate the mechanism underlying the disorder. Raab (1969) has argued that emphasis on specific factors in heart disease has obscured the significance of more general neuroendocrine factors. While atherosclerosis is undoubtedly a contributing factor in IHD it cannot be said to be directly causal.

5.2 The Role of Neuroendocrine Factors in IHD

Earlier work by Selye (1958, 1961) on the effects of catecholamines and glucocorticoids on heart muscle has been confirmed and extended by other researchers, notably Raab. Raab (1969, 1971) suggested that the myocardial cell, perhaps with any oxygen supply limited by atherosclerosis, would lose intracellular potassium and magnesium and gain sodium when its oxygen requirements were increased by catecholamine activity. These effects would be enhanced by corticosteroid activity on the myocardial cell membrane. Cell necrosis has been attributed to this ionic disequilibrium. Coronary thrombosis was regarded as a contributing rather than an explanatory factor. Thus it would appear that neuroendocrine activity of the kind shown to be associated with the experience of emotional and environmental stresses was at least as important a factor as atherosclerosis in the etiology of IHD.

There is some specific evidence to suggest a direct link between catecholamines and atherosclerosis. Haft and his colleagues (1972) have shown that infusions of noradrenalin may cause platelet aggregation in the myocardial blood vessels of dogs, suggesting a possible role of stress-induced increases in circulating catecholamines in coronary atherosclerosis and clinical manifestations of IHD.

Models propounding the importance of stress in the development of IHD depend upon evidence that individuals who develop the disease respond to stressful situations with an excessive degree of sympathetic activity compared with individuals who remain healthy. However, if such an association were shown in persons presenting symptoms of IHD it would be equally possible that it was the disease which led to the excessive reaction to stress. Prospective studies required to solve this problem of interpretation are necessarily lengthy and tend to be problematic. However there is considerable evidence from retro-spective work and some from prospective studies that certain types of behaviour patterns are associated with high catecholamine secretion in response to stressful experiences and with increased incidence of IHD.

5.3. The Role of Personality in Ischaemic Heart Disease

The work of Friedman and Rosenman on individual differences in the development of IHD has been extensive. They have described two extreme behaviour patterns; a predisposing Type A behaviour pattern and a relatively immune Type B pattern. Rosenman and Friedman and their colleagues (1970) described six behavioural characteristics typical of Type A individuals as follows:

1. An intense, sustained drive to achieve self-selected but usually poorly defined goals.
2. Profound inclination and eagerness to compete.
3. Persistent desire for recognition and advancement.
4. Continuous involvement in multiple and diverse functions constantly subject to time restrictions.
5. Habitual propensity to accelerate the rate of execution of many physical and mental functions.
6. Extraordinary mental and physical alertness.

Type A behaviour is said to be overtly portrayed in rapid, tense body movements and speech, impatience, excessive unconscious gesturing and a strong sense of urgency. Initial studies found higher serum cholesterol levels and a significantly increased incidence of IHD among men exhibiting a Type A behaviour pattern. There were no differences found between the groups in smoking, diet or alcohol intake (Friedman and Rosenman, 1959).

A series of papers by Friedman and his colleagues followed concerning a prospective study of 3524 males over a period of four and a half years. 133 of the 3182 subjects still available for study had manifested some form of IHD by the end of this period. The disease was found to be significantly associated with the following factors:

1. Parental history of IHD.
2. Elevated blood pressure.
3. Smoking.
4. Elevated serum cholesterol, triglyceride and beta lipalbumin levels.
5. Type A behaviour.
(Rosenman and others, 1970)

The early work of Friedman and Rosenman (e.g. 1959) was based largely on clinical experience, and assessment of personality relied heavily on the opinions of physicians and 'lay executives' rather than on independent assessment through questionnaires. A study by Gertler and others (1954) of 100 young men with IHD did not find any significant differences in their personalities compared with normal men. Friedman and Rosenman (1959) claim that 'careful scrutiny of their data reveals that the majority of these 100 men actually did exhibit many of the qualities characterising behaviour pattern A'. The 'evidence' they presented (Friedman and Rosenman, 1959) is questionable. Friedman and Rosenman's later work appears to be rather more reliable although in some studies judgements of both personality and clinical data seem to be made by the same experimenter and this type of methodology is notoriously susceptible to experimenter bias.

Studies by other investigators have, however, provided supporting evidence. Keith, Lown and Stare (1965) used 'blind' interviewing and rating procedures in a cross-sectional study of patients with IHD and other chronic diseases. They confirmed Friedman and Rosenman's findings that Type A behaviour was associated with increased prevalence of IHD.

Further studies have concentrated on perceptual aspects of personality differences. For example, Raff and others (1969) focused attention on sensory information processing as one important determinant of cardiovascular function. Raff and his colleagues observed that patients who sustained recurrent MI within twelve weeks of their first infarction were more vigilant,hyperalert and 'overinclusive of stimulus input' than patients who did not sustain an early recurrence. Williams (1975) suggested that

> 'the association of stimulus intake behaviour with increased plasma catecholamine levels (Williams, 1974) could provide a basis - via the effects of catecholamines to increase myocardial oxygen consumption - for the increased reinfarction rate among overscanners'.

Williams (1975) reviewed studies of other measures of individual differences in perceptual style such as field dependence vs field independence, augmenters vs reducers, and associated levels of sympathetic nervous system activity. He suggested that such factors could account for the relationships between psychosocial factors and the risk of coronary disease.

Raab (1968) provided evidence that certain 'emotionally irritable' individuals may be predisposed to IHD. He examined responses to 'mild sensory and mental annoyances' (noise, flickering light and mental arithmetic). These stimuli were found to provoke significant increases in plasma cortisol levels and manifestations of cardiac sympathetic stimulation in individuals shown, by means of questionnaire assessment to be emotionally excitable with regard to everyday annoyances. Raab cited evidence from other studies including studies which showed that individuals with catecholamine-overproducing pheochromocytoma (Raab, 1953; Van Vliet and colleagues, 1966) and cortisol overproducing Cushings disease (Raab, 1953; Kalinin and colleagues, 1966; Zairatyants and Kilinsky, 1967) were more prone towards myocardial disease. Conversely individuals with hypoadrenalism in Addison's disease, showed a total absence of myocardial disorders (Raab, 1953). On the basis of this extensive evidence Raab suggested that the individuals who were hyperreactive towards everyday annoyances would be more prone to IHD.

5.4. Association between IHD and Diabetes

It is clear from this brief statement of the present state of research that there is much evidence to suggest that the experience of stress is intimately linked with the pathogenesis of IHD via the activity of various endocrine systems. Catecholamines released in response to stressful conditions may directly affect the demands of the myocardium, particularly in the presence of certain adrenocortical hormones such as cortisol which have been shown to be active in conditions of chronic stress. Vagal and sympathetic-inhibitory mechanisms are also implicated in the manifestation of IHD since their counter-regulatory function may be inadequate in controlling excessive catecholamine activity.

Several researchers have noted further associations between IHD and diabetes mellitus. Yudkin considered the role of nutrition in the conditions of diabetes and atherosclerosis to be of central importance. He believed that dietary sucrose was of particular significance in the etiology of these disorders, and stated that sucrose

> 'now contributes between 15% and 20% to the average dietary calories of the wealthy countries in which obesity, diabetes and atherosclerotic disease have increased in prevalence, (Yudkin, 1972(a)).'

Yudkin (1972(b)) provided evidence to show that sucrose profoundly affected hormone secretion in the body. Sucrose has been shown to cause a rise of 50% in the level of insulin in fasting blood and a rise of 300% to 400% in the level of corticosteroids.

There is evidence, summarised by Mahler (1965) and by Stout and Vallance-Owen (1969) to suggest that a high concentration of insulin may be the mechanism that produces atherosclerosis. Stout and Valance-Owen noted that despite improvements in the control of hyperglycaemia and ketosis which have resulted from insulin therapy, the incidence of diabetic arteriopathy has steadily increased. They also provided evidence that a large proportion of non-diabetic patients with IHD had mild abnormalities of carbohydrate metabolism (e.g. impaired glucose tolerance) similar to those found in diabetic subjects. The authors suggested that ingestion of refined carbohydrates stimulated the secretion of disproportionately large amounts of insulin in certain individuals. They proposed a mechanism which incriminated insulin and carbohydrate in atherosclerosis. They suggested that this scheme would link atherosclerosis with diabetes and other disorders of metabolism.

> 'Ingestion of large quantities of refined carbohydrate would stimulate the secretion of insulin. In certain individuals, including those with increased synalbumin antagonism[1], the output of insulin would be disproportionately large, although exercise would diminish the secretion. The immediate result would be enhanced absorption of further carbohydrate, and thus more insulin secretion. The individual has now in his circulation large amounts of glucose and insulin, and the action of this insulin is modified in favour of lipogenesis. The carbohydrate is disposed of in three sites - adipose tissue, liver and arterial wall. Obesity is produced.

> In the liver, triglyceride and cholesterol are synthesised and find their way into the circulation. Lipid synthesis is also stimulated in the arterial wall and is augmented by deposition of plasma lipids. Local haemodynamic factors govern the distribution of the arterial lipid, which in a few decades would reach significant proportions.'

Szanto and Yudkin (1969) also proposed that persons in whom sucrose produced hyperinsulinism were those who were susceptible to the action of sucrose in producing IHD. Yudkin (1972(c)) suggested that a hormonal inbalance, perhaps of insulin or perhaps of an adrenal cortical hormone is the cause of the multiple disturbances associated with IHD rather than a simple biochemical aberration such as the rate of cholesterol synthesis.

It appears that the hormones involved in sugar metabolism and blood glucose regulation may be involved in the disorders of both IHD and diabetes. If such hormonal imbalance does exist in IHD patients it may be reflected in the blood glucose changes associated with stressful conditions. The study of blood glucose changes in diabetic patients under stress was therefore extended to examine the effects of stress on blood glucose levels in patients with IHD. Patients with IHD were studied in order to investigate their behavioural, perceptual and physiological responses to various experiences of stress. The laboratory study was designed in the same way as the diabetic study to examine the specific effects of noise stress on performance and blood glucose levels. The study of life

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1. Synalbumin is present in all serum but is present in increased amounts in diabetics and pre-diabetics. It antagonises the action of insulin on muscle but not on fat. Increased levels of synalbumin have been found among patients with MI. (Vallance-Owen, 1969).

change concentrated only on the psychological factors involved in reactions to life events by patients with histories of MI. It was not within the scope of this research to attempt any form of prospective study or to measure physiological variables that may be associated with the experience of life events by patients with IHD.

5.5. Life Events and Ischaemic Heart Disease

It has already been mentioned that much research has concentrated on the relationship between life events and IHD. Most studies have attempted to demonstrate a positive correlation between life change and IHD manifestations using questionnaires such as the SRE. Many of these studies have found that MI patients and their relatives tend to report retrospectively that the six to twelve month period preceding the disease onset was characterised by an unusual number of important changes in the patient's life, (e.g. Rahe and Romo, 1974; Rahe and Paasikivi, 1971; Theorell and Rahe, 1971).

Several investigators have measured physiological reactions to life change which may be relevant to the pathogenesis of MI. Theorell and his associates (1972) studied 21 male, rehabilitated survivors of MI and found that the mean level of life change experienced per week was correlated with the subjects' mean adrenalin output over the same period. A prospective study was undertaken by Theorell and his colleagues in order to eliminate the possibility that bias may be created by the patients (or the relatives) knowledge about their illness. Such bias, if it exists, may lead to an increase in the number of life changes reported in an attempt to 'explain' the origins of the disease. This study is still ongoing. Using large samples from a population of seven thousand, middle aged, building construction workers, Theorell aimed to study the effects of change on health data such as ECG, blood pressure and serum lipid measures. Evidence of illness other than that indicative of IHD is also being collected, (Theorell, 1976.).

A two year follow up study of this work was reported in 1976 (Theorell, 1976). One of the measures used was the 'discord index' devised by Theorell and his co-workers (Theorell and others, 1976). It was previously found that a high 'discord index' - including mainly irritability and life dissatisfaction variables - indicated a significant increase in the risk of sustaining MI in the near-future. In the two year follow up study, it was found that those workers characterised by both high 'life change' (LC) and high 'discord' (D) indices had higher blood pressure than the other groups (high LC, low D; low LC, high D; and medium and low scores on both LC and D). Among 'low discord' subjects, those with many life changes had no excess illness. This work therefore suggests that the manner in which people habitually respond to psychosocial events has to be taken into account in evaluating the impact of such events on their health. This factor is not considered in the majority of studies of life change and may account for the lack of impressive correlations in such studies between life change and illness noted by Nelson (1974).

Theorell and his colleagues have also been working towards further refinements in the use of measurements of life change. It has already been mentioned in section 4.7 that Theorell has developed the use of a form of the SRE to be rated for both 'adjustment' and 'upsetting'. Theorell and his associates (Lundberg and Theorell, 1976) gave these questionnaires to groups of patients with low back pain, patients with neurosis and to MI patients in order to investigate the possibility that quantitative differences in rating change may exist. The experiment showed that on average, neurotic patients gave higher values than their controls to the life change events on both scales, while MI patients gave higher values only on the 'upsetting' scale. Low back pain patients did not differ in their scaling means from the controls. The authors tentatively suggested that the higher values in the patient groups might reflect some characteristic which both had preceded their illness and had contributed towards it. They also point out, however, that higher values might also be an effect of a response bias due to assumptions of the patients concerning the causes of their illness. However, MI patients gave significantly higher values only for the upset scale and it is therefore possible that this scale is more relevant for their reaction to life changes.

In the same paper, Lundberg and Theorell compared ratings of experienced and non-experienced events. It was thought that if retrospective response bias was influencing the results it would tend to be most apparent for experienced events. However, although the MI patients tended to give higher values than controls, there was no significant difference between the ratings of experienced and non-experienced events by MI patients. In addition, several of the experienced events were given higher values by the controls. The authors suggested that these findings indicated that response bias was having little affect on the results and went on to propose that:

> 'A more likely explanation is that MI patients do perceive various life changes differently from control subjects and that some events are considered to be more important by the MI patients, while others are considered to be more important by the controls. Group differences in personality, such as a larger proportion of Type A persons among the MI patients may be the reason for these differences.'

The SRE questionnaire revised by Theorell and his colleagues was applied to the study of MI patients as well as to the study of diabetic patients. A replication of Theorell's findings was attempted with British patients. In addition the use of the concepts 'upsetting' and 'adjustment' was examined. It has been suggested earlier, in section 4.8 describing the use of these methods with diabetic patients, that differences in perception and use of the concepts 'upsetting' and 'adjustment' may exist between the populations studied. Theorell's extensive research with MI patients demonstrated considerable quantitative and perhaps qualitative differences in the experience and rating of life changes by MI patients. Throughout his research Theorell recognised the need for greater precision in the use of the rating scales if they were to be of any predictive value. Investigation of individual differences in perception and use of the concepts upon which such rating scales depend, will perhaps increase the precision with which the instrument is used. It is hoped that information gained from further study of the terms 'upsetting' and 'adjustment' will be useful in the interpretation of results from life change situations.

6. Factors which may influence the Psychophysiological Effects of Stress

The studies by Cox, Simpson and Rothschild in 1973 developed on the one hand into the present series of studies with hospital patients and on the other into an extended series of experiments with healthy subjects. This parallel series of studies of healthy people was carried out by Mackay, Cox and other colleagues in Stress Research at Nottingham University. The effects of glucose preloading on blood glucose levels and performance were examined in response to various forms of stress using a variety of experimental tasks. Sex differences were also examined in this healthy population. The results of this work will be referred to at relevant points in this thesis.

In Chapter 6 two experiments with healthy subjects are reported. These experiments were designed and carried out in collaboration with Mackay to investigate further some of the questions arising both from the hospital studies and from the studies carried out at the University by Mackay and other members of the research group.

The possibility that some of the differences in response to noise stress might be due to the amount of glucose preloading was investigated. The relative importance of psychological and physiological factors in determining the results of glucose preloading was also studied.

In addition it was possible to run the experiments in conjunction with Mackay in such a way that any effects of experimenter differences on the results could be examined. It was thought that experimenter effects might have contributed towards some of the unexpected differences between the results of the two experimenters' respective studies. This 'joint' experiment provided an excellent opportunity to investigate any such effects.

These experiments will be introduced more fully in Chapter 6 where they can be considered in the context of earlier studies.

7. Summary

Different applications of the concept of stress were considered. The use of the term 'stress' in the present thesis was discussed and the specific stressors studied (noise stress and life stress) were described.

Psychophysiological responses to stress were then considered with particular reference to factors affecting blood glucose regulation.

Changes in blood glucose levels were shown to be of particular significance under stressful conditions. It was suggested that measures of blood glucose may provide an important indication of the physiological responses of healthy subjects, diabetic, heart disease and control patients under stressful conditions.

The clinical manifestations of diabetes mellitus and ischaemic heart disease were described and the role of stress in the etiology and course of both conditions was considered. The studies of these patients were introduced in the context both of related work already described in the literature and of ongoing work by other researchers.

The results of studies of diabetic, IHD and control patients were considered in relation to work carried out in parallel investigations by other researchers at Nottingham. Two experiments which evolved from and were relevant to both these lines of research were introduced.

The sequence of the experimental work is presented in the following summary.

8. SEQUENCE OF EXPERIMENTS DESCRIBED IN THIS THESIS

Chapter 2

METHODOLOGY

The methods employed throughout the thesis are described. Necessary pilot studies and the development of the semantic differential scales are discussed in detail.

Chapter 3

DIABETES MELLITUS: LABORATORY STUDIES OF NOISE STRESS

Two laboratory studies of the effects of noise stress on physiological and behavioural measures of patients with diabetes mellitus are described and discussed.

Chapter 4

DIABETES MELLITUS: STUDIES OF LIFE STRESS

Attitudes towards and experience of life events by diabetic and control patients are examined. The effects of life change on the management of diabetes is investigated. The perception of concepts used in the questionnaires is studied using the semantic differential technique.

Chapter 5

ISCHAEMIC HEART DISEASE: STUDIES OF NOISE AND LIFE STRESS

A laboratory experiment on the effects of noise stress on physiological and behavioural measures of patients with IHD is described and discussed. Psychological reactions of life events by IHD and control patients are investigated. The perception of concepts used in the questionnaires is studied.

Chapter 6

HEALTHY SUBJECTS : STUDIES OF FACTORS AFFECTING THE RELATIONSHIP BETWEEN GLUCOSE, NOISE AND PSYCHOMOTOR PERFORMANCE

Two laboratory experiments with healthy subjects are reported. The first investigates the possibility of titrating the amount of glucose preloading with the degree of noise stress. The second investigates experimenter differences and the relative influences of psychological and physiological components in the effects of glucose preloading.

CHAPTER 2.

METHODOLOGY

This chapter deals with the various methodological questions that have arisen. The independent and dependent variables involved in the laboratory experiments are each considered separately. The methodological problems inherent in the use of life change questionnaires are discussed with reference to pilot studies which preceded the studies of life change presented in chapters 4 and 5. The development of a semantic differential questionnaire for the assessment of the meanings of concepts used in the life change questionnaire is also discussed.

Laboratory Experiments

The dependent variables measured throughout the series of laboratory experiments are considered first. These are followed by discussion of the independent variables studied.

Dependent Variables

1. Blood Glucose Levels

Capilliary blood samples of 0.05 ml. of blood were taken from the nail bed of the thumb of the subject's non-preferred hand. Handedness was determined by enquiry. The area was cleaned, a tourniquet was applied around the base of the thumb, which was bent, and the skin ruptured using a 'sera-sharp' sterile blood lancet. The small amount of blood required was drawn using a blood pipette and precipitated in 0.5ml of perchloric acid (0.33M). The sample was centrifuged at 70 revs/min for 10 minutes and the supernatant cold stored until assay.

Samples were analysed by the GOD-Perid Method (Boehringer kit No. DBPI-648-840) using a Pye SP600 spectrophotometer. Blood glucose estimations in mg/100ml were recorded.

The technique of blood sampling described above was selected by Bradley and Cox after consideration of several alternative methods. The possibilities of ear-lobe and ball of thumb samples were also explored. However capilliary blood sampling in the manner described above was found to be painless and quick and incurred the minimum inconvenience to both subject and experimenter. Venous blood samples might have provided more accurate measures of absolute blood glucose levels but the procedure involved is generally considered to be unpleasant and would have been disruptive (more stressful) in these experiments. Venous blood sampling would also require the presence of a para-medic and such a requirement would have been an added complication. Since changes in blood glucose levels rather than absolute measures were of primary interest, capilliary samples from the same location provided a satisfactory estimate for this purpose.

A reliability study was carried out by the present writer (CB) and Mackay (CJM) in order to assess the degree of reliability of the sampling technique and the method of analysis used.

1.1. Reliability Study: Blood Sampling and Glucose Estimations

The aims of this experiment were as follows:-

i) To assess 'split-half' reliability for each experimenter i.e. to compare two blood glucose estimations, of the same sample, made by one experimenter.

ii) To assess the degree of reliability between the experimenters i.e. to compare blood glucose estimations of the same sample made by two different experimenters.

iii) To assess the reliability of the blood sampling technique between experimenters by comparing blood glucose determinations of different blood samples taken by two experimenters from the same subjects.

Method

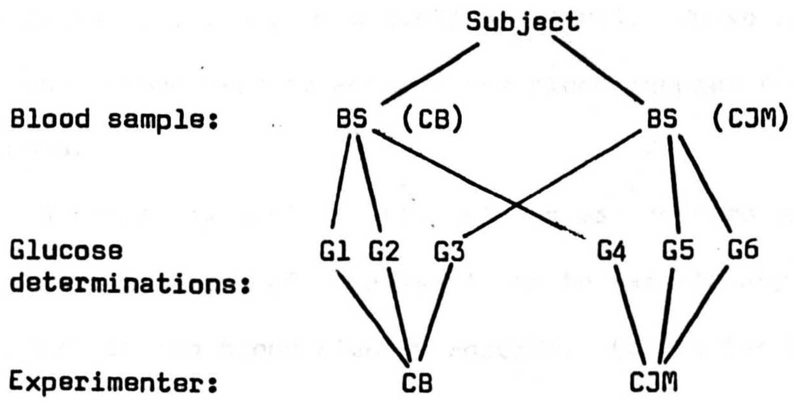
Subjects 3 male and 3 female colleagues participated as subjects in this study.

Experimenters CB and CJM.

Procedure A capilliary blood sample of 0.05 ml was taken by each of the experimenters from each of the six subjects in the manner described above. The order in which the experimenters were to take the samples was balanced. The second sample was taken by the second experimenter as soon as possible after the first sample.

Each experimenter analysed his/her own sample twice and the other experimenter's sample once. Thus three analyses were made of each sample. The procedure is summarised below in figure 1.

Figure 1: Summary diagram of blood sampling and glucose determinations by experimenters



Results and Discussion

The results are summarised in Table 1 as means and standard deviations.

Table 1: Means and Standard Deviations of Blood Glucose Estimations

SAMPLER

			CB		CJM	
ANALYSER	CB	Mean	109.1	108.4	113.3	
		S.D.	12.79	12.39	14.12	
	CJM	Mean	108.3		112.4	112.5
		S.D.	9.93		10.30	10.61

The two determinations made by each experimenter of his/her own blood samples were correlated using Pearson's Product Moment correlation. The correlations were highly significant for both experimenters, (CB: $r = 0.979$, sig.$<.001^{***}$; CJM: $r = 0.918$ sig.$<.01^{**}$). The correlations of determinations made by the two experimenters separately for each of the blood samples were also highly significant. ($r = 0.974$ sig.$<.001$, $r = 0.931$ sig.$<.01$). These results suggest that the method used to analyse the blood samples for glucose was reliable.

A three way analysis of variance was carried out to confirm that there was no effect of 'analyser' and to examine any effects of 'sampler' on the blood glucose results. (Where two blood glucose determinations had been made on one sample by the same experimenter, the first value was used in the analysis of variance).

The results confirmed that there was no effect of 'analyser' i.e. differences in blood glucose measures were not due to the biochemical analysis of the samples. However there were significant differences in blood glucose measures from the same subject. These differences were dependent upon which experimenter took the sample (the 'sampler'). A summary of results from the analysis of variance is presented in Table 2 below.

Table 2. Analysis of Variance of Blood Glucose Determinations

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F.	DF2	P.
A (Subjects)	3184.0704	5	636.8141			
B (Analyser)	2.6642	1	2.6642	0.108	5	N.S.
C (Sampler)	112.6642	1	112.6642	18.960	5	0.00733** sig
AB	123.6718	5	24.7344			
AC	29.7108	5	5.9422			
BC	0.1093	1	0.1093	0.017	5	N.S.
ABC	31.4454	5	6.2891			
Total	3484.3400	23				

While it was expected that there would be some difference between the two blood samples taken from each subject, a consistent and significant difference was not expected. The data showed that the three blood glucose determinations of samples taken by CJM were consistently higher than samples taken by CB (Means: 112.9 and 108.7 mg/100ml. respectively). Because the order in which the experimenters took their blood samples was balanced, this factor could not account for the results. It is possible, but unlikely, that the subjects' blood glucose levels actually changed; increasing during the short interval between samples when CB took the first samples and decreasing when the first sample was taken by CJM. The difference was more likely to have been due to the amount of blood taken. On further observation, it appeared that CJM slightly but consistently overestimated the quantity of blood required while CB slightly but consistently underestimated the amount. However, since it was the change in blood glucose levels rather than the actual levels that was of primary interest in the work involving such samples, the degree of reliability found in this study was satisfactory provided that the same experimenter took each of the blood samples required from any one subject during an experimental session. Problems would arise only if, for example, CB consistently took the first sample and CJM the second; a difference between the blood samples would then be found that was greater than the actual difference.

Conclusion

The estimation of blood glucose by the analytical method described above in section 1 was reliable both within and between experimenters.

There were small but consistent and significant differences in blood glucose estimates between the samples taken by the two experimenters. The result would be of little significance provided that only one experimenter took all of the necessary blood samples from each subject during an experimental session. In the experiments described in Chapter 6, where both CB and CJM were experimenters, the experimenter for each subject was kept constant. Experimenters results only varied between subjects.

2. Performance

Performance at the pursuit rotor task (described later in this chapter) was measured automatically by means of Grason Stadler and AIM-Biosciences programming modules. Two measures of performance were obtained. The time on target (TOT) score indicated the total time in minutes that the subject managed to keep the probe in contact with the light. The number of deviations (Dev.) from the light was also recorded. These measures tended to be negatively correlated; higher time on target scores were usually associated with fewer deviations.

However different strategies used in coping with the task might be reflected in different correlations between the two measures.

3. Experimental Procedure

A standard experimental procedure was followed throughout the various laboratory studies. The procedure was briefly described to potential subjects although explanations of the purpose of the experiments were generally withheld until the session was over. On arrival at the laboratory, a blood sample (BSI) was taken in the manner described in section 1. Glucose preloaded subjects and controls were then given the appropriate drink. Information given concerning the drink varied according to the populations studied and the aims of the experiment.

Subjects then sat quietly for 30 minutes completing any questionnaires required (see sections 4,5 and 6a) and/or reading "neutral" magazines provided by the experimenter. Smoking was not allowed.

After the 30 minute period allowed for glucose absorption, a second blood sample (BS2) was taken. The subject was then shown the pursuit rotor task and appropriate instructions were given (section 8). The subjects either performed the task or sat quietly at the apparatus, for 15 minutes. All subjects wore headphones which transmitted 50 or 80dB white noise.

At the end of the 15 minute period, the subject removed the headphones and returned to the original area where the third blood sample (BS3) was taken. Questionnaires concerned with subjective experience of the previous 15 minute session were then completed. Finally explanations were given and subjects' questions were answered. The procedure is summarised diagrammatically in figure 2.

4. Information sheets

A variety of questionnaires were devised in order to gather data from subjects concerning such factors as age, sex, occupation, health and medical treatment, height, weight and time since last meal.

In the experiments on healthy subjects, the time since the last meal was controlled but this was not possible with the hospital patients, most of whom volunteered and participated in the study during a single clinic visit. The period of fasting was always recorded, this being an important factor in determining blood glucose levels. Body weight was also a factor which might influence the regulation of blood glucose. The discrepancy between actual and ideal weight was calculated. The ideal weight for age, sex and height was determined from the Preludin Calculator based on data published in the Journal of the Institute of Actuaries, London.

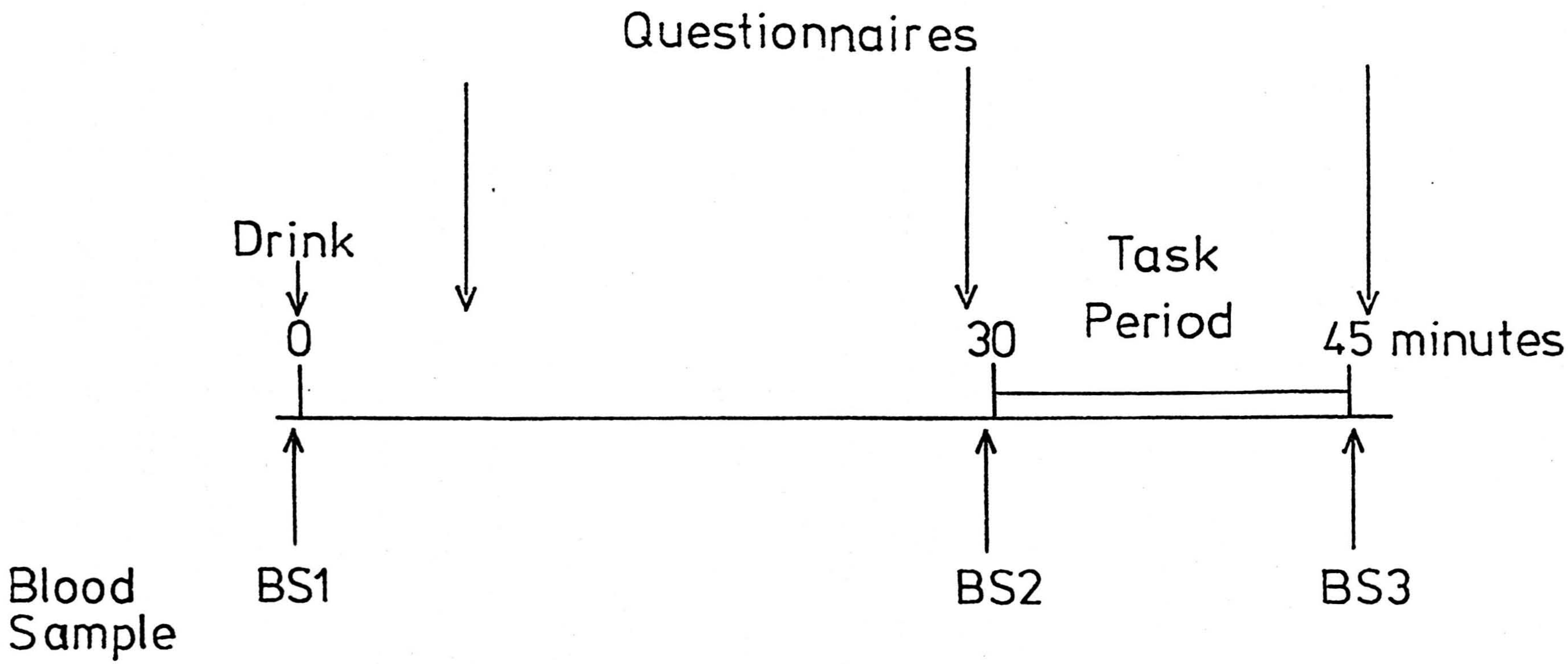
5. Personality Measures: The Maudsley Personality Inventory (MPI)

The MPI (Maudsley Personality Inventory) developed by Eysenck (1959) was used to estimate measures of personality along the two dimensions of Extraversion-Introversion(E) and Neuroticism-Stability (N). Eysenck claimed that these two dimensions were unrelated and together provided a broad picture of an individual's personality.

Figure 2. General Form of Experimental Procedure

This figure describes the 45 minute experimental session. The points at which blood samples (BS1, 2 and 3) were taken and the points at which the various questionnaires were given are indicated.

GENERAL FORM OF EXPERIMENTAL PROCEDURE



'While not wishing to deny the existence and importance of factors additional to E and N, we believe that these two factors contribute more to a description of personality than any other set of two factors outside the cognitive field.' (Eysenck and Eysenck, 1964).

The MPI consists of 48 questions in yes/no form. 24 questions relate to the E dimension and 24 to the N dimension. A question mark could be circled if the subject was uncertain of his answer to the question but its use was discouraged in the instructions.

A large number of validation studies have been carried out with the MPI and standardisation data for a variety of population samples are available (Eysenck, 1959). However, there are several weaknesses inherent in the questionnaire. Subjects scored high on the N scale if they responded with 'yes' to the N questions; this allowed for the possibility of bias due to acquiescence response style. This methodological deficiency did not apply to the E scale of the questionnaire.

Other problems involved semantic difficulties experienced by certain subjects. Some questions were ambiguous in their construction; e.g. "Is it difficult to 'lose yourself' even at a lively party?"
The term 'Gay' has recently acquired an additional colloquial meaning giving the question "Can you usually let yourself go and have a hilariously good time at a gay party?" an alternative meaning.
The problems of personality measurement have been discussed in detail elsewhere (e.g. Heim, 1970).

Despite these deficiencies, the MPI is comparatively straightforward and the majority of subjects were able to complete it without great difficulty. In the few cases where the subjects were unable to complete the questionnaire due to reading problems or poor eyesight for reading, it was possible to read the items to the subjects and record their answers.

6. Subjective Report of Experience

In the experiment by Cox, Simpson and Rothschild (1974) no attempt was made to estimate the subjective degree of stress experienced by the subjects. The noisy (80dB) condition was assumed to represent a stressful situation because it was associated with performance impairment and the quiet (50dB) condition was thought to be non-stressful. However, glucose preloaded subjects showed no impairment with 80dB noise: their performance was impaired in the quiet condition. It could be suggested that this finding indicated that glucose preloaded subjects experienced the quiet condition as more stressful. Clearly some estimate of subjective experience was necessary in order to interpret the results more fully. Cox (personal communication) has since recognised that the lack of subjective measures of experience was a deficiency in that experiment.

6.1. Subjective Experience Questionnaire

In the experiments with diabetic, IHD and control patients, subjects were questioned about their experience of the experimental session by means of a short questionnaire.

In three of the questions the subjects were asked to tick one of four items which best described how they felt, for example:

Very pleasant

Pleasant

Unpleasant

Very Unpleasant

Questions two and three involved the dimensions tense-relaxed and bored-interested. Theoretically boredom might be conceived as a factor in or a correlate of stress; understimulation as well as overstimulation might be stressful (Levi, 1974). It was suspected that boredom might have been a complicating factor affecting subjects who were not asked to perform the task. However the responses to these four-choice questions were not statistically examined, they were merely used to obtain a subjective impression of the subjects' reactions to the experimental situation. The responses to question 4 were analysed statistically. Three alternative responses were suggested to question 4 'How stressful did you find the session?' Very, Slightly and Not at All. This question was useful in determining the degree of stress subjects were prepared to report that they had experienced. Many researchers would doubt that a true impression of the subjects' experience could be gained merely by asking them. The final question (five) was an attempt to achieve an indirect measure of the subjects' experience in terms of estimation of the length of the time period. Subjects were asked to estimate the duration of time (i.e. the number of minutes) they were sitting at the apparatus.

The relationship between physiological variables and time estimation has been a source of interest for over a century. However, the study of time estimation has been confounded by variations in the definition of time experience and by the diversity of approaches to the study of the phenomenon. Ornstein (1969) extensively reviewed the area of time experience and considered the theoretical and methodological problems involved. Studies attempting to relate time estimations and physiological changes have on the whole been inconclusive. Studies investigating the effects of various drugs on time estimation have been rather more consistent.

Frankenhaeuser (1959) confirmed the findings of Goldstone and colleagues (1958) that amphetamine lengthened duration experience relative to a placebo. The experience of duration under amphetamine was shown to be significantly longer than under a sedative, phenobarbitol.

Frankenhaeuser also showed that caffeine lengthened experience of duration. Thus stimulant drugs which increased awareness or alertness appeared to extend estimates of time while sedative drugs depressed alertness and decreased time estimates. These findings were explained by Ornstein (1969) in terms of 'Storage Size' metaphor. He suggested that duration depended on the size of the storage space for the information of a given interval. The size of this space would depend upon both the amount of information or number of occurrences in the interval that reached awareness and the way in which that information was 'chunked' or stored. Stimulant drugs might increase awareness of information and lead to an impression of increased duration. Comparable results have also been shown with psychedelic drugs which increased awareness, for example Bromberg (1934) with marijuana, Fischer (1967) with psilocybin and Masters and Houston (1966) with LSD. With such drugs it has been consistently shown that duration is lengthened relative to 'no drug' experience.

It could therefore be hypothesised that naturally occurring changes in awareness or alertness, which may perhaps be termed 'arousal', might be related to the experience of duration: longer estimates of duration being associated with higher levels of arousal. However, attempts to relate time estimation as a measure of arousal with physiological changes associated with arousal have been disappointing (e.g. Kopell and colleagues, 1969).

In the studies in this thesis, estimates of duration are examined along with other subjective measures of arousal and measures of stress. The possible relationship between these measures and the physiological and behavioural variables studied was investigated and reported in chapters 3, 5 and 6.

6.2 Stress Arousal Checklist

Later experiments reported in Chapter 6 employed a self-report questionnaire of arousal which was rather more sophisticated than the previous questionnaire. Comparisons were made between the two.

The Stress Arousal Checklist (SACL) was developed by Mackay, Cox, Burrows and Lazzerini for this purpose. The inventory was developed by factor analytic techniques for use with a British population and is based upon the work of Thayer (1967). It appeared to measure two factors. These have been labelled 'stress' and 'arousal'. Both factors were bipolar. The adjectives loading on each of the factors are listed as follows:-

Stress Factor

Stress +	Stress -
Tense	Peaceful
Worried	Relaxed
Apprehensive	Cheerful
Bothered	Contented
Uneasy	Pleasant
Dejected	Comfortable
Up Tight	Calm
Jittery	(7)
Nervous	
Distressed	
Fearful	
(II)	

Arousal Factor

Arousal +	Arousal -
Active	Drowsy
Energetic	Tired
Vigorous	Idle
Alert	Sluggish
Lively	Sleepy
Activated	Somnolent
Stimulated	(6)
(7)	

The SACL questionnaire contained the above 31 adjectives in random order. Four responses were possible for each adjective ++, +, ?, or -. If a ++ or a + had been circled to a positive adjective then a score of 1 was recorded for that factor, otherwise no score (0) was assigned. If a ? or a - had been circled for a negative adjective then 1 was scored, otherwise 0. Scores for all the adjectives were added up and a total score was calculated for each of the two factors. Thus the scale for stress ranged from 0 to 18 and the scale for arousal from 0 to 13. (After Mackay, 1978).

This method of scoring assumed that a ? response to a negative adjective implied agreement with the unspecified polar opposite of the term. Thus when, for example, a ? response was made to 'Calm' it was taken that the subject did not merely <u>not</u> feel calm but actually felt the opposite of calm to some degree. Justification for this assumption may be controversial.

Nevertheless the SACL provided answers to some of the semantic problems inherent in the previous questionnaire. The SACL did not depend entirely on the subjects' understanding of and response to the term 'stress'. Eighteen adjectives were used to describe different feelings which might arise under stressful conditions. Some adjectives referred to feelings which might be assessed primarily in terms of somatic response such as "tense" and "jittery". Other adjectives, such as worried or apprehensive, described feelings more in terms of cognitive appraisal of the situation. Thus a range of adjectives describing both thoughts and feelings were used to estimate the degree of stress experienced. The experiments described in Chapter 6 used both the SACL and the previous questionnaire of Subjective Experience. The relationship between the two questionnaires is discussed in Chapter 6.

Independent Variables

The independent variables manipulated in the laboratory experiments involved noise, task and glucose preloading. Pilot experiments eliciting dose-response curves for glucose preloading were carried out and are described in this section. Further pilot studies concerned with the problem of determining a suitable placebo for the glucose drink were also conducted and are described.

7. Noise

In the noisy condition, 80dB of continuous white noise was presented to the subject through headphones. The noise was produced by a Campden Instrument White Noise generator (CI530), and transmitted through an 'Advance' step attenuator Type A64 with 600 ohms impedance.

In the quiet condition, subjects wore the headphones with the white noise level set at 50dB.

Headphone noise levels were standardised using a Brüel and Kjäer sound level meter, type 2205.

The levels of white noise, 80dB and 50dB, had previously been used in the studies by Cox (1973), Simpson (1974) and their colleagues. The 80dB noise was described by these authors as stressful and was associated with time on target scores that were signficiantly lower than scores obtained during exposure to 50dB noise.

8. Task

The experimental task was a stellate pursuit rotor tracking task (track width of 20mm, stylus diameter of 4mm). This task was the one used by Cox and Simpson and their colleagues (1973, 1974). The speed of rotation of the light to be tracked was kept constant at 10 rev/min giving an overall distance time requirement of 0.014 metres per second. The task lasted for 15 minutes. Performance measures were described in Section 2.

This tracking task is usually described as a complex psychomotor task. The most commonly performed real-life equivalent task is driving a car, although it has been suggested that driving a tank would probably resemble the task more closely. Subjects were able to comprehend the nature of the task without difficulty. Instructions to subjects, which were accompanied by a practical demonstration, were as follows:

> 'This is a tracking task. I would like you to track the light with this light sensitive pencil which will measure the time you are on the light and the number of times you miss the light. Try and keep the pencil on the light for as much of the time as you can. While you are doing this, I would like you to wear these headphones. They will provide this continuous hissing noise. Now if you put the headphones on and begin when you are ready I will let you know when the session is over*. All right?'

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* For subjects at the hospital this sentence was extended to include the phrase '. . . but stop and tell me if you feel unwell'.

Subjects were observed while they tracked once around the star in order to ensure that the instructions were understood. The programming equipment was then switched on and TOT (time on target) and Dev. (deviations) scores were recorded for 15 minutes.

In the control conditions subjects merely sat at the machine wearing headphones presenting 50 or 80dB noise. Most of the subjects were quite unfamiliar with experimental design, consequently some explanation was needed in order to reassure subjects that there was a purpose underlying these seemingly odd requirements. Instructions were as follows:

> 'This is a tracking task which I am asking some people to work at. In order to understand what happens when people work at the task while listening to noise I need to know what happens when people just sit here listening to this noise from the headphones <u>without</u> doing the task. I would like you to be one of these comparison subjects. All I want you to do is to put the headphones on which will provide this continuous noise. I shall let you know when the session is over.* All right?'

Subjects were not told how long they would be working at the task since they were subsequently required to estimate this period of time. Occasionally subjects called out to ask how much longer they would have to go on. This was a rare occurrence but happened noticably more frequently with IHD patients. The experimenter would reply reassuringly but non-committally with for example, 'Not much longer' or 'You're over half way through'. Although the subjects were at liberty to give up the task, and patient groups had been specifically told to do so if they felt unwell, no one did give up although many reported that the situation was very stressful. (See sections on self-report).

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* For subjects at the hospital this sentence was extended to include the phrase ". . .but stop and tell me if you feel unwell."

9. Glucose Preloading

In earlier studies (Cox and colleagues, 1973; Simpson and colleagues, 1974;) some of the subjects were preloaded with 18 gm. glucose in 100ml. water (after Murrell, 1971). The remaining subjects were given only 100ml. water to drink. Preloading with glucose induced an average elevation of blood glucose after 30 minutes of 50mg./100ml. above fasting blood glucose levels.* The mean value of the initial fasting blood glucose levels was 77mg./100ml. Thirty minutes after glucose preloading blood glucose levels were thus elevated to a mean value of 127mg/100ml.

In the present work, diabetic and IHD patients were to be compared with control patients. One group of control patients was to be preloaded with glucose in order to elevate their blood glucose to levels comparable with those of the diabetic subjects. The second group of control patients was not preloaded with glucose and nor were the diabetic or IHD patients.

In order to assess the range of blood glucose levels expected of the insulin treated diabetic men who were to be studied in the laboratory experiments, data from the hospital files of 8 such patients were collected. The five most recent blood glucose estimates for each patient were examined. The mean of the 40 data points was 214.Img/100ml. Only 5 data points fell below 120mg/100ml. - i.e. within the range expected for non-diabetics. It was apparent that elevations of blood glucose greater than those induced by 18gm. preloading would be required in order to increase the initial blood glucose levels of control subjects to levels approximating those of the diabetic patients. Two pilot experi-

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* All measures were taken in the morning following a minimum three hour fast.

ments were therefore carried out in order to estimate the necessary degree of glucose preloadings.

9.1 Pilot Experiment 1: Investigation of changes in blood glucose levels following ingestion of one of four doses of glucose

The purpose of this experiment was to elicit dose response curves using doses of 0, 20, 30 and 40gm. glucose dissolved in 100ml. water.

Method

Subjects Four male students aged between 18 and 25 years participated in the experiment. All were healthy by their own report. None was diabetic.

Design A standard Latin square design was employed. This design served to reduce the number of subjects required. The subjects A B C and D were each tested four times, once on each of four days with one of the four doses under study. This procedure is summarised below in table 3.

Table 3: Summary of Latin Square Design

		Dose: Glucose gm.			
		0	20	30	40
DAYS	1	A	B	C	D
	2	B	C	D	A
	3	C	D	A	B
	4	D	A	B	C

Subjects were tested in the afternoons between 1500 and 1630 hours and on each occasion, two hours had elapsed between lunch and the experimental session. Afternoon sessions were necessary because the clinics for diabetic outpatients were held in the afternoon and the laboratory experiments were to be carried out at the hospital during these clinics. The possibility of diurnal variations in blood glucose regulation was recognised (Kanabrocki and colleagues, 1969; Aparicio and colleagues, 1974).

Blood Samples Capilliary blood samples of 0.05ml. were taken in the manner described earlier in this chapter (Section 1).

Procedure The procedure was comparable with the standard procedure employed throughout the series of laboratory experiments, and summarised earlier in figure 2. The subjects sat quietly during the waiting periods and either chatted or read "neutral" magazines.

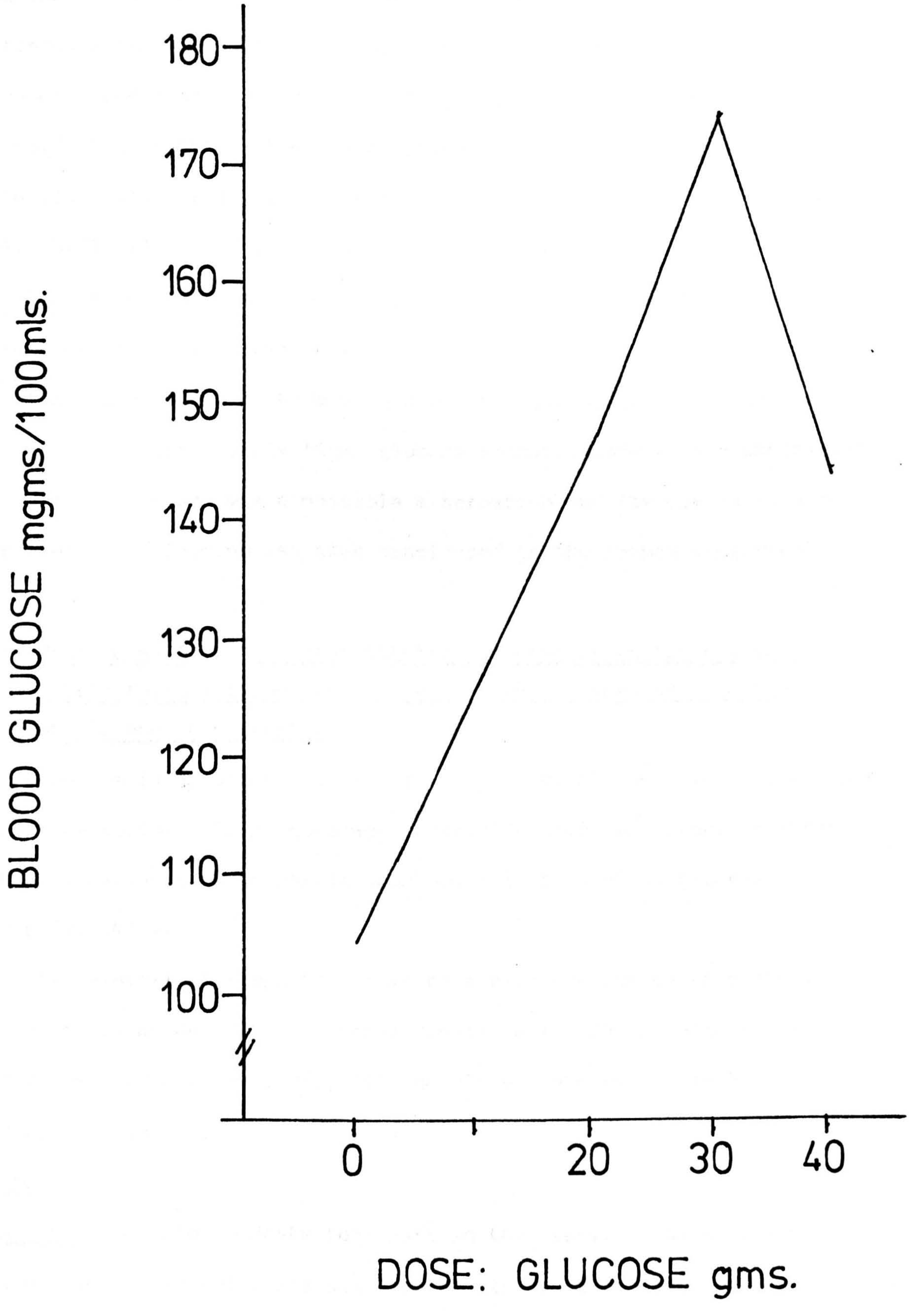
Results Blood glucose levels measured 30 minutes after preloading are described graphically in figure 3. Analysis of variance for a Latin square design showed that there was no significant difference between subjects in terms of their blood glucose levels after preloading. The effects of dose were highly significant. The order in which subjects received the drinks was not a significant factor. The results are summarised in Table 4.

Table 4: Summary of Latin Square Analysis of Variance: Blood Glucose Levels after Preloading

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	DF2	F	P.
Subject	1654.17	3	551.39	6	4.6	n.s.
Order	166.32	3	55.44	6	0.47	n.s.
Dose	10126.92	3	3375.64	6	28.3	.01**
Residual	714.45	6	119.08			
Total	12661.86	15				

Figure 3: Mean Blood Glucose Levels 30 minutes After Glucose Preloading

The effect of dose on blood glucose levels was significant ($p < .01$**)


180
170
160
150
140
130
120
110
100
BLOOD GLUCOSE mgms/100mls.
0
20
30
40
DOSE: GLUCOSE gms.

Discussion It can be seen that blood glucose levels at 30 minutes increase in a simple linear fashion as a function of dose up to 30gm. glucose preloading, producing a maximum increase of 68mg./100ml. This reflects a mean absolute blood glucose level of 173.3mg./100ml. However, 40gm glucose produced a smaller rise in blood glucose levels (54mg./100ml increase) than 30gm. glucose after 30 minutes. The overall mean blood glucose level 30 minutes after 40gm. glucose preloading was 144.9mg./100ml. This result was not anticipated.

The second experiment was designed to investigate dose response curves elicited by larger doses of glucose. In addition, the possibility of using alternative methods of glucose preloading was examined. Doses of 30gm. and particularly 40gm. glucose in water were rather unpleasant to drink. Lucozade was a possible alternative and its use as an agent for glucose preloading was also considered in the second experiment.

9.2 Pilot Experiment 2: Investigation of changes in blood glucose levels following ingestion of one of three doses of lucozade or glucose in solution.

Lucozade is a carbonated glucose drink commonly used in oral glucose tolerance tests. 235ml. Lucozade containing 23.5% w/v liquid glucose B.P.C. provides a carbohydrate load equivalent to 50gm. glucose (Beecham, 1973).

This experiment aimed to elicit dose response curves from three doses of 30, 40 and 50 gm. glucose dissolved in 100ml. water and from three doses of Lucozade, 141, 188 and 235 ml. equivalent to 30, 40 and 50 gm. glucose.

Method

Subjects Six male students took part in the study. They were aged between 19 and 26 years and all were healthy by their own report.

Design A randomised Latin square design was used; again to reduce the number of subjects required. The 6 subjects A,B,C,D,E and F were each tested 6 times on each of 6 days with one of the 6 doses under study (3 Lucozade (L), 3 Glucose, (G)) as shown in table 5.

Table 5: Summary of Latin Square Design

		Dose; Glucose gm.					
		G30	G40	G50	L30	L40	L50
DAYS	1	F	D	C	B	E	A
	2	C	A	F	E	B	D
	3	B	F	E	D	A	C
	4	E	C	B	A	D	F
	5	D	B	A	F	C	E
	6	A	E	D	C	F	B

Subjects were tested as before in the afternoons between 1500 and 1630 hours, 2 to $2^1/2$ hours after lunch.

Blood Samples Capilliary blood samples of 0.05 mls were taken according to the standard procedure (Section 1).

Procedure As in experiment 1, summarised in Figure 2.

Results The results are shown in Figure 4. Data from experiment 1 are included for comparison. Latin square analysis of variance revealed that Subject differences in blood glucose levels were significant in this study. There was again no effect of the order in which the drinks were presented during the series of sessions. There were no significant differences due to the drink. This was further analysed for the effects of glucose versus Lucozade and for the effects of dose, 30, 40 or 50gms.

The interaction of glucose and Lucozade with dose was also considered. No significant effects were found. The results are summarised in Table 6.

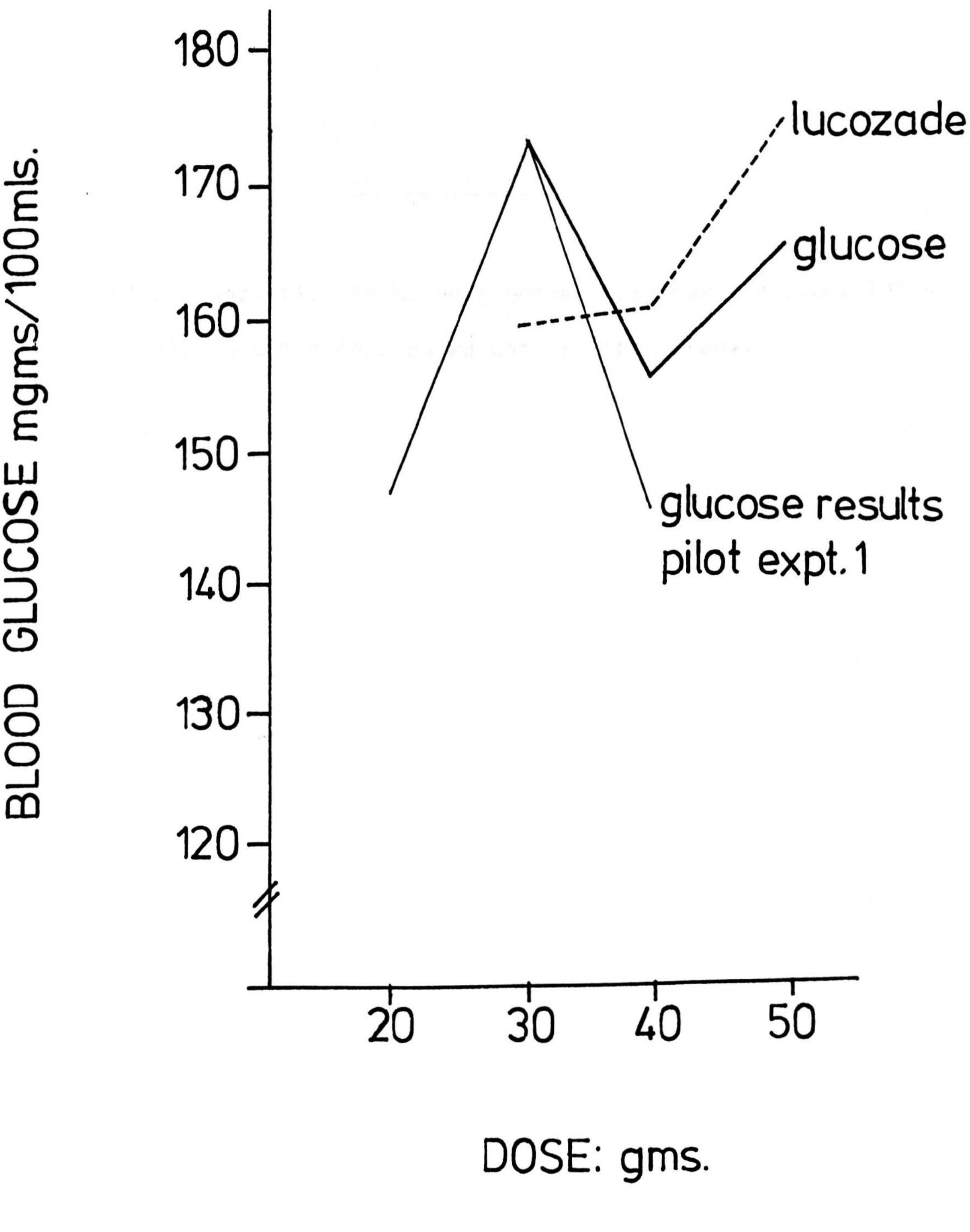
Table 6: Summary table of Latin square analysis of variance; Blood glucose levels 30 minutes after preloading with one of 3 doses of glucose or Lucozade.

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	DF2	F	P
Subject	7885.76	5	155.15	20	2.96	0.05*
Order	736.98	5	147.40	20	0.30	n.s.
Treatment	1691.78	5	338.36	20	0.64	n.s.
A.Dose	(900.03)	(2)	450.02	20	0.85	n.s.
B.G/L	(1.28)	(1)	1.28	20	0.00	n.s.
AB.Interaction	(790.47)	(2)	395.24	20	0.74	n.s.
Residual	10649.05	20	532.45			
Total	20963.57	35				

Discussion It can be seen from the graph (Figure 3) that 30gm. preloading with glucose in water again produces higher mean blood glucose levels after 30 minutes than 40gm. (or 50gm) glucose. However, the difference between 30 and 40gm. was shown by a planned comparison not to be significant ($F = 1.35$, df 1,30, n.s.) It is possible that the larger doses of glucose (40 or 50gm.) stimulate greater or more rapid insulin secretion which results in faster disposal (probably through storage under these conditions) of the blood glucose than occurs with smaller doses of glucose. An alternative explanation of the results

Figure 4: Mean blood glucose levels 30 minutes after preloading

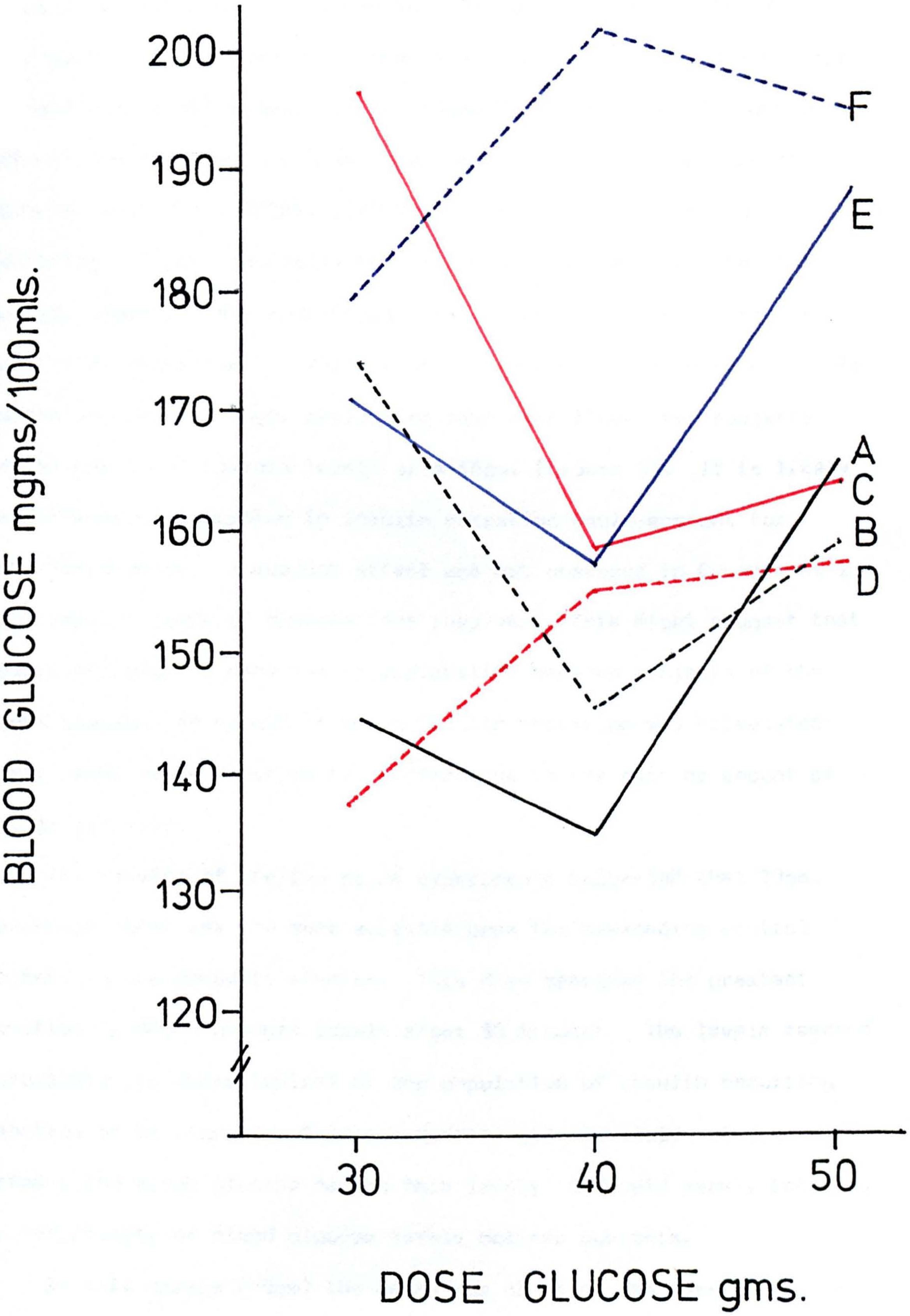
Differences between subjects were significant in this study ($P < .05^*$) The effects of dose were not significant. The data from experiment 1 are included for comparison.



BLOOD GLUCOSE mgms/100mls.
180
170
160
150
140
130
120
lucozade
glucose
glucose results
pilot expt. 1
20
30
40
50
DOSE: gms.

<u>Figure 5: Blood glucose changes 30 minutes after preloading</u>

Individual variation in blood glucose increases was significant ($P < .05^*$) with the higher doses used in this study.


BLOOD GLUCOSE mgms/100mls.
200
190
180
170
160
150
140
130
120
30
40
50
DOSE GLUCOSE gms.
F
E
A
C
B
D

could be that glucose is absorbed up to a certain limit before insulin secretion is stimulated. At this point any further absorption will not result in an additional increase in blood glucose levels because such an increase is countered by clearance of glucose from the circulation by insulin-promoted storage or by kidney filtration into the urine. Whatever the explanation, blood glucose levels reach a maximum of approximately 173mg./100ml. with 30gm. preloading and additional glucose preloading will not generally be reflected in elevations above this maximum. Nevertheless individual differences are apparent and were shown to be significant. While four of the subjects show higher blood glucose levels with 30gm. preloading than with 40gm., two subjects show higher blood glucose levels with 40gm. (Figure 5). It is likely that individual variation in insulin secretion would account for these differences. A subject effect was not observed in Experiment 1 where smaller doses of glucose were involved. This might suggest that subject differences were due to variability between subjects of the (blood glucose) threshold at which insulin secretion was stimulated rather than, or in addition to, differences in the rate or amount of insulin secreted.

The results of the two pilot experiments suggested that 30gm. glucose in water was the most suitable dose for preloading control subjects in the diabetic studies. This dose provided the greatest elevation in blood glucose levels after 30 minutes. The levels reached approximated to those typical of the population of insulin requiring diabetics to be studied. A larger dose of glucose would not generally increase the blood glucose beyond this level; it would merely increase the variability of blood glucose levels between subjects.

At this dosage (30gm) the advantage of using the more palatable

Lucozade, was outweighed by the disadvantages. Comparisons between the present work and earlier studies would be complicated not only by the use of larger doses of glucose but also by a qualitatively different preloading agent. Plans were being made by the writer to determine a suitable placebo for glucose preloading, and a control for glucose in water posed fewer problems than a control substance for Lucozade. 30gm. glucose dissolved in 100mls. water was therefore used to preload one of the two control patient groups in the laboratory study of diabetic patients.

10. Control Conditions for Glucose Preloading

In the studies by Cox (1973), Simpson (1974) and their colleagues the subjects who were not preloaded with 18gms glucose in 100mls water were given 100mls of water to drink. Clearly a placebo was needed which would act both as a physiological control and also as a psychological control. The effects of glucose preloading on performance and individual differences in mood might in part be due to the subject's expectations of the drink. Subjects knowing that glucose was a source of energy could reasonably deduce that it might enhance their performance. Although such an effect could not explain the decrement in performance in the quiet (50dB) condition found to occur in glucose preloaded subjects, the use of unsweetened water as a control substance would be a criticism of this work.

A control substance was required that would look and taste like glucose in water while being physiologically inactive. Such a substance could not, however, be used in studies with diabetic subjects without defeating the object by telling the diabetics that the substance was not a sugar. Diabetics are required to control their intake of carbohydrates very carefully and if they were asked to drink a substance which appeared to be a concentated sugar solution, feelings of anxiety concerning their condition might well have been aroused. In the diabetic studies, therefore, 100ml water was used as the control substance (c.f. Cox and colleagues, 1973; Simpson and colleagues, 1974;) and all patients and their controls were informed of the nature of their drink.

The problem of controlling for the psychological effects of glucose preloading was considered in a separate study of healthy subjects. The second experiment described in Chapter 6 investigated the relative importance of physiological and psychological factors in glucose preloading. Pilot studies were carried out to determine a suitable placebo for use in this experiment. Saccharin is known to be a sweet tasting, though physiologically inactive substance and its use as a control for glucose preloading was considered in the following experiments.

10.1. Pilot Experiment 3: Experiment to Determine the Amount of Saccharin in 100ml. Water that had Subjectively the Same Sweetness as 30gm. Glucose in Water

30gm. glucose was used as the standard comparison. It was hoped that this dose could be used in a later study of healthy subjects when a subjectively similar control substance would be required.

Method

Subjects 10 males from the psychology department at Nottingham University (students, staff and technicians) took part. Ages ranged from 18 to 56 years.

Design A psychophysical scaling method was used. A series of paired comparisons was completed by each subject. One of each pair was the glucose standard while the other was one of 7 concentrations of saccharin in water. The 7 concentrations used ranged from 60mg. to 120mg. saccharin in water, increasing in steps of 10mg. saccharin.

<u>Procedure</u> Each subject was told that the experimenter wished to compare two different sugars for subjective sweetness. The instructions were as follows:-

> 'I will give you two sugars to taste on each trial. Don't swallow them. Just taste the first one and spit it out. Then rinse your mouth with water, spit that out and then taste the second sugar. I would like you to judge which one is sweeter'.

Whether saccharin or glucose was tasted first was determined randomly for each of the 10 trials before the experimental session. The concentration of saccharin to be presented in the first comparison was also decided randomly. Subsequent presentations of the different saccharin concentrations depended upon the subjects' response. If the subject indicated that the glucose solution was sweeter, a solution of saccharin 10mg. stronger was given on the next trial. Similarly if the subject said that the saccharin solution was sweeter, a 10mg. less concentrated saccharin solution was given on the next trial. If the subject reached the maximum of 120mg. saccharin the next sample given was 60mg. saccharin. This procedure was continued for 10 trials unless the subject reached a decision after a minimum of 4 trials. A decision was judged to be made if for example the subject said that 70mg. saccharin was sweeter than the glucose, then 60mg, was less sweet, then 70mg. saccharin was sweeter and finally 60mg. saccharin was again judged to be less sweet, (judgement shown in parentheses in tables). It was then concluded that the equivalent concentration lay between 60 and 70mg. saccharin. The session was also terminated if all 7 concentrations of saccharin were presented and the subject consistently judged the glucose solution to be sweeter.

Results Four of the ten subjects consistently reported that the glucose was sweeter than the saccharin regardless of the concentration of saccharin. Only in 9 of the total 78 paired comparisons carried out was saccharin judged to be sweeter than glucose. This suggests that the solutions were not meaningfully comparable in terms of sweetness. Four subjects judged one of the concentrations of saccharin to be equivalent to the glucose but the concentration was different for each subject. Table 7 summarises the responses recorded.

Table 7: Frequency of responses to 7 concentrations of saccharin compared with a 30gm. glucose in water standard

CONCENTRATION OF SACCHARIN SOLUTION	NO. OF PRESENTATIONS	RESPONSE		
		GLUCOSE SWEETER	SACCHARIN SWEETER	=
60	9	9	0	0 (1)
70	11	8	3	0
80	12	11	0	1
90	14	11	2	1
100	14	12	2	0
110	11	8	2	1
120	7	7	0	0

Statistical analysis was unnecessary. It was clear that the comparison of saccharin with 30gm. glucose was inappropriate.

Discussion The main problem with saccharin appeared to be that at these concentrations there was a bitter component to the sweetness. Woodworth and Schlosberg in 1954 considered the relationship of bitter and sweet substances; they noted, that in some cases, bitter and sweet substances were very similar in chemical composition. There was some reason to believe then that the mechanisms for the perception of bitterness and sweetness were closely related. Woodworth and Schlosberg suggested that

> 'There might even be a single bitter-sweet mechanism which if tipped one way would yield the sweet, in the other way the bitter.'

It would appear that in certain circumstances some subjects perceived saccharin to be sweet but more often in this pilot study, the subjects perceived saccharin as bitter. Saccharin therefore appeared to be unsuitable as a control substance for 30gm. of glucose. However, it was thought that less concentrated solutions of saccharin might be comparable in sweetness to 18gm. glucose. This experiment was repeated with 18gm. glucose as the standard in the following study.

10.2 Pilot Experiment 4. Experiment to determine the amount of Saccharin in 100ml. water that has subjectively the same sweetness as 18gm. glucose in water

18 gm. glucose was the amount used to preload subjects in the studies by Cox, Simpson and their colleagues (1973; 1974). 18gm. glucose was the standard for comparison in the present experiment. If this dose could be matched with saccharin it could be used in the later study of healthy subjects when a subjectively similar control substance would be needed (see Experiment No. 9, Chapter 6).

Method

Subjects The 10 male subjects were drawn from the same population as the subjects described in Pilot Experiment 3.

Design The design employed in the previous experiment (3) was again used. Here 8 concentrations of saccharin were used, ranging from 10mg. to 80mg./100ml. water.

Procedure The procedure used in Pilot Experiment 3 was followed.

<u>Results</u> In this study only one of the subjects consistently reported that glucose was sweeter than saccharin, and 5 of the 10 subjects judged one of the saccharin concentrations to be of equivalent sweetness to the glucose standard. The results are presented in Table 8.

Table 8: Frequency of reponses to 8 concentrations of saccharin compared with an 18gm. glucose standard.

CONCENTRATION OF SACCHARIN SOLUTION	NO. OF PRESENTATIONS	RESPONSE		
		GLUCOSE SWEETER	SACCHARIN SWEETER	=
10	2	2	0	0
20	3	2	1	0
30	6	6	0	0
40	7	4	1	2
50	10	7	3	0
60	10	6	3	1
70	11	7	2	2
80	9	6	3	0

<u>Discussion</u> Although the results with 18gm. glucose preloading were more promising than those with 30gm. glucose, the problem of bitterness was not solved merely by reducing the concentration of saccharin. The other factor which might have influenced the results of the studies was the rate or degree of adaptation to the taste of the different substances. There is evidence (Hahn, 1934) to suggest that adaptation is most marked to salt, next to sweet and considerably less to sour and bitter. Hahn showed that the difference in adaptation to the four tastes was not so much in the speed of adaptation as in the completeness that could be

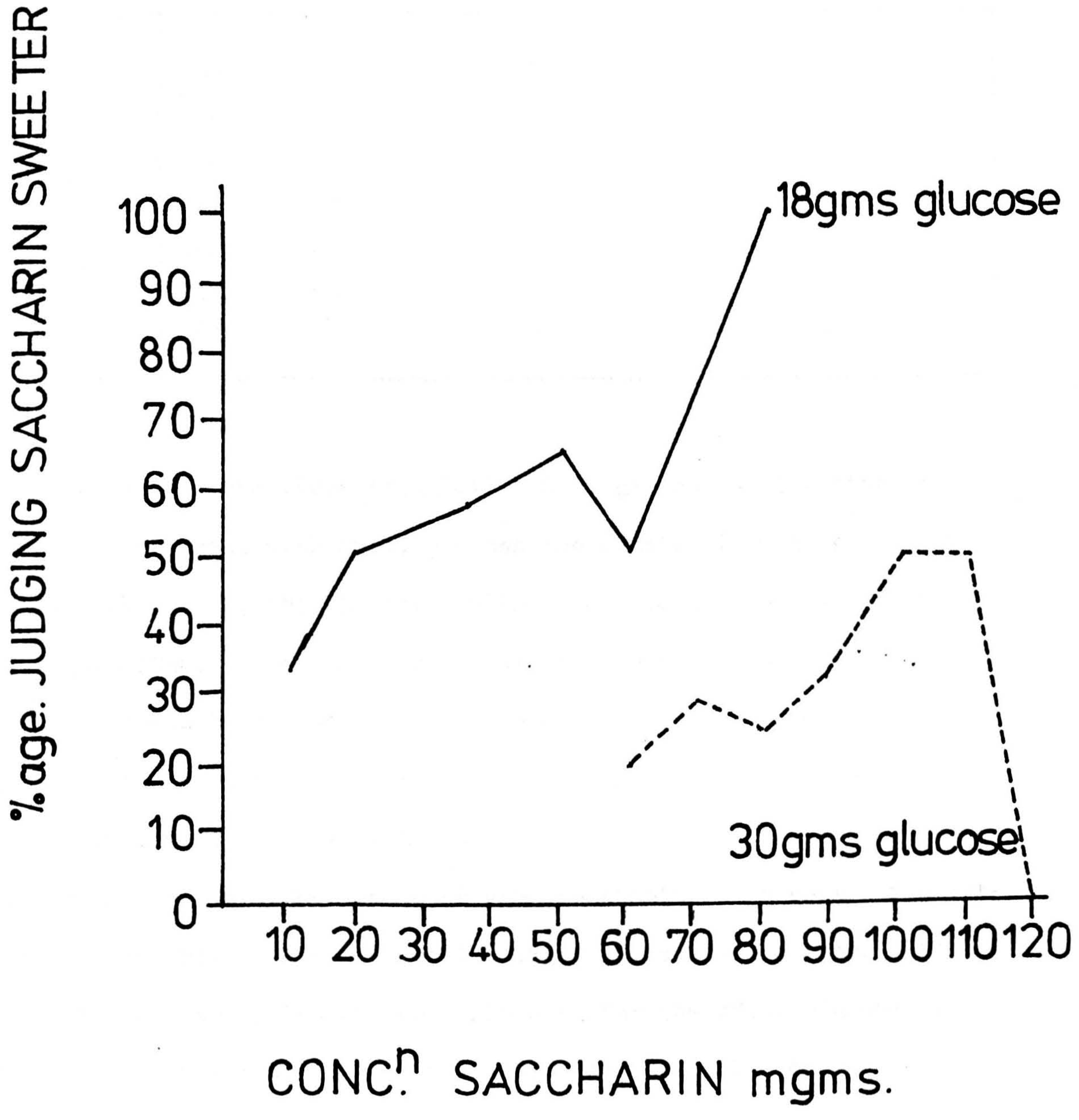
attained; or in the maximum attainable shift of the threshold. The resting or unadapted threshold was raised in the following proportions: sugar 6 to 20 times: bitter 2 to 3 times. It was therefore possible that subjects were adapting more to the sweet taste than they were to the bitter taste as each session progressed and more comparisons were made. In this way the sweetness of saccharin would be adapted to, more than the bitterness; i.e. the bitter taste would come to override the sweet taste. In order to see whether adaptation was affecting the results, the data were re-examined in terms of the order of the trials. The percentage number of times saccharin was judged to be sweeter than glucose was calculated for each concentration of saccharin for the first comparison made by each subject. This was repeated for the second, third, fourth, fifth and sixth trials across the subjects. Where there were missing data the mean point was calculated from the surrounding data. The percentage number of times saccharin was judged to be sweeter than 18gm. glucose across the six trials is shown in Table 9. Table 10 presents the equivalent summary for the 7 concentrations of saccharin compared with 30gm. glucose.

Table 9: Percentage judgements that saccharin was sweeter than 18gm. glucose

TRIAL		1	2	3	4	5	6
CONCENTRATION OF SACCHARIN	10	33	0	0	0	0	0
	20	50	0	0	0	0	0
	30	55	40	0	0	0	0
	40	60	50	0	0	0	0
	50	67	50	0	0	0	0
	60	50	50	20	33	33	0
	70	75	67	50	33	20	0
	80	100	67	50	33	0	0

Figure 6: Percentage of subjects judging saccharin to be sweeter than glucose

The results of the first trials made by each subject are plotted for the comparison with 18gm and with 30gm. glucose separately.



%.age. JUDGING SACCHARIN SWEETER
100
90
80
70
60
50
40
30
20
10
0
18gms glucose
30gms glucose
10 20 30 40 50 60 70 80 90 100 110 120
CONC.n SACCHARIN mgms.

Table 10: Percentage judgements that saccharin was sweeter than 30gm. glucose

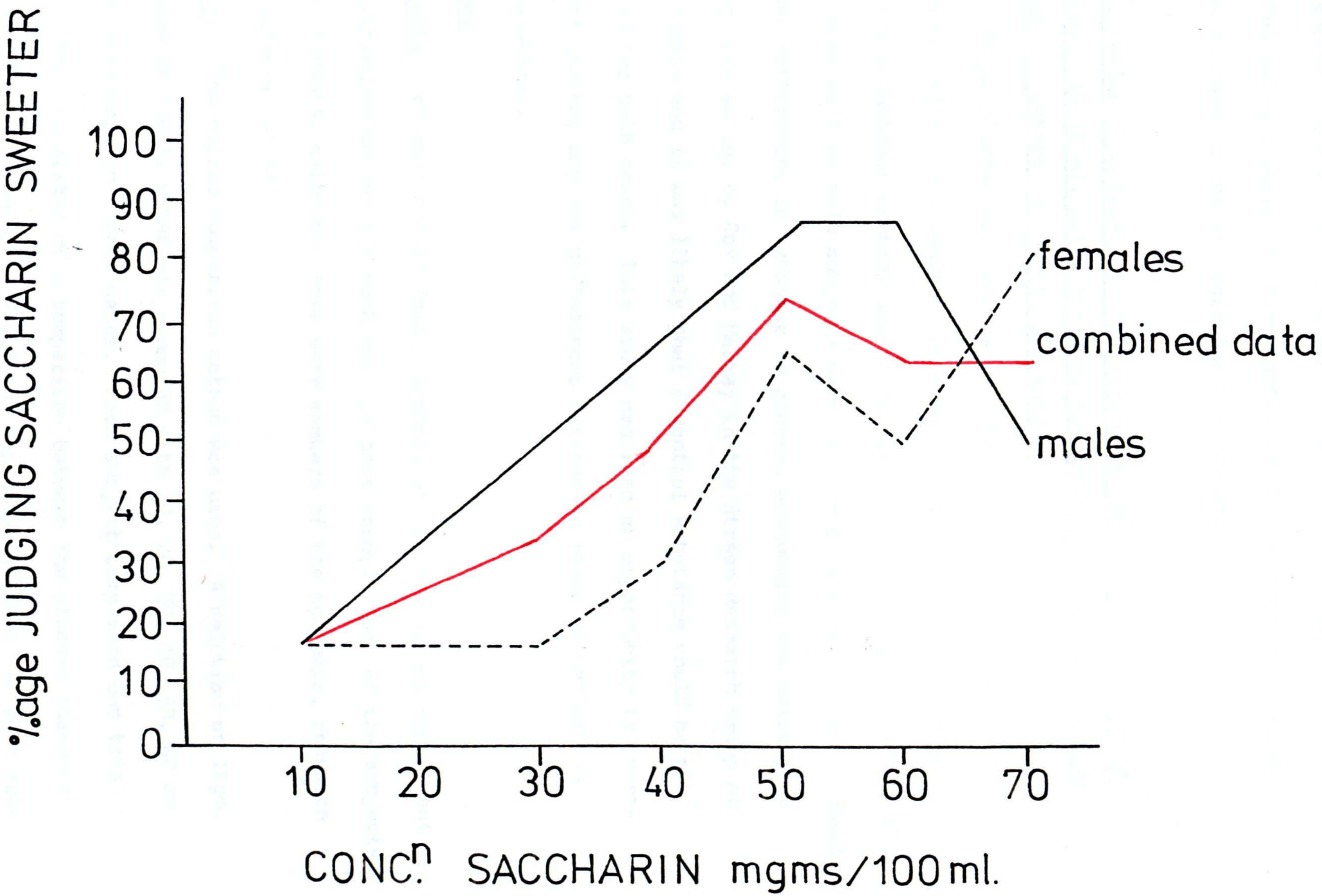
TRIAL		1	2	3	4	5	6	7
CONCENTRATION OF SACCHARIN	60	20	33	33	0	0	0	0
	70	29	50	50	20	0	0	0
	80	25	50	20	50	0	0	0
	90	33	50	33	8	33	25	0
	100	50	33	50	0	33	43	0
	110	50	33	50	0	25	50	0
	120	0	0	50	0	0	33	0

The results from the first trial with 18gm. glucose as the standard and the first trial with 30gm. glucose are plotted in Figure 6. The tables show that by the 6th trial with 18gm. glucose and by the 7th trial with 30gm. glucose all the subjects judged that glucose was sweeter. Subjects appeared to have adapted to the sweetness in the saccharin to the extent that the taste they perceived was the bitter taste. On the first trials, however, this was not the case. Subjects were able to compare the two substances meaningfully in terms of sweetness particularly in the case of the 18gm. glucose comparison. With the higher concentration of saccharin used for the 30gm. glucose comparison, the bitterness of the saccharin was apparent even on the first trial.

These results suggested that a further study was required where each subject made only one comparison. If saccharin was to be used as a placebo it would only be tasted once by each subject and the problem of adaptation would not arise. However the results obtained with 30gm. glucose suggested that the higher concentrations

Figure 7: Percentage of subjects judging saccharin to be sweeter than 18gms. glucose

The results for males and females are described separately and combined. The difference between the sexes was not statistically significant.


%age JUDGING SACCHARIN SWEETER
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
CONCn. SACCHARIN mgms/100 ml.
females
combined data
males

of saccharin needed would not provide a good match for the glucose. The following experiment investigated one-trial comparisons using 18gm. glucose as the standard for comparison.

10.3. Pilot Experiment 5: Experiment to determine the amount of saccharin in 100ml. water that was subjectively equivalent to 18gm. glucose in water; one trial per subject

18gm. glucose was used as the standard for comparison. The previous pilot experiments 3 and 4 suggested that saccharin might provide a suitable control substance for this concentration of glucose. Female as well as male subjects were studied in this experiment. Studies of sex differences in response to glucose preloading and noise were being carried out by Cox and Mackay in the Stress Research Group at Nottingham and it was likely that a control substance would be required for both sexes. This study provided an opportunity to investigate whether any sex differences existed in terms of perception of sweetness.

Method

Subjects 42 male and 42 female members of the psychology department at Nottingham University took part in this study. Most of the subjects were students, although some were members of the academic, research or technical staff.

Design The paired comparison method was used. A solution of 18gm. glucose in 100ml. water was compared with 10, 20, 30, 40, 50, 60 or 70mg. saccharin in 100ml. water. Each subject completed one trial only; this consisted of a comparison between the glucose standard and one of the 7 saccharin solutions randomly selected for each subject. The order of presentation of glucose or saccharin was also determined randomly for each subject.

<u>Procedure</u> The procedure was changed slightly from that previously used in Pilot Experiment 3 and 4. The practical purpose of the experiment was to find a control substance that the subject would drink. It was therefore considered to be more realistic to ask the subject to swallow the solutions he was comparing. It was then certain that the solutions would have contact with the back of the tongue and would be assessed using all taste receptors involved in drinking the solution. Instructions to subjects were as follows:

> 'Take a sip of the first substance and swallow it. Drink some water and then take a sip of the second substance and swallow that. I would like to know which of the two solutions tastes sweeter.'

<u>Results and Discussion</u> The percentage of subjects judging saccharin to be sweeter for each of the 7 concentrations of saccharin are presented graphically in figure 7. The graph suggests that men equate a lower concentration of saccharin with 18gm. glucose than women. However, Chi Square on data collapsed across doses suggests that this trend was not significant ($\chi^2 = 1.72$, d.f.= 1, p = 0.2 n.s.). The perception of bitterness did not affect the judgements except perhaps with the highest dose of saccharin used here (70mg.). It appeared that bitterness was only perceived at concentrations higher than 60mg. (see also Pilot Experiments 3 and 4) or when methods entailing repeated trials were used and adaptation to sweetness occurred.

Probit analysis (Finney, 1971) was carried out on the data which closely approximated the ogive curve. The 50% point for males was 34.5mg. saccharin. However, the confidence intervals were large (-52.11 to 62.25). For females the 50% point was 48.9, again the confidence intervals were large. The data were combined on the grounds that Chi Square demonstrated no significant sex difference. A 50% point of 42.7 was estimated by probit analysis. The confidence interval on the combined data was considerably narrowed (30.87 to 56.53). On the basis of these analyses the dose of 43mg. saccharin in 100ml. water was determined as a placebo for 18gm. glucose in water. These doses are used in the second experiment reported in Chapter 6 to investigate the relative importance of psychological and physiological factors in glucose preloading.

11. Life Change Questionnaires

The decision to employ the particular form of Life Change Questionnaire used in the studies described in Chapters 4 and 5 was made in the light of observations and findings from two preliminary studies. Pilot work was carried out on the "Life Events Inventory" of Cochrane and Robertson. Cochrane and Robertson (1973) produced a revised version of the SRE (Schedule of Recent Experience) devised by Holmes and Rahe (e.g. 1967). Cochrane and Robertson aimed to eradicate some of the deficiencies of the SRE. The revised instrument was called the Life Events Inventory and consisted of 55 items weighted by groups most likely to have had experience of the events involved. This version was felt to be more comprehensive and the items included were felt to be more suited to an English sample; it was therefore chosen as the basis for the inventory used in the present pilot work. The work was carried out with the help of Linda Hannaford, a Nottingham psychology student who graduated in 1975.

11.1. Pilot Experiment 6. **Weighting of Life Change Inventory**

Cochrane and Robertson's Inventory was revised and a corresponding set of weightings was produced using a new sample of subjects appropriate to the present studies.

<u>Revisions made to the original Life Events Inventory</u>

Cochrane and Robertson divided their Inventory into items to be considered by 'All', 'Ever-Married', and 'Never-Married' people. Such a division implies that marriage is an event which dramatically alters the kind of life events which a person will go on to experience. However, this may also be true for factors other than marriage. An obvious example is employment. A considerable proportion of the population, most of whom are women, are not employed in a job outside the home and some have never been employed. Clearly lack of employment will alter the range of life events likely to be experienced. Other factors such as education and presence or absence of close family may well alter the kind of life events which may arise.

Rather than include further divisions in the questionnaire, the distinction of 'Ever-Married' and 'Never-Married' was omitted from the revised version. 48 items were included in the <u>Life Change Inventory</u> as the revised questionnaire was called. A copy is included in the Appendix.

<u>Method</u>

<u>Subjects</u> The Life Change Inventory along with instructions for its completion, was distributed to acquaintances by members of the Stress Research Group. Subjects were from a wide range of occupational backgrounds including academics, nurses, cleaners and accountants. Both married and single men and women took part in the study. Ages ranged from 20 to 59 years.

<u>Procedure</u> Subjects were asked to rate the events according to the relative degrees of necessary readjustment they felt would be required in general rather than rating them with specific personal experiences in mind.

Following the method of Holmes and Rahe, and Cochrane and

Robertson, marriage already possessed an arbitrary value of 50 as a standard against which the other events were to be rated with values ranging from 0 to 100. Thus events thought to require less readjustment than marriage would be rated from 0 to 49 and those requiring more readjustment from 51 to 100, with 50 if the readjustment was thought to be equal to that required by marriage.

However, this method of rating was soon found to be unsatisfactory. It was logically impossible to impose two such rating restrictions at once. With this method, no event could be said to require more than twice as much readjustment as marriage. It was therefore decided to omit the arbitrary value of 50 for marriage and subjects were asked to rate all events from 0 to 100 as they saw fit. The instructions were as follows:

> 'Life Changes include the amount and duration of change in one's accustomed pattern of life resulting from various life events. Life change is a measure of the intensity and length of time necessary to adjust to a life event, <u>regardless of the desirability of that event</u>.
>
> You are asked to rate a series of life events according to their relative degrees of necessary readjustment. In scoring, use all of your personal experience where it applies as well as your knowledge of other peoples' experience. Some people accommodate to change more readily than others; some people adjust with particular ease or difficulty depending on the event. Therefore try to give your opinion on the average degree of re-adjustment necessary for each event in general rather than for yourself on any particular case.
>
> You should rate each life event on a scale from 0 to 100. 0 represents absolutely no change in or effect on one's life, while 100 represents the most drastic and long-lasting effect imaginable. Nothing could have less effect than 0 or more effect than 100. When considering the value to be given to each event please take into account both the intensity and the length of time needed to adjust to the change. Please use your imagination for those events that you have not experienced.'

<u>Results</u> The first version of the questionnaire (with 50 for marriage: Inventory 1) was returned by 19 subjects before it was decided that the methodology was unsound. 57 copies of the second version (without

50 for marriage: Inventory 11) were returned complete.

Means and standard deviations were calculated for each item on both inventories 1 and 11. Correlations were made between the two sets of means and standard deviations. The coefficient of correlation for the means was 0.96, significant at the 1% level. However, the positive correlation between the standard deviations was not significant.

A multiple correlation was then carried out between the means of inventories 1 and 11 and the corresponding item means of the Cochrane and Robertson inventory, (44 items were common to all three questionnaires). There were significant positive correlations at the 0·1% level between the inventories. The correlation coefficients were as follows:

Cochrane and Robertson Inventory x Inventory 1: r=0.92

Cochrane and Robertson Inventory x Inventory 11: r=0.91

Discussion Correlations between the inventory means were not reduced by the new instructions. Cochrane and Robertson do not report standard deviations so no comparisons could be made using this measure. However, the lack of significant correlations between the standard deviation scores for items from Inventories 1 and 11 suggests that the new instructions alter the range of responses. With these two inventories the standard deviations ranged from 9.5 to 28.7; the mean standard deviation for each inventory was 18.7 and 19.8 respectively. Interestingly the largest standard deviation (28.7) was obtained from the ratings of marriage in Inventory 11. This suggested that subjects varied most in their assessments of the degree of readjustment required for marriage. The validity of assigning an arbitrary value of 50 to this item was therefore doubtful. The similarity between the mean scores obtained from Inventories 1 and 11 suggested that subjects might even have ignored the value of 50 assigned to marriage when making their estimates for other items. However, the spread of responses was clearly affected by this restriction in rating.

Although the more obvious methodological problems have been dealt with in this pilot study, this form of the questionnaire was by no means considered to be a totally satisfactory measure of life change. It was shown to be possible to achieve high correlations between mean scale values for different life change events across the various populations sampled. This suggested that people tend to agree about the general significance of such events as death of spouse or change of job. However, the personal significance of any one event and the associated physiological and behavioural coping patterns are likely, nevertheless to vary according to the personal characteristics of the individual and the context in which the event occurs. Previous experience of an event, active or passive participation in an event and the predictability of an event are factors which may vary from individual to individual and affect the degree of adjustment or upset associated with an event. The SRE and similar questionnaires were too vague in specifying the situation to be rated; the mean weighting of an event might therefore be a quite inaccurate measure of the impact of an individual's particular experience broadly subsumed under a general heading such as "Trouble with people at work" or "Marriage".

One solution to this problem was suggested by Brown (1974). He used a structured interviewing technique in order to establish more precisely for each individual the effect of events experienced. However, such an approach relied heavily upon the interviewer's interpretation of the subject's reports. The type of events to be considered were determined in advance; thus some restrictions were still made which reduced individual variability.

An alternative solution to the problem was sought that would not involve lengthy interviewing procedures. If subjects were asked to rate the events themselves, they would be able to indicate the degree of impact that they felt had been caused by those events that they had experienced. In this way, a measure of an individual's personal response to events would be gained in addition to measures of the number and type of events. The events in the questionnaire might be seen as broad categories of possible events within which specific events might be experienced. The studies reported in Chapters 4 and 5 used such an approach; subjects were asked to describe and rate other events that had occurred which were not mentioned in the list. The questionnaire was not considered to be a definitive list of life events.

11.2 The Version of Life Events Inventory Used in the Experimental Studies

The form of questionnaire used in the studies reported in this thesis was that version of the SRE used by Theorell (e.g. Lundberg, Theorell and Lind, 1975). This questionnaire (see Appendix) was similar though not identical to Inventory II. The advantage of Theorell's approach was that he studied the degree of upset and readjustment to life events separately by means of two versions of the questionnaire. In this way it was possible to gauge more precisely the meaning of the subjects' rating.

It was thought that diabetics might face more upset and adjustment as a result of life events than non-diabetics if the control of their condition were disturbed. On the other hand, diabetics might measure upset and adjustment in terms of the control of their diabetes rather than in terms of the broader implications of an event.

If this were so it might be that non-diabetics would feel that life changes demanded greater adjustment. These possibilities were investigated and the results are reported in Chapter 4. The questionnaire used in the present studies of diabetic, IHD and control subjects was identical to that used by Theorell with the exception that subjects were invited to add to the list, any events that had occurred to them but were not listed. In this way it was felt that a more comprehensive picture would be gained of the subjects' experience of stressful events during the 12 month period under study.

The Inventories used in the pilot study were rated numerically on a scale from 0 to 100. However, Theorell had used analogue scales for the rating of items on his questionnaires. There appeared to be no reason why the questionnaire employed in the present studies should not conform in this respect as well. These scales have been popularised by Joyce (1968) and Aitken (1969) who discuss their advantages in some detail. The questionnaires in the studies reported later in this thesis have used 10 cm lines labelled appropriately at the extreme and centre points. Subjects were asked to place a cross at the point which they felt best represented the degree of upset or adjustment engendered by each event listed. (After Theorell, 1975). In retrospect, however, subjects were more at ease with numerical scales which they were able to handle quite competently. When using the analogue scales, several subjects were found to be considering their response numerically in the first instance before translating that response into a point on the line. This tendency was inadvertently encouraged by the presence of labelled mid and end points on the scales. In addition, scoring of the analogue scales was a time consuming procedure involving the measurement of each line for each of the 46 items per subject. The effort involved did not seem to be justified, when numerical scales appeared to be at least as adequate as the analogue scales.

The use of Theorell's questionnaire allowed more detailed comparisons to be made between the present work and the Swedish studies. The study of IHD patients reported in Chapter 5 was a replication of Theorell's study of myocardial infarction patients with similar patients from the British population. Unlike the diabetic study, this study did not attempt to measure physiological changes that might be associated with life change; it was concerned only with measuring the psychological impact of life events on MI patients and their controls.

12. Semantic Differential Rating Scales

The Semantic Differential was devised by Osgood in 1952 as an instrument for measurement of 'meaning'; it is described in detail in several publications (Osgood, 1952; Osgood and Suci, 1955; Osgood, Suci and Tannenbaum, 1957). The purpose of the semantic differential technique was to provide a structure for the assessment of individual judgement of concepts on a set of bipolar adjective rating scales. Semantic differential booklets typically consisted of several pages containing a series of rating scales varied for sequence and left-right position. At the top of each page would be a concept title, a word or sentence, to be rated on each of the bi-polar scales. Subjects recorded their judgement of a concept on each scale by placing a mark on one of the points of each scale between the pair of adjectives. The closer the mark was placed to one of the polar adjectives the more applicable was the particular adjective to the concept as far as the subject was concerned.

Most forms of the semantic differential questionnaire employ scales which have an uneven number of response alternatives so that a response placed at the centre point of a scale indicates that the polar terms are equally inapplicable (or applicable) to the concept, or that the subject is unable to decide. Osgood and his colleagues provided seven divisions along each scale. They noted that fewer divisions irritated respondents and more divisions were found to be overwhelming by most subjects of average or below average intelligence (Osgood, Suci and Tannenbaum, 1957).

The raw data obtained with the semantic differential consist of checkmarks made against the series of bipolar scales. A numerical value may be attached to each response in order to treat the data statistically. The responses of one subject to a set of scales can be represented diagramatically by drawing a profile of these responses.

The responses of groups of subjects may be examined using factor analytic techniques in order to reduce the number of rating scales to a smaller number of meaningful dimensions or factors which are important in understanding the meaning of a concept. Jenkins, Russell and Suci (1958) produced an "Atlas of Semantic Profiles" for 360 words using 540 student subjects. Scales were selected to sample six factors which were thought to be important. These factors and the scales chosen to sample them were as follows:

"Evaluation"	good-bad
	kind-cruel
	beautiful-ugly
	successful-unsuccessful
	important-unimportant
	true-false
	wise-foolish
	timely-untimely
"Potency"	hard-soft
	masculine-feminine
	strong-weak

"Activity"	active-passive
	excitable-calm
	fast-slow
"Tautness"	angular-rounded
	straight-curved
"Novelty"	new-old
	unusual-usual
"Receptivity"	savoury-tasteless
	colourful-colourless

This form of sampling was used to ensure that no important dimension was overlooked. However, although the dimensions used were judged to be important by the experimenters they were not necessarily seen to be the most important dimensions by the subjects. One of the major criticisms of the semantic differential technique is that subjects are constrained to make judgements of meaning within the limits set by the instrument. Response categories are restricted to those considered appropriate by the experimenter. Most semantic differential questionnaires appear to consist of scales selected in this way. Many authors fail to report their reasons for selecting certain scales.

The semantic differential technique was used in this thesis in an attempt to assess the meanings attributed to the concepts "upsetting" and "adjustment". These concepts were used in the Life Change Inventory and the populations studied differed significantly in their ratings of events as upsetting or as requiring adjustment. The semantic differential technique was used to examine the possibility that the concepts held different meanings for the different populations studied. The following pilot study was carried out to elicit scales to be used in the construction of the semantic differential questionnaire.

12.1. Pilot Experiment 7: Construction of the Semantic Differential Rating Scales

The items from Lundberg and Theorell's Life Change Inventory which had been employed in the present work on Life Events, were used to elicit dimensions important in the perception of these events. In this way, it was possible to determine those terms which were considered important by subjects judging the effects of life changes.

Method and Procedure The technique devised and used by Kelly (e.g. 1961) to elicit 'personal constructs' for use in repertory grids was here used to elicit bipolar adjectives for the construction of semantic differential scales.

Instructions to subjects

> 'You will be given three cards. On each card is described an event which you may or may not have experienced. You are asked to consider the ways in which these events would affect you and to state the way in which two of the events are the same while being different from the third.'

Subjects 14 subjects took part in the experiment; 7 males and 7 females. These subjects came from a variety of occupational backgrounds. Ages ranged from 20 to 62.

The instructions were read to the subject and the first three cards were used as a working example. The subject was then given three more cards at random and was reminded of the instructions where necessary. This procedure was repeated until the subject had elicited 6 dimensions. Thus 84 dimensions were obtained in all.

Results 50 different dimensions were mentioned. Many of these overlapped or were equivalent. Some were too specific to the particular events concerned e.g. financial benefit vs expense. However, 24 different dimensions were produced on the basis of the information obtained. Nine of these dimensions were mentioned specifically by the subjects in the pilot study e.g. good-bad, permanent-temporary, pleasant-unpleasant. Other dimensions were elicited in a form that was not bipolar e.g. anger-no anger, important-neutral, worrying-not worrying. The more abstract scales used were chosen as summaries of dimensions described by subjects in sentence form e.g. "This would have an immediate effect while those wouldn't have much effect straight away". could be described by the adjectives fast-slow.

The 24 scales produced were as follows:

good-bad

relief-worry

permanent-temporary

attractive-unattractive

excitable-calm

straight-curved

tight-loose

emotional-unemotional

cheerful-miserable

pleasant-unpleasant

active-passive

angry-peaceful

important-unimportant

positive-negative

interesting-boring

settled-unsettled

puzzling-understandable

hard-soft

strong-weak

fast-slow

timely-untimely

tense-relaxed

controllable-uncontrollable

masculine-feminine

A seven point scale was used for rating each pair of adjectives; this had been previously shown to be the most acceptable length of scale (Osgood, Suci and Tannenbaum, 1957). Scales were randomised for sequence and left-right position for each of the concepts to be judged. In addition to the two concepts 'adjustment' and 'upsetting' five other concepts were taken from the Atlas of Semantic Profiles (Jenkins and colleagues, 1958) in order to compare the results of the present studies with the results obtained from Jenkins' extensive study of 580 subjects. The additional concepts were 'trouble', 'calm', 'happy', 'health', and 'afraid'. The concept 'adjustment' was qualified with the phrase 'to an event' in order to limit the understanding of the word to the context in which a judgement of meaning was required. The semantic differential booklet consisted of 7 sets of randomised scales, one for each of the 7 concepts which were printed at the top of the page. The order in which the concepts appeared in the booklet was varied systematically.

An instruction sheet at the front of the booklet outlined the purpose of the exercise, described the procedure and presented an example using the concept 'frightening'. (See Appendix).

12.2. Scoring and Analysis

Completed questionnaires were scored on a scale of 1 to 7 in a predetermined way independent of the left-right positioning on the questionnaire. Thus a cross placed at the 'good' extreme of the good-bad scale would always receive a score of 1, and at the 'bad' extreme, a score of 7. The mean value allotted to each scale for each concept by the different groups studied could be calculated and semantic profiles for the 24 scales constructed for the different populations.

Product-moment correlation coefficients were calculated for each pair of scale adjectives, the correlation matrix subjected to a principal components analysis, and the significant components rotated to the Varimax criterion. In this way, factors were produced from the different groups' data, allowing examination of qualitative differences in rating of concepts by the different populations. Quantitative differences were examined where appropriate using analysis of variance.

This semantic differential questionnaire was used with diabetic subjects and their controls and with myocardial infarction and control patients. The results of both studies were analysed in the manner described above. These studies are presented and discussed in Chapters 4 and 5 of this thesis.

CHAPTER 3

DIABETES MELLITUS: LABORATORY STUDIES OF NOISE STRESS

1. INTRODUCTION

Chapter 1 reviewed the evidence which suggested that the regulation of blood glucose levels in non diabetic subjects was affected by the experience of stress, and that in laboratory situations, both environmental factors and blood glucose levels could be related to the efficiency of performance of psychomotor tasks. (Cox and colleagues, 1973; Simpson and colleagues, 1974). In moderately stressful conditions, a fall in blood glucose levels had been demonstrated in non-diabetic subjects and evidence existed to suggest that a similar change might occur in diabetic subjects, (Hinkle and Wolf, 1952; Vandenberg and colleagues, 1965; 1967; 1967a). The decrease in blood glucose levels observed in the diabetic subjects did not appear to be due to increased excretion of glucose. Vandenberg and his colleagues suggested that it was due to increased uptake of glucose by the body cells.

It was hypothesised from the earlier work that the diabetic's elevated blood glucose levels would fall markedly in stressful conditions and that this decrease would be associated with improved performance.

The following experiments were designed to test these predictions by examining the responses of insulin-requiring diabetic subjects to noise stress and by comparing these responses with the responses of non-diabetic control subjects under the same conditions.

The first experiment reported in this chapter was a single-subject study with repeated measures. The same insulin requiring diabetic male was repeatedly observed in noisy and quiet conditions while working and while not working at the task.

The second experiment was an extension of the first, but employed a multi-subject design and compared the response of diabetic and non-diabetic subjects. The effects of glucose preloading were examined in non-diabetic subjects and compared with the results from the diabetic and control subjects who were not preloaded with glucose.

2. Experiment 1: Single-subject Diabetic Study

This study was designed to investigate the effects of two levels of white noise (50 and 80dB) and performance of a pursuit rotor task on the blood glucose levels of an insulin-requiring diabetic subject. The efficiency of performance was observed in relation to changes in blood glucose levels.

Subject The subject (A.L.) was a 19 year old male engineering student who required once-daily injections of 80 strength soluble insulin in order to control his diabetic condition. During the period of the experiment A.L. was 7 lbs overweight for his age and height. Responses to the Maudsley Personality Inventory (Chapter 2, Section 5) showed A.L. to be a relatively stable extravert in comparison with Eysenck's standardisation group means.

A.L. (who was contacted through mutual acquaintances), volunteered to participate in the study. Unlike the other subjects studied in the author's research, A.L. was paid. It was hoped that this would ensure his continued motivation to participate in the fairly extensive series of trials involved.

2.1. Method

The task was the pursuit rotor task described in Section 8 of the Methodology Chapter (Chapter 2).

During each trial 50 or 80dB white noise was presented through headphones in the manner described in Chapter 2, Section 7.

The two independent variables studied, noise and task, were examined using a factorial design involving 4 experimental conditions as shown in table 11.

Table 11: Summary of experimental design

	Noise Level dB	
	50	80
Task	N=5	
No Task		

Blood samples of 0.05ml. were taken before and after the task period. The sampling technique and analytical procedure are described in Section 1, Chapter 2.

Time on target and Deviations were recorded as the performance measures (Section 2, Chapter 2).

Testing was carried out in the afternoons between 2 and 2½ hours after lunch.

Procedure A preliminary blood sample was taken. A.L. was then shown to the test cubicle and presented with, or reminded of, the instructions (Section 8, Chapter 2). Head phones presenting 50 or 80 dB white noise were put on. He then either performed the task for 15 minutes or he merely sat at the apparatus without working for 15 minutes. The order of the experimental conditions was randomised within the blocks of the four conditions. At the end of the 15 minute session a second blood sample was taken.

The first four sessions were used to familiarise A.L. with the experimental situation and to reduce practice effects which, it was thought, might contaminate the data. During these four sessions A.L.

worked at the task wearing the headphones which presented 50dB white noise. The following 20 sessions consisted of the 4 experimental conditions. The results from these 20 sessions were analysed.

2.2. Results and Discussion

During the 4 adaptation sessions with 50dB noise, time on target consistently improved across the 4 sessions from 12.85 minutes to 14.07 minutes on target (from a possible total of 15 minutes). Deviation scores correspondingly decreased from 1145 to 163 deviations from the light. It would appear that practice at the task considerably improved performance.

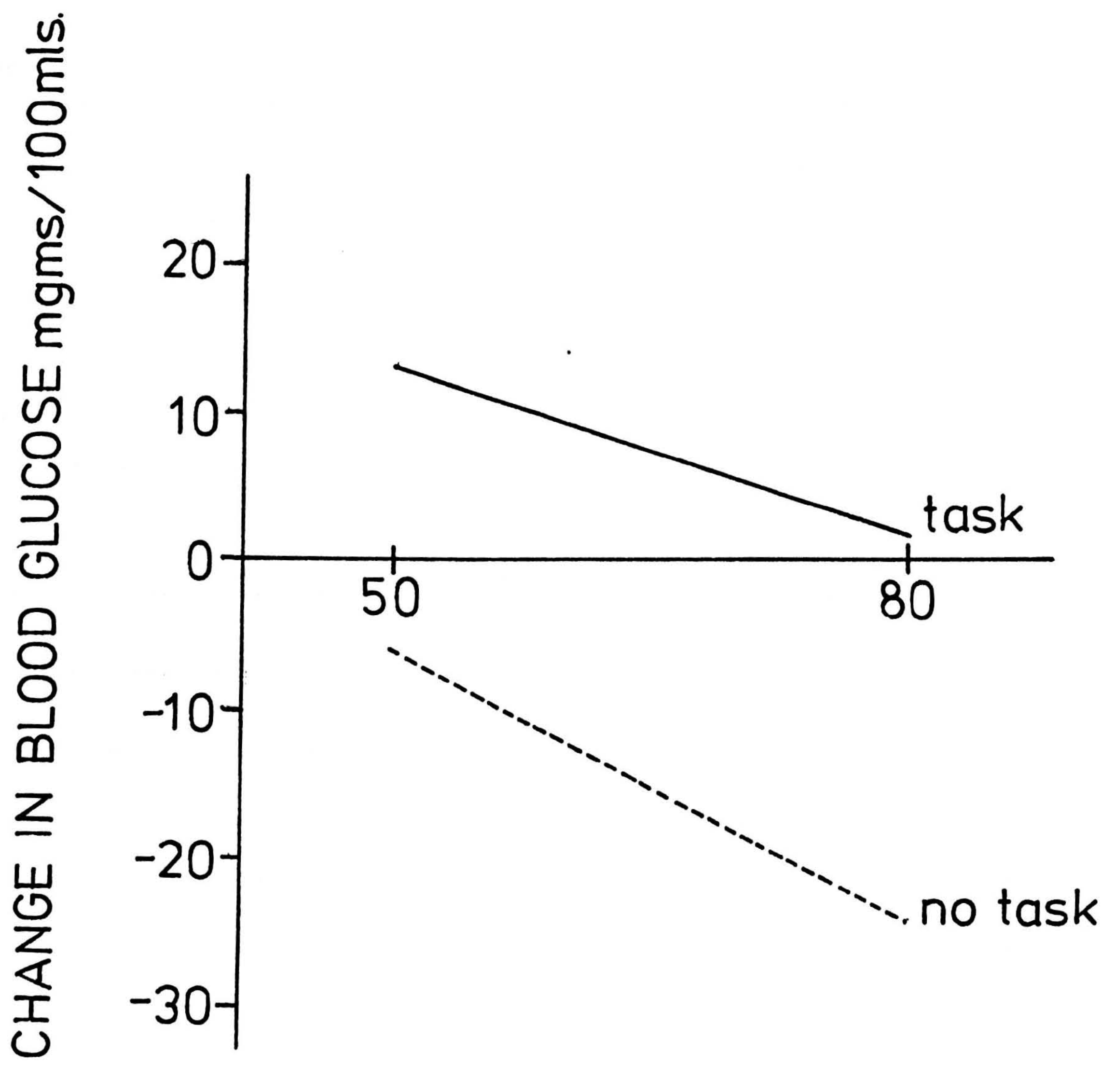
During the adaptation sessions blood glucose levels consistently fell during the 15 minutes of task performance. The mean decrease was 31.65 mg./100ml.

Observations of the results from the 20 experimental trials, however, showed a greater fall in blood glucose levels during the 'No Task' conditions. Mean blood glucose in the Task conditions showed slight increases in blood glucose across the task period. These effects of the task (figure 8) were not shown to be statistically significant by analysis of variance (F=1.61, df 1,16, n.s.).

When the effect of noise on performance measures was tested with one way analysis of variance, there was no evidence of a difference due to the level of noise. However, the low F values(F=0.95 for deviations and 0.16 for time on target) suggested that other factors might be influencing the results. Two way analysis of variance was carried out to examine both the effects of noise and the order of the trials. Scores from the first two trials with 50dB and with 80dB noise were compared with the scores from the last two trials for each noise level. The order of trials was shown to have a significant effect on time on

Figure 8: The Effects of Noise Level and Task Performance on the Change in Blood Glucose Levels

The effects of the different experimental conditions were not statistically significant.



CHANGE IN BLOOD GLUCOSE mgms/100mls.
20
10
0
-10
-20
-30
50
80
task
no task
NOISE LEVEL dBA

target scores. The effect of trial order on deviation scores just missed significance. Tables 12 and 13 summarise the analysis of variance results.

Table 12: Summary of Analysis of Variance of Time on Target Scores

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Order	0.2738	1	0.2738	9.361	4	0.03768*
B Noise	0.0648	1	0.0648	2.215	4	0.21089
AB	0.0648	1	0.0648	2.216	4	0.21085
Within	0.1170	4	0.0292			
Total	0.5204	7				

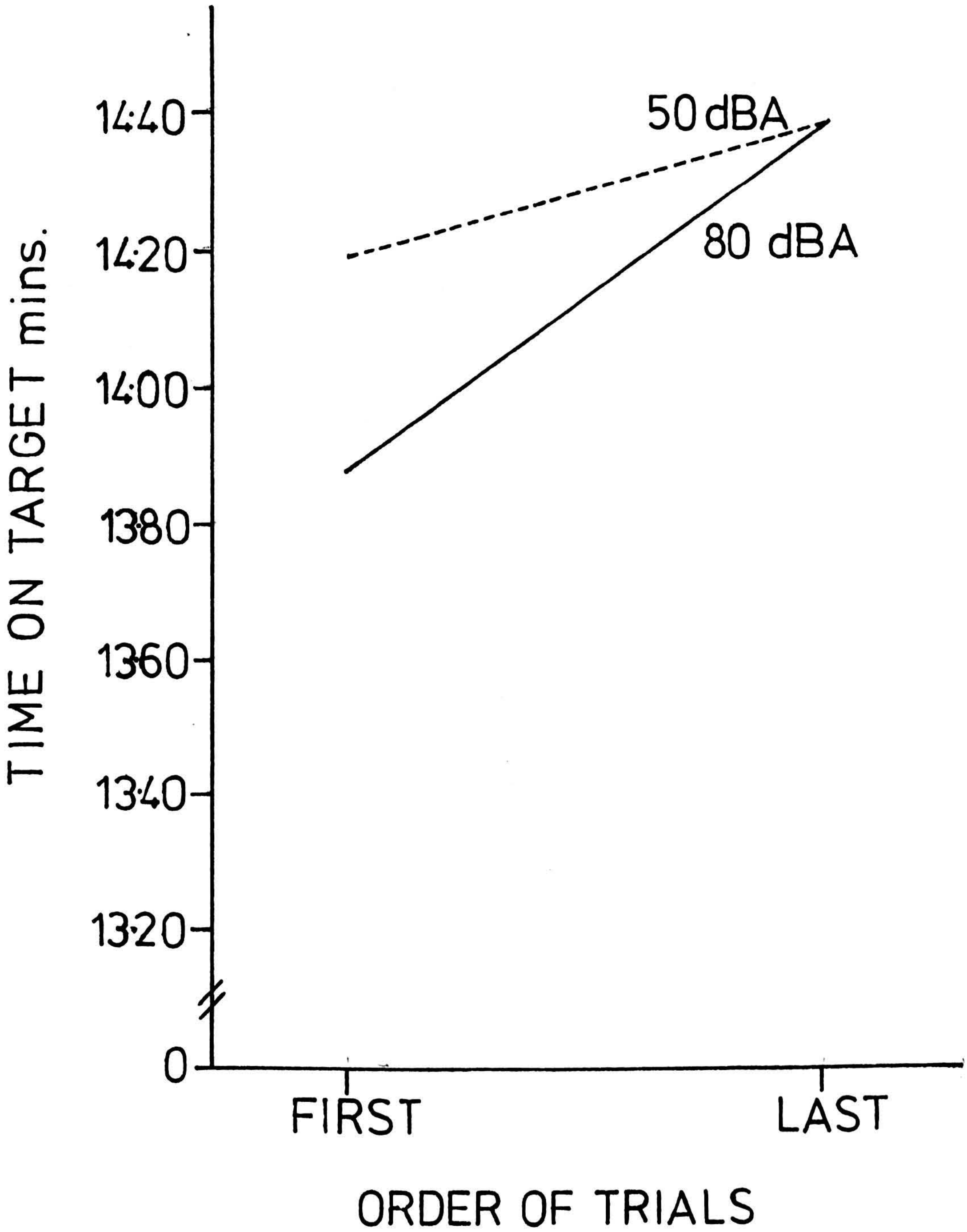
Table 13: Summary of Analysis of Variance of Deviation Scores

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Order	24976.1250	1	24976.1250	6.616	4	0.06183
B Noise	5253.1251	1	5253.1251	1.392	4	0.30350
AB	17391.1251	1	17391.1251	4.607	4	0.09838
Within	15099.5001	4	3774.8750			
Total	62719.8753	7				

There was some indication of an interaction between the effects of order of trials and noise. Performance improvement with practice was most apparent in the noisy (80dB) condition (see figures 9 and 10). There was less effect of trial order on performance in the quiet (50dB) condition. It seemed that practice tended to reduce the detrimental effect of 80dB noise on performance which was apparent during the earlier

Figure 9: The Effects of Noise and the Order of Trials on Time on Target Scores

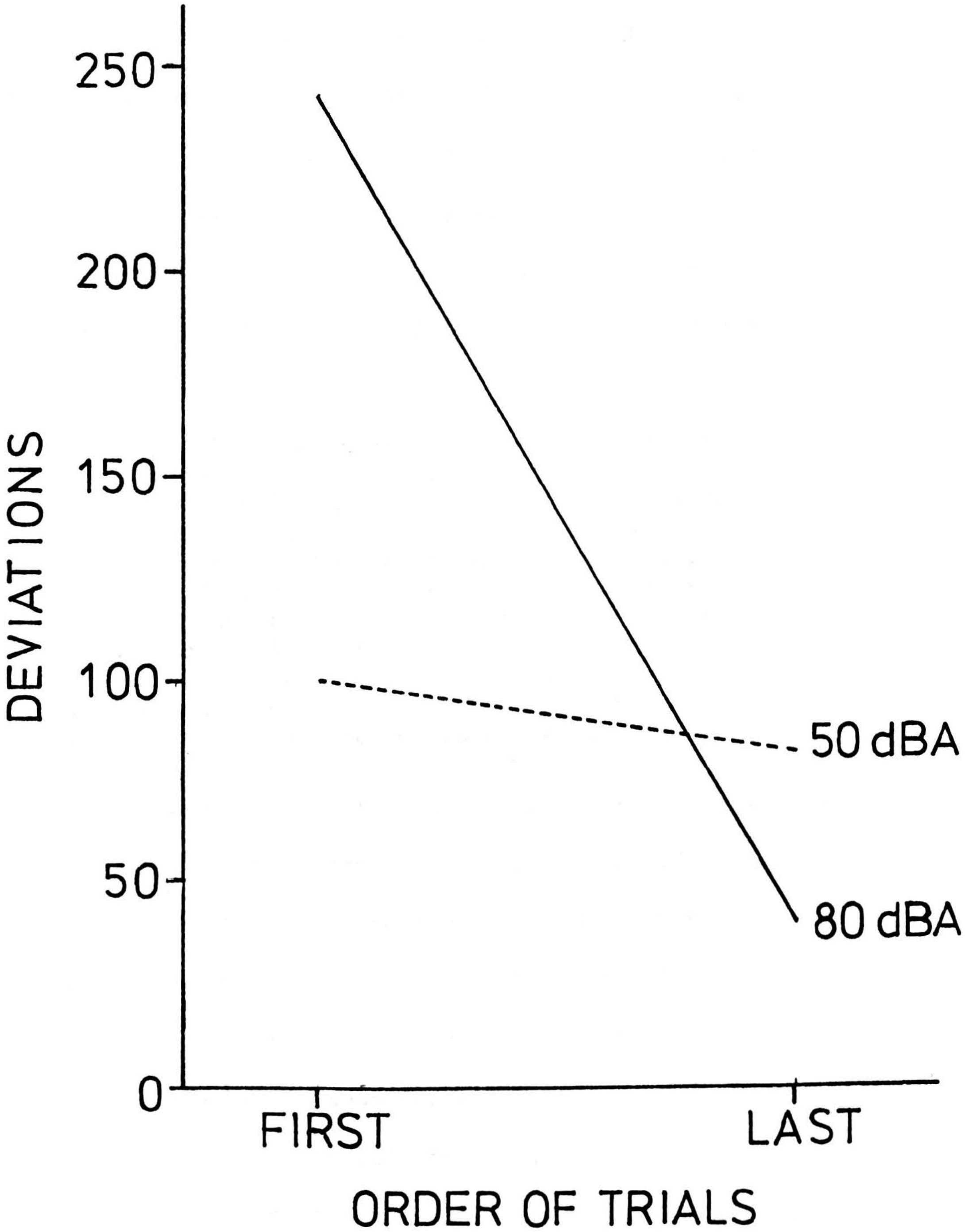
The order of the trials significantly affected time on target scores ($p=0.03768^*$). Time on target scores tended to be impaired by 80dB noise during the first trials but not during the last trials but this result did not reach statistical significance.



TIME ON TARGET mins.
14·40
14·20
14·00
13·80
13·60
13·40
13·20
0
50 dBA
80 dBA
FIRST
LAST
ORDER OF TRIALS

<u>Figure 10: The Effects of Noise and the Order of Trials on the Number of Deviations Scored</u>

Both order effects (p=0.06183) and the interaction between trial order and noise level (p=0.09838) approached significance.



250
200
150
100
50
0
DEVIATIONS
50 dBA
80 dBA
FIRST
LAST
ORDER OF TRIALS

experimental trials. A high degree of proficiency was achieved during the adaptation sessions which was little improved by additional practice in the quiet condition.

It should be noted, however, that the adaptation trials consisted of 4 quiet conditions. The impairment of performance that occurred during the first two 80dB sessions compared with the later sessions and with the quiet conditions may have been due to the change in the situation rather than to the specific noise level. Such an impairment might have occurred with the 50dB experimental sessions if the adaptation sessions had employed 80dB noise. Overton (1966) observed, in animal studies, that decrements in performance might arise initially because of change per se in the experimental condition regardless of the nature of the change.

> 'If an animal is trained while some particular chemical condition (drug state) prevails and is then subsequently tested while in a different drug state, a response decrement is frequently observed. Such decrements may appear when the change between the training and test sessions is (a) from the nondrug state to the drug state, (b) from a drug to the nondrug state, or (c) from one drug state to another drug state. They are caused by state change, and can be distinguished from response decrements produced by the usually disruptive effects of drugs on behaviour when appropriate experimental procedures are employed".

It is possible that the impairment of performance in the present study was due to such a state change rather than to the specific effects of 80dB noise. It may not be concluded from these data that the initial impairment with 80dB was a result of the higher noise level. It is clear, however, that the effects of practice on performance scores extended beyond the adaptation sessions and continued to influence the data throughout the experimental sessions.

There were no significant effects of noise on the change in blood glucose levels. Blood glucose levels decreased during the task period with 50dB noise (mean BS2-1 = -10.7mg/100ml.) and with 80dB noise (mean BS2-1 =-18.84mg/100ml.). The slight differences in degree of fall was not statistically significant (F=0.006, df 1, 16, n.s). When time on target scores were correlated with changes in blood glucose levels there was some indication, though this was not statistically significant, that higher performance levels were associated with decreases in blood glucose levels in the noisy condition (r=-0.7301, N=5) but this was not the case in the quiet condition (r=0.3199, N=5). The number of trials was too small for these results to be reliable.

There was rather more evidence of an effect of task on blood glucose changes. While blood glucose levels tended to decrease during the 'No Task' sessions, increases in blood glucose levels were more often found when A.L. was working at the task. However, variability in response was high and blood glucose change was not shown to be significantly affected by the task/no task factor (F=1.61, df 1,16, n.s.).

There was extreme variability in A.L.'s absolute blood glucose levels which ranged from 49mg/100ml. to 455mg./100ml. He worked irregular hours, and the timing of the morning insulin injection varied considerably. Little attempt was made by A.L. to regularise his meal times and control carbohydrate intake, particularly in the form of alcohol. A.L. was a sociable, friendly character (scoring 31 on the Extraversion scale of the M.P.I.) and he was loath to restrict his social activities which conflicted with adequate control of his diabetes. The variability of his blood glucose levels which resulted from his erratic treatment regime might well have obscured any pattern of smaller blood glucose changes due to the experimental variables studied.

In this study, no attempt was made to estimate the subject's experience of the experimental situation. There was thus no way of assessing the degree of stress, if any, arising from the 4 experimental conditions.

2.3. Conclusions

No significant effects of noise on task performance or blood glucose levels were found in this study. Nor were there any significant effects of the task on changes in blood glucose levels.

Performance measures were significantly related to previous task experience but were not significantly affected by the level of noise. Any initial impairment due to noise was soon reduced by practice.

The following experiment reduced the practice effect and eliminated the possibility of state change affecting the results with a multi-subject design which investigated the effect of noise on one trial task acquisition rather than on performance of a well learned task.

Blood glucose levels were extremely variable in this present study and little effect of the experimental conditions could be seen. The second experiment investigated a sample of diabetic out-patients who led more routine lives and attended the out-patient clinic regularly for check-ups. It was hoped that within subject variability of blood glucose levels would be smaller in such a sample which was probably more typical of the diabetic population as a whole.

3. Experiment 2: Multi-subject Laboratory Study of Diabetic and Control Patients

This study compared measures of performance, blood glucose, personality and subjective experience obtained from diabetic and non-diabetic outpatients under different conditions of noise, task and glucose preloading using a multi-factorial design.

3.1. Method

Subjects 32 insulin-requiring diabetic males aged between 17 and 78 years formed the diabetic sample. These subjects were outpatients at the Nottingham City Hospital and were invited by letter to participate in the study during their next routine visit to the clinic. Initial approaches were made by the consultant physician Dr. J. M. Macfie, who was personally acquainted with the patients. 64 non-diabetic male subjects ranging in age from 17 to 81 years were selected by consultants from general medical and surgical outpatient departments. These subjects manifested disorders unrelated to diabetes, such as varicose veins or asthma, or were returning for post-operational check-ups for such conditions as duodenal ulcer. None of the sample was known to have experienced any symptoms of ischaemic heart disease. A smaller proportion of the non-diabetic group was formed by other members of the hospital population such as the staff and visitors to the hospital. The main consideration in the selection of the control group, in addition to the elimination of diabetes-related disorders, was to match this population with the diabetic population broadly in terms of age, sex and socio-economic status.

All subjects were tested during the course of the outpatient clinics which were held in the afternoons between 1400 and 1700 hours.

Design A factorial design was used to investigate the effects of noise (white noise at 80 or 50dB, see Chapter 2, Section 7) and task (task or no task, Chapter 2, Section 8) in diabetic and non-diabetic subjects.

The effects of glucose preloading were also examined in the case of the non-diabetic subjects. Half of the non-diabetic subjects were preloaded with 30gm. glucose in 100ml. water, (Chapter 2, Section 9). The remaining 32 non-diabetic controls and the 32 diabetic subjects were given 100ml. water only.

The experimental design is summarised below in Table 14.

Table 14: Summary of Experimental Design

	DIABETICS		GLUCOSE CONTROLS		NO GLUCOSE CONTROLS	
NOISE LEVEL dBA	50	80	50	80	50	80
TASK	N=8					
NO TASK						

The dependent variables examined were as follows:-

a) Blood glucose levels (Chapter 2, Section 1)

b) Performance measures; Time on Target and Deviations (Chapter 2, Section 2)

c) Extraversion and Neuroticism (Chapter 2, Section 5).

d) Time estimation and Subjective view of stress (Chapter 2, Section 6).

It was hypothesised from the findings of Cox and colleagues (1973) and Simpson and colleagues (1974) that glucose preloaded controls would perform more efficiently than the no glucose controls in the 80dB noisy conditions but less efficiently in the 50dB quiet conditions. It was also hypothesised that marked decreases in the elevated blood glucose levels of the preloaded controls would be found in the 80dB noisy conditions.

From the work of Hinkle and Wolf (1952) and Vandenberg and his colleagues (1965; 1967; 1967a) it was hypothesised that diabetic subjects would show decreases in blood glucose levels in the noisy conditions. Thus diabetic subjects might show similar blood glucose responses to those expected to occur in the glucose preloaded controls. It was reasoned that this hypothesised fall in blood glucose levels in the noisy conditions might be associated with improved performance efficiency in diabetic as well as the preloaded control subjects. Simpson, Cox and Rothschild (1974) found no such fall in blood glucose levels with preloaded controls at 50dB and performance was impaired. It was thought that this pattern of response might also be shown by the diabetic subjects.

Procedure The general purpose of the research was explained to the subjects and the procedure involved was briefly described. It was emphasised that the patient-subjects were taking part in the experiment on a voluntary basis and that the experiment had no connection with their programme of treatment.

A blood sample was taken from the subject according to the procedure described in Section 1 of Chapter 2. The subject was then asked to drink either 100ml. water (diabetic and 'no glucose' control groups) or 30gm. glucose in 100ml. water (glucose preloaded non-diabetic group). The subject then sat quietly for 30 minutes completing the questionnaires (information sheet and MPI; see Chapter 2) after which time a second blood sample was taken. He was then exposed to one of the two noise levels for 15 minutes (50 or 80dB white noise). During this time some subjects performed the tracking task; the others sat quietly by the task. The third blood sample was taken immediately after the 15 minute test period. Finally the short questionnaire on the subject's experience of the test period was completed (Chapter 2, Section 6).

3.2. Results

The results were analysed using multiple correlation techniques and analysis of variance. These results are considered separately for each sample group studied before being compared and discussed.

Diabetics

Analysis of variance showed that there was a significant effect of noise on the change in blood glucose during the task period. Whether or not the subjects performed the task appeared to have no effect on blood glucose changes. (See Table 15).

Table 15: Summary of Analysis of Variance of Blood Glucose Changes

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Task	652.5079	1	652.5079	0.815	28	n.s.
B Noise	3764.9503	1	3764.9503	4.701	28	0.03879*
AB	228.4453	1	228.4453	0.285		
Within	22423.0890	28	800.8246			
Total	27068.9927	31				

Contrary to expectations, the quiet (50dB) condition was associated with a decrease in blood glucose levels while there was little overall change in blood glucose with the noisy condition (figure 11). Blood glucose levels were not significantly affected by the task factor.

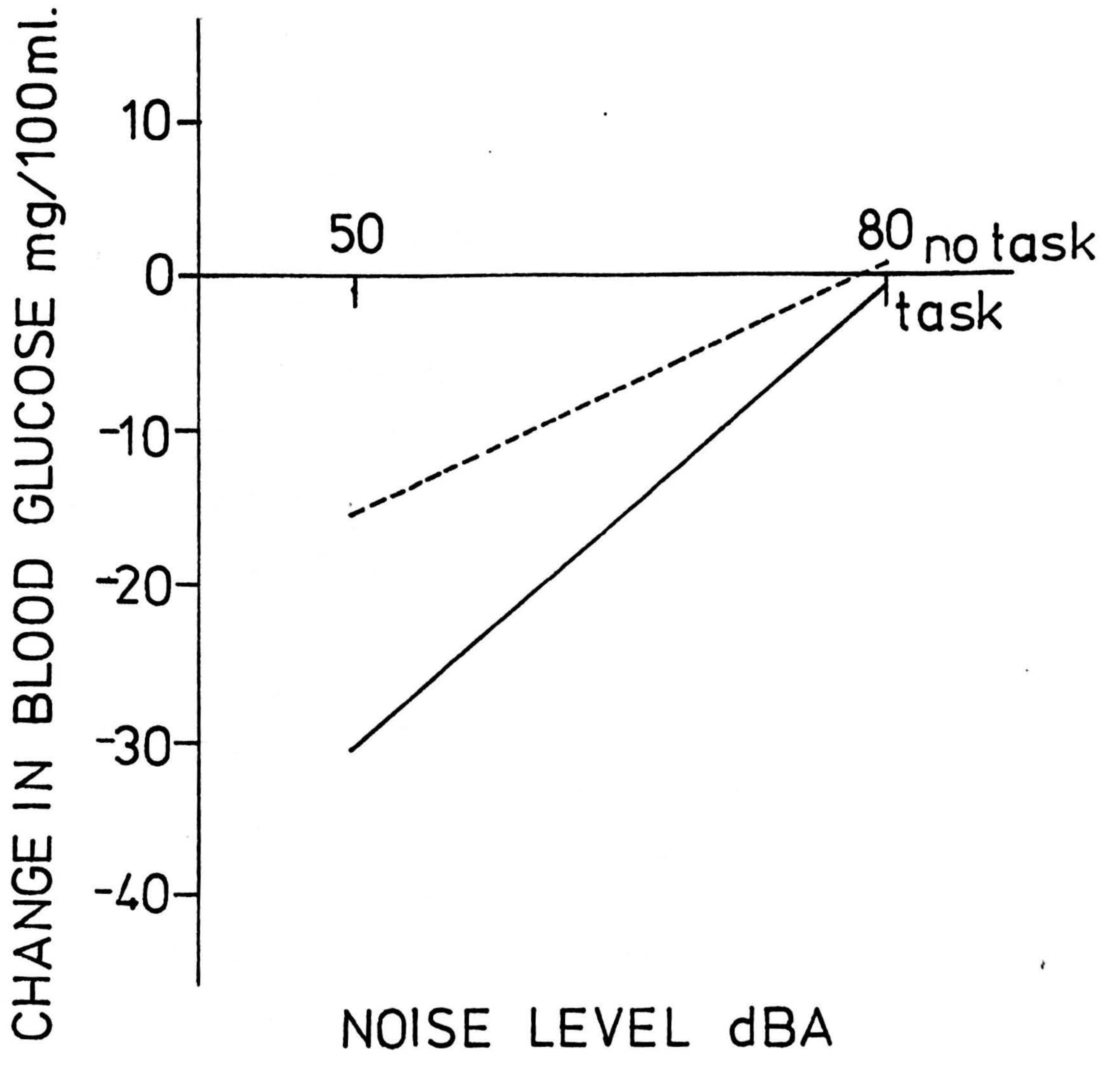
There was no apparent effect of noise on performance measures (TOT: F=0.116, df 1,14, n.s. DEV: F=0.224, df 1,14, n.s.). Correlations between performance measures and blood glucose changes were not significant.

The variability of blood glucose levels was much greater than expected among the diabetic population studied. Initial values ranged from 72.2 to 627.6mg./100ml. The standard deviation of the initial blood samples for the 32 diabetics was 112.3 compared with 21.7 for the non-diabetic controls.

It was thought to be unlikely that a single pattern of response in terms of blood glucose and performance would apply throughout such a variable sample. Post hoc analyses were carried out on the data with

Figure 11: The Effects of Noise and Task on the Change in Blood Glucose Levels of Diabetic Subjects

The decrease in blood glucose levels was greater in the quiet condition (p=0.03879*). There was no significant effect of task.



CHANGE IN BLOOD GLUCOSE mg/100ml.
10
0
-10
-20
-30
-40
50
80
no task
task
NOISE LEVEL dBA

the diabetic sample subdivided into two groups: (1) Those with initial blood glucose levels which exceeded the normal renal threshold of 180mg./100ml. (high glucose diabetics), (2) Those with initial blood glucose levels below this threshold (low glucose diabetics). Although 180mg./100ml. represents the average normal renal threshold, the threshold is considerably more variable among diabetics. However, this figure is used as a guide line by many physicians in judging the adequacy of control in their diabetic patients and it therefore provided a sensible cut off point for dividing the well controlled diabetics from the poorly controlled diabetics. An additional 8 diabetic subjects took part in the experiment increasing the sample size to 40: 24 high glucose diabetics and 16 low glucose diabetics.

Post hoc analysis of diabetic results. Noise was again shown to have a significant effect on blood glucose change. In addition the high and low glucose diabetics were shown to have significantly different blood glucose responses to noise (Table 16, figure 12).

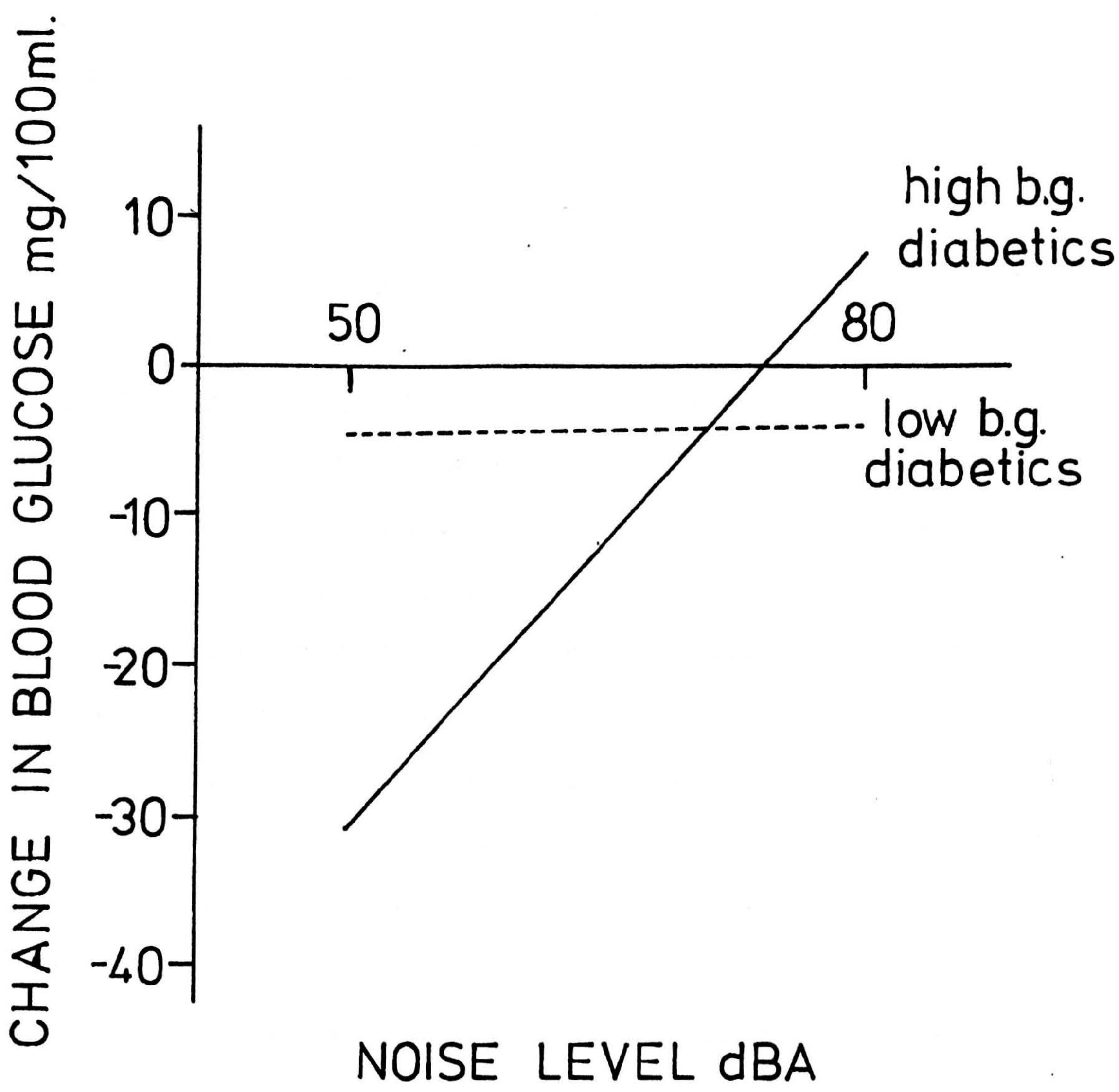
Table 16: Summary of Analysis of Variance of Blood Glucose Change

SOURCE	SUM OF SQUARES	DFI	VAR EST.	F	P
A NOISE	4208.1589	1	4208.1589	5.200	0.02938*
B TASK	6.1678	1	6.1678	0.008	n.s.
C INITIAL BGL	497.4907	1	497.4907	0.615	n.s.
AB	222.8760	1	222.8760	0.275	n.s.
AC	3334.7445	1	3334.7445	4.121	0.05073*
BC	365.7799	1	365.7799	0.452	n.s.
ABC	1691.4185	1	1691.4185	2.090	0.15796
WITHIN	25893.9872	32	809.1871		
TOTAL	36220.6236	39			

Separate analyses were carried out for each of the two diabetic groups.

Figure 12: The Effects of Noise on the Change in Blood Glucose Level of Diabetics with High or Low Initial Blood Glucose Levels

The interaction between noise and the initial level of blood glucose was significant (p=0.05073*)



CHANGE IN BLOOD GLUCOSE mg/100ml.
10
0
-10
-20
-30
-40
50
80
high b.g. diabetics
low b.g. diabetics
NOISE LEVEL dBA

High glucose diabetics. 80dB noise was associated with an overall increase in blood glucose while the quiet condition was associated with a marked decrease in blood glucose (F=7.506, df 1,20, p=0.01**). No significant effects of task on blood glucose levels were apparent. (Figure 13).

Low glucose diabetics. The interaction between noise and task significantly affected blood glucose change (F=5.949, df 1,12, p=0.03121*). See figure 14. Thus the low glucose diabetics responded in the manner hypothesised with enhanced decreases in blood glucose levels when working under noise, while the high glucose diabetics showed quite different reactions.

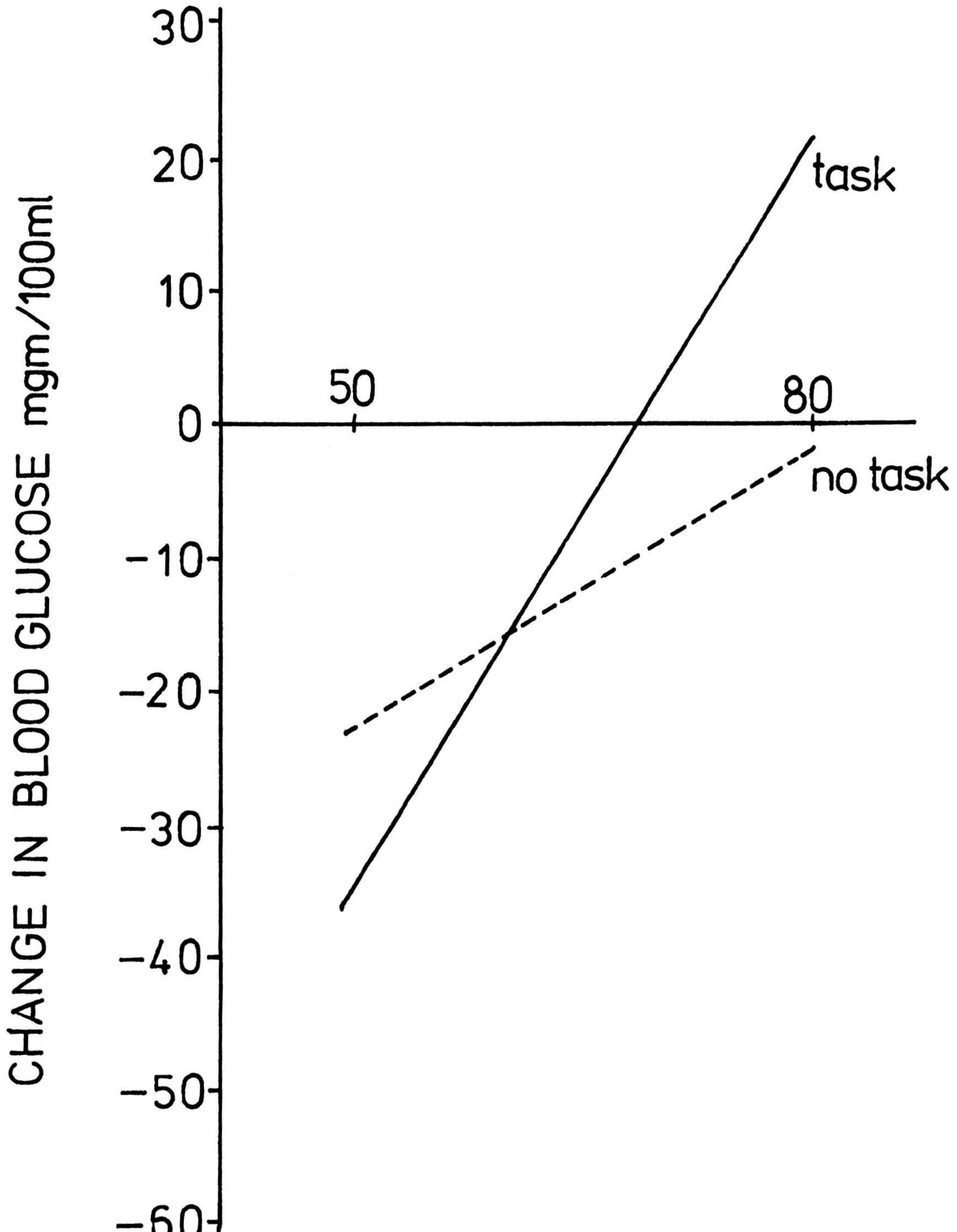
Diabetics' performance results There was no effect of noise on time on target scores in either diabetic group (F=0.321, df 1,16, n.s.). There was some effect of noise on the deviation scores of the low glucose diabetics (F=2.092, df 1,7, p=0.19135): fewer deviations from the light were made in the quiet condition. However, although noise tended to increase the number of deviations made it did not impair time on target scores which tended to be higher in the noisy condition. The high negative correlation that was usually found between time on target and deviation scores was not shown by either diabetic group and was notably absent in the low glucose diabetic group (r= -0.11).

Observation of the data means suggested that higher time on target scores were associated with greater decreases in blood glucose levels within the diabetic groups. (Table 17).

However, there was little evidence of such an association from the correlation matrices (High glucose diabetics; r=0.16, N=11 n.s.: Low glucose diabetics: r= -0.22, N=9, n.s.). Higher mean deviation scores were also associated with a greater fall in blood glucose levels when it would normally be expected (from the usual negative correlations between time on target scores and deviations) that fewer deviations

<u>Figure 13: The Effects of Noise and Task on Changes in the Blood Glucose Levels of High Glucose Diabetic Subjects</u>

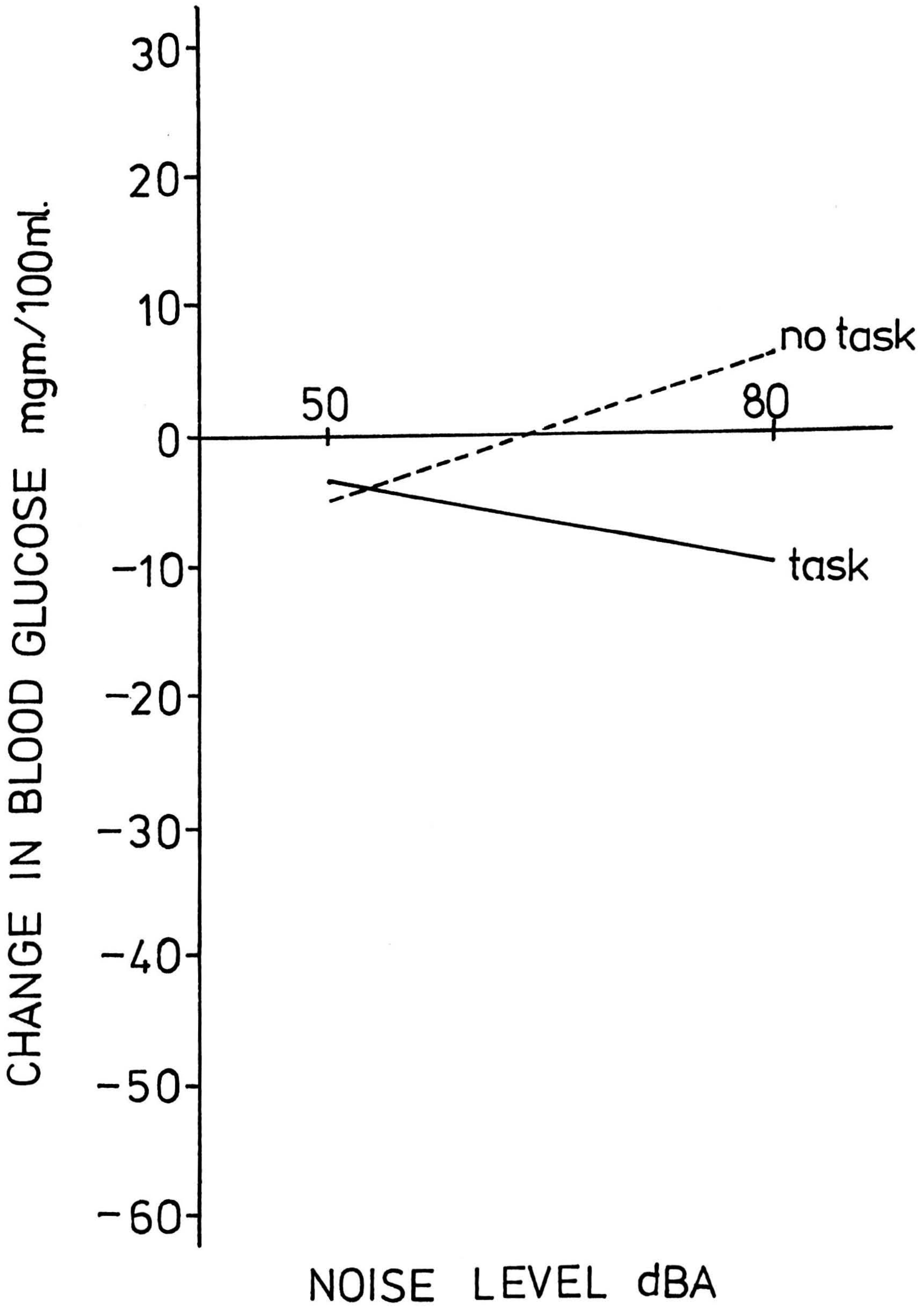
The effect of noise on blood glucose change was highly significant (p=0.01**). There was no significant effect of task.



30
20
10
0
-10
-20
-30
-40
-50
-60
50
80
task
no task
CHANGE IN BLOOD GLUCOSE mgm/100ml
NOISE LEVEL dBA

Figure 14: The Effects of Noise and Task on the Change in Blood Glucose Level of the Low Glucose Diabetic Subjects

The interaction between noise and task factors was significant ($p = 0.03121$*)



CHANGE IN BLOOD GLUCOSE mgm./100ml.
30
20
10
0
−10
−20
−30
−40
−50
−60
50
80
no task
task
NOISE LEVEL dBA

Table 17: Mean Values of Time on Target Scores and Change in Blood Glucose

	NOISE LEVEL dBA			
	80		50	
	TOT	BS3-2	TOT	BS3-2
High glucose diabetics	9.06	21.6	9.43	-36.8
Low glucose diabetics	9.84	-9.7	8.50	-3.4

would be associated with a greater fall in blood glucose. However the negative correlations found between deviation scores and blood glucose change did not reach significance (High glucose diabetics, r= -0.32, N=11, Low glucose diabetics r= -0.44, N=9).

It has been mentioned that analysis of variance showed some difference in deviation scores between the diabetic groups. Interesting correlations were also found. In the High glucose diabetic group, BSI correlated significantly with deviation scores (r=0.71, N=11, sig .05 level). In the Low glucose diabetic group there was a negative correlation between the scores (r= -0.49, N=9, n.s.). There was no significant association between BSI and time on target scores for either group. (High glucose diabetics: r= -0.45, n.s. Low glucose diabetics; r= -0.01, n.s.). Thus diabetics with extremely high blood glucose levels scored more deviations from the light.

Summary: High glucose diabetics tended to produce higher time on target scores in the quiet condition where decreases in blood glucose levels were found. Low glucose diabetics had higher time on target scores in the noisy condition which for this group was associated with greater decreases in blood glucose level. Thus the hypothesis that diabetics would show decreases in blood glucose levels with noise and that the noisy condition would be associated with improved performance, was supported by the results of the low glucose diabetics but not by the results of the high glucose diabetics. The usual negative relationship between time on target and deviation scores was not found with the diabetic results.

Non-diabetic subjects. Glucose preloaded and no glucose groups showed significantly different blood glucose changes during the task period. (Table 18, Figure 15).

Table 18: Summary of Analysis of Variance of Change in Blood Glucose

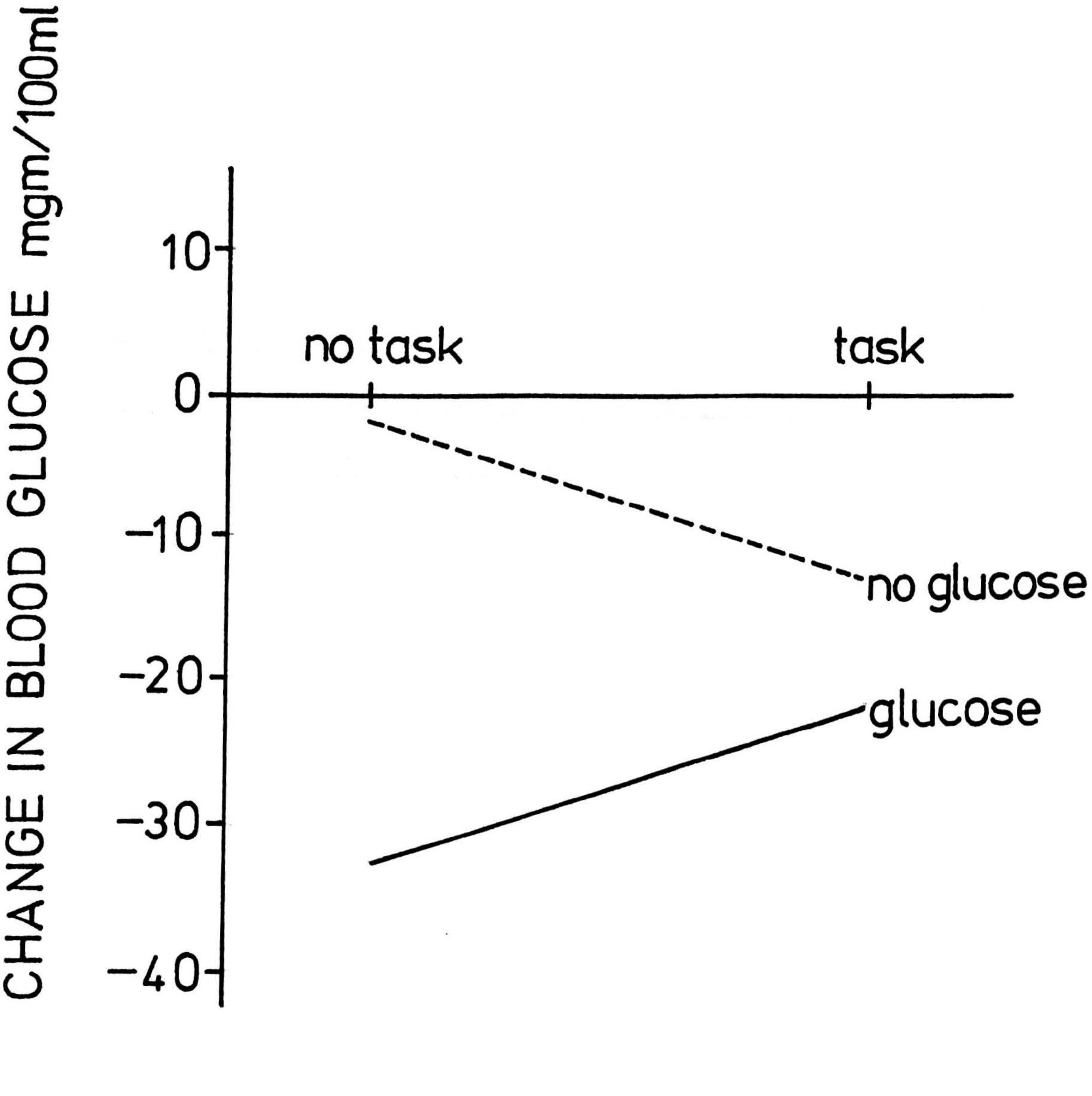
SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A GLUCOSE PRELOADING	6201.5625	1	6201.5625	14.261	56	0.00039***
B TASK	0.3909	1	0.3909	0.001	56	n.s.
C NOISE	66.4226	1	66.4226	0.153	56	n.s.
AB	1900.9597	1	1900.9597	4.371	56	0.04110*
AC	735.7654	1	735.7654	1.692	56	0.19867
BC	2289.6223	1	2289.6223	5.265	56	0.02553*
ABC	1574.1057	1	1574.1057	3.620	56	0.06224
WITHIN	24352.3205	56	434.8629			
TOTAL	37121.1499	63				

The no glucose group showed small decreases in blood glucose in all four conditions. This decrease was enhanced in the task conditions (figure 16). Blood glucose changes in the glucose group were affected by the significant interaction between task and noise. It was hypothesised that greater decreases in blood glucose would occur while performing the task in the noisy condition. However only a small decrease in blood glucose was observed in this condition. More dramatic decreases were found in the no task groups (figure 17).

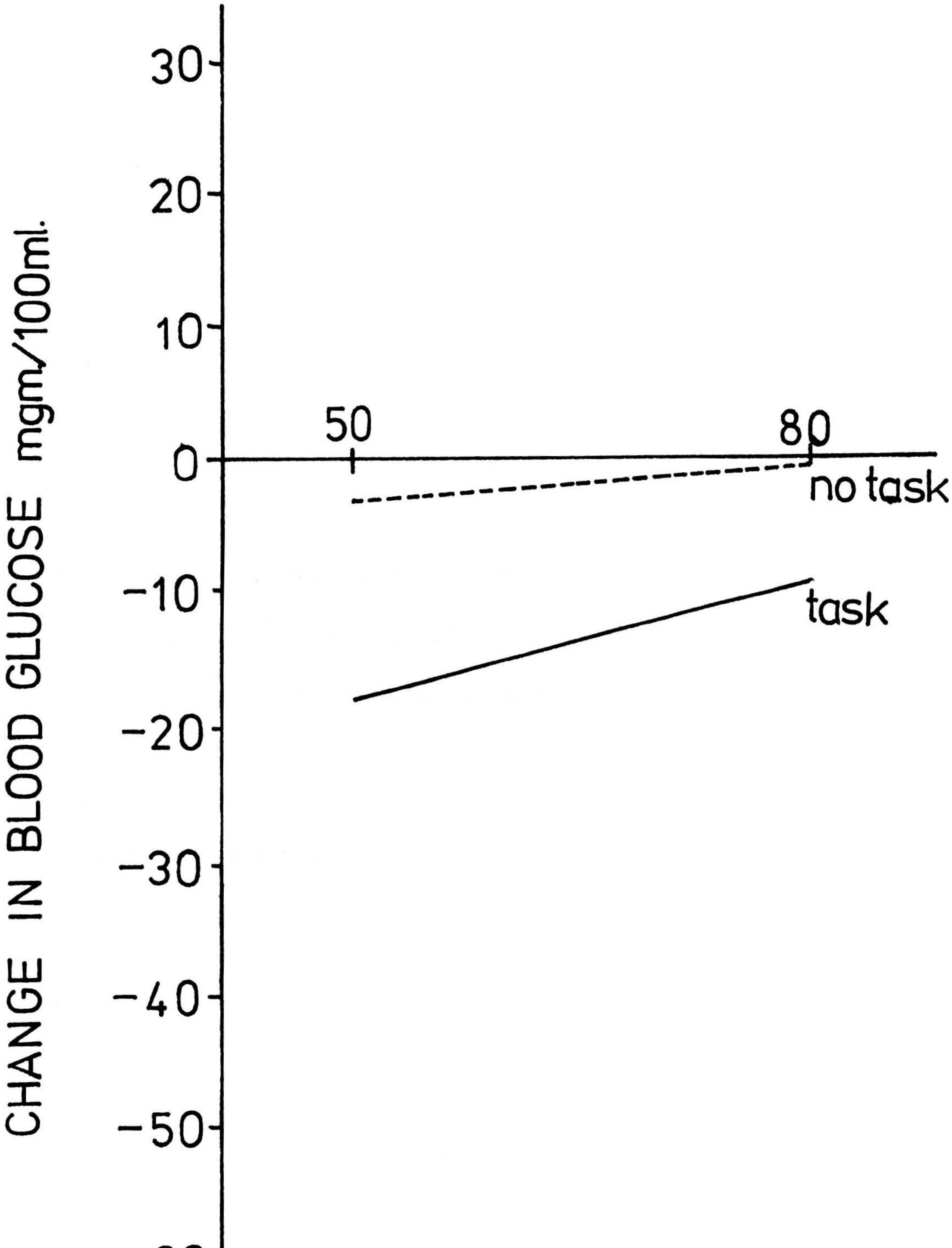
Non-diabetic groups, performance. There were no significant differences due to glucose preloading or noise in time on target or deviation

Figure 15: The Effects of Glucose Preloading and Task on the Change in Blood Glucose Levels of the Control Subjects

The effects of glucose preloading were highly significant ($p=0.00039$***). The interaction between task and glucose preloading was also significant ($p=0.04110$*).


CHANGE IN BLOOD GLUCOSE mgm/100ml
10
0
−10
−20
−30
−40
no task
task
no glucose
glucose

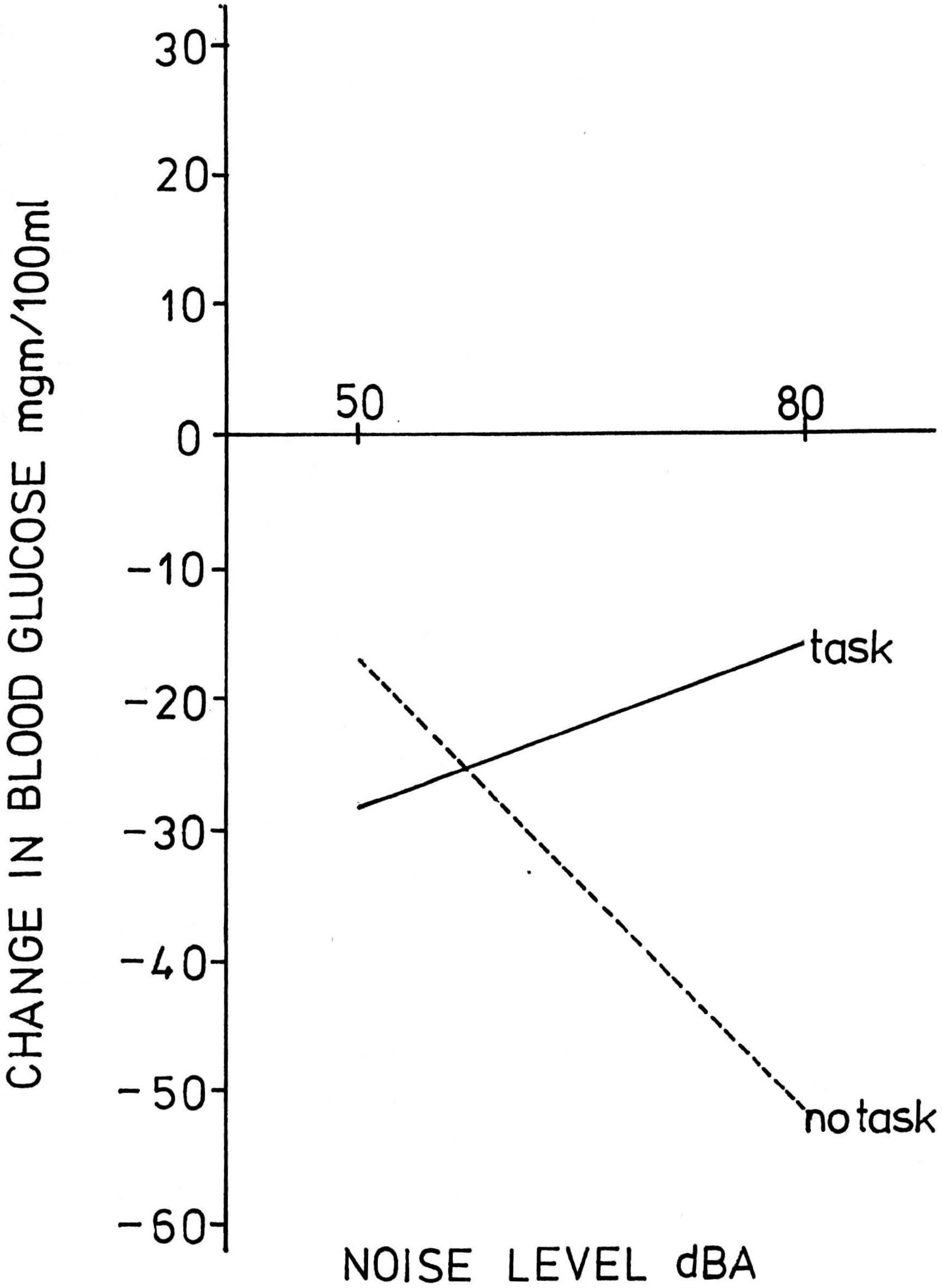
<u>Figure 16: The Effects of Noise and Task on the Change in Blood Glucose Levels of the No Glucose Control Subjects</u>



CHANGE IN BLOOD GLUCOSE mgm/100ml.
30
20
10
0
−10
−20
−30
−40
−50
−60
50
80
no task
task
NOISE LEVEL dBA

Figure 17: The Effects of Noise and Task on the Change in Blood Glucose Levels of the Glucose Preloaded Control Subjects

The results of this group accounted for the significant interaction of noise and task (p=0.02553*)


30
20
10
0
-10
-20
-30
-40
-50
-60
CHANGE IN BLOOD GLUCOSE mgm/100ml
50
80
task
no task
NOISE LEVEL dBA

scores. Time on target correlated negatively with deviation scores showing the usual pattern of performance: higher time on target associated with fewer deviations. This correlation was significant for the no glucose groups (r = -0.57, N= 16, sig. 0.05 level*) but did not reach significance in the glucose groups (r = -0.41, N =16, n.s.).

It was hypothesised that the glucose preloaded group would perform more efficiently with 80dB noise than the no glucose group and that the glucose group would show greater decreases in blood glucose in association with the better performance results. These were the findings obtained by Simpson, Cox and Rothschild (1974). However, there was little evidence of such a pattern of response in the present data. Possible reasons for the differences in the findings are discussed in Section 3.3.

Comparison of diabetic and non-diabetic results. Blood glucose changes were significantly different in the four groups studied. The analysis of variance results are summarised in Table 19.

Table 19: Summary of Analysis of Variance of Blood Glucose Change

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A GROUP	7817.3013	3	2605.7671	4.564	88	0.00510**
B TASK	5.5335	1	5.5335	0.010	88	n.s.
C NOISE	2169.3295	1	2169.3295	3.799	88	0.05446*
AB	1867.2709	3	622.4236	1.090	88	0.35763
AC	7940.9051	3	2646.9684	4.636	88	0.00467**
BC	1675.0741	1	1675.0741	2.934	88	0.09027
ABC	3592.4642	3	1197.4880	2.097	88	0.10633
WITHIN	50246.3081	88	570.9808			
TOTAL	75314.1866	103				

The significant effect of noise indicated an overall trend towards enhanced blood glucose decreases in the quiet (50dB) condition compared with a smaller decrease at 80dB. This result was due mainly to the high glucose diabetic group. There was clearly more variation in response between the four groups in the noisy condition and the interaction between noise and subject group was highly significant. There was little difference between the low glucose diabetics and the no glucose control group but high glucose diabetics showed an increase in blood glucose levels in the noisy condition while glucose preloaded controls showed a decrease (Figure 18). These results are discussed in section 3.3.

Time on target scores did not differ significantly between the four groups (F=0.130, DF 3,44, n.s.) and no effect of noise on these scores was found. (F=0.104, DF 1,44 n.s.). (Figure 19). There was, however, some difference between the groups with deviation scores, (F=2.624, DF 3,44, P=0.06). Figure 20 suggested that the greatest difference was between diabetic and non-diabetic groups. When the data from the two diabetic groups were combined and compared with the data from the non-diabetic groups, the number of deviations differed significantly between the two populations as shown in Table 20.

Table 20: Summary of Analysis of Variance of Deviation Scores

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A DIABETICS/ CONTROLS	$2.2481_{10}+05$	1	$2.2481_{10}+05$	7.974	49	0.006844**
B NOISE	1355.3440	1	1355.3440	0.048	49	n.s.
AB	5265.3440	1	5265.3197	0.187	49	n.s.
WITHIN	$1.3814_{10}+06$	49	28192.3876			
TOTAL	$1.6129_{10}+06$	52				

Figure 18: The Effects of Noise on Blood Glucose Change: the Four Groups Compared

The interaction between noise and experimental group was highly significant (p=0.00467**) High glucose diabetics show an increase in blood glucose with noise, glucose preloaded controls show a decrease and the low glucose diabetics and no glucose controls show little change in blood glucose with noise.

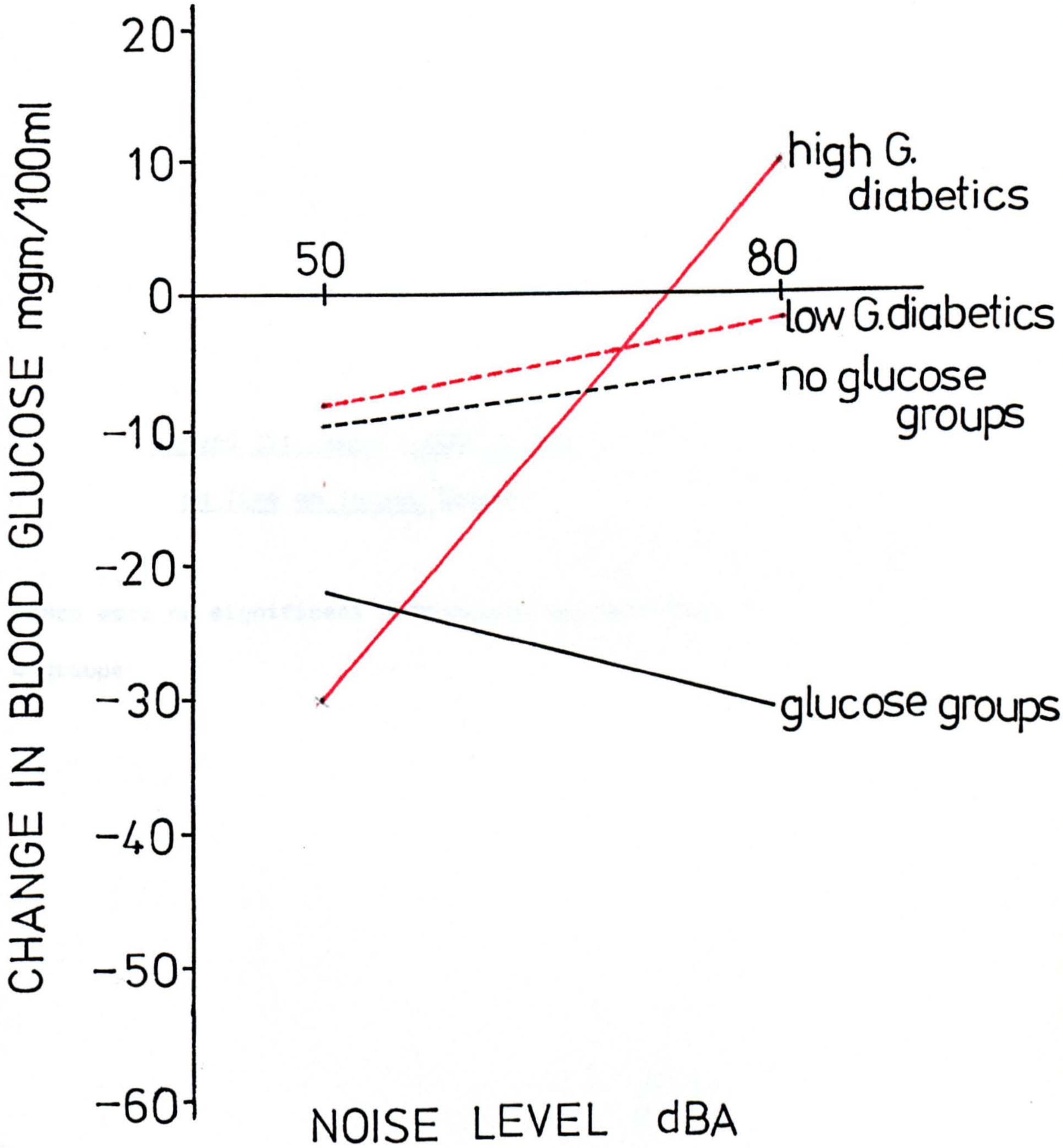

CHANGE IN BLOOD GLUCOSE mgm/100ml
20
10
0
-10
-20
-30
-40
-50
-60
50
80
NOISE LEVEL dBA
high G. diabetics
low G.diabetics
no glucose groups
glucose groups

Figure 19: The Effects of Noise on Time on Target Scores

There were no significant differences between the 4 groups

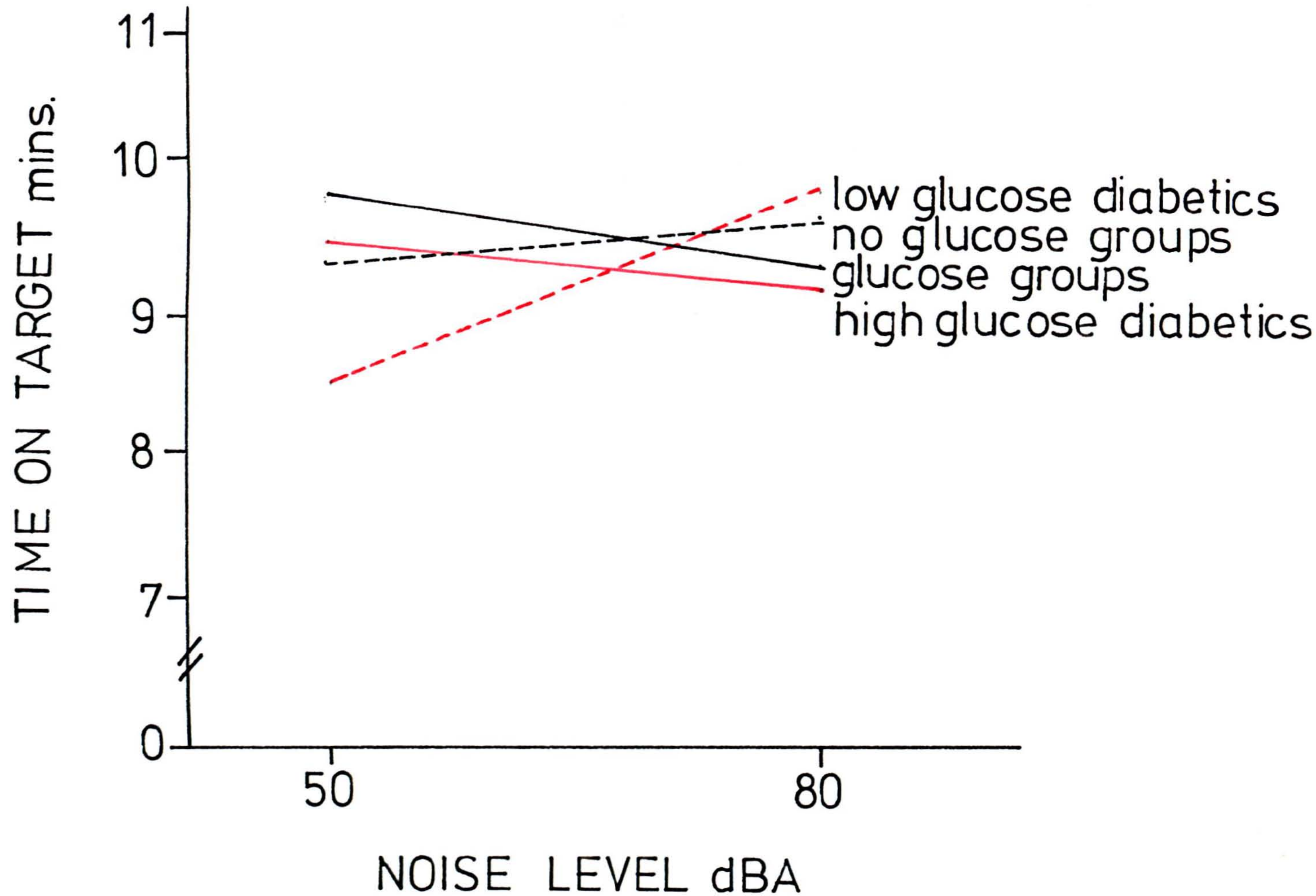
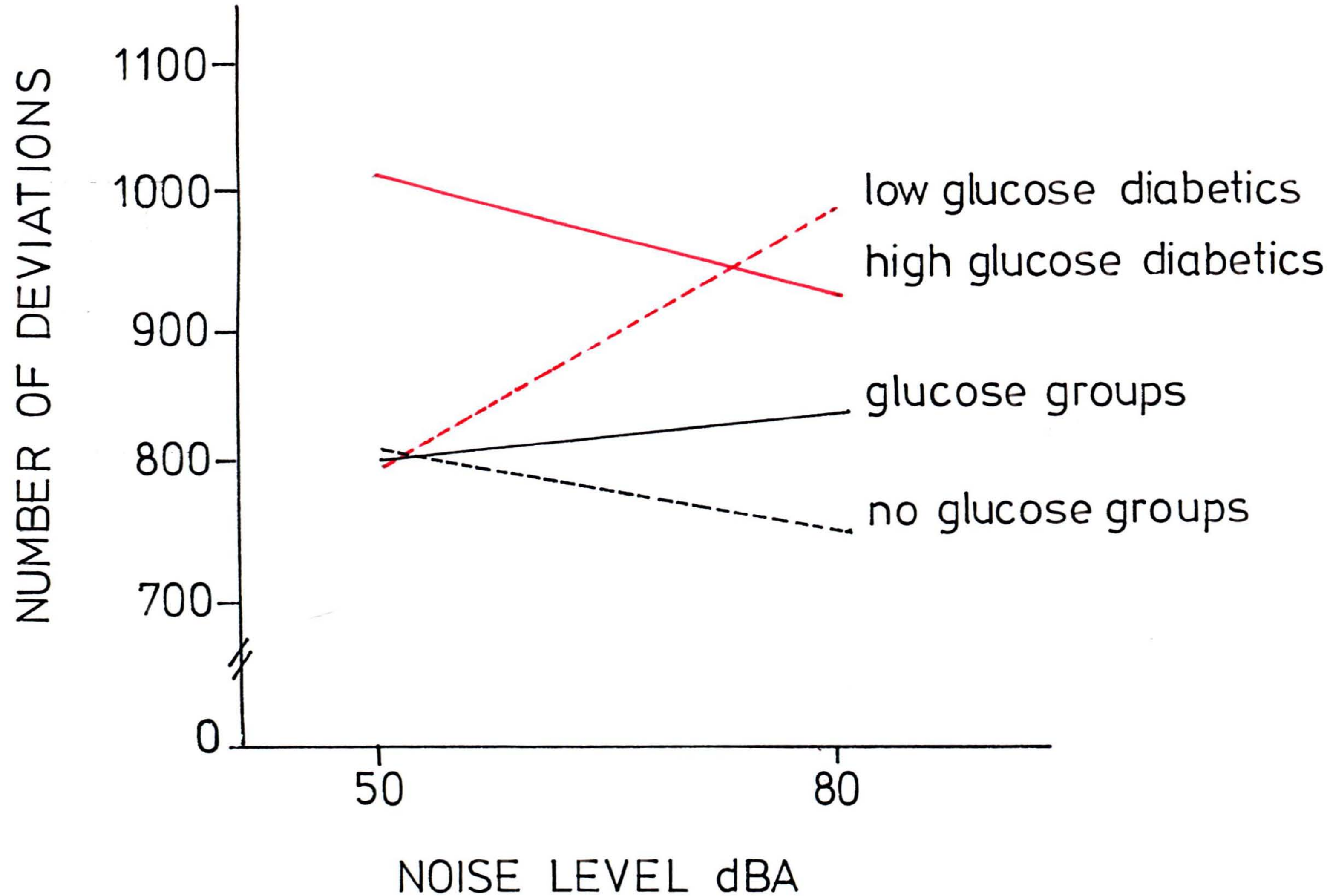

TIME ON TARGET mins.
11
10
9
8
7
0
50
80
NOISE LEVEL dBA
low glucose diabetics
no glucose groups
glucose groups
high glucose diabetics

Figure 20: The Effects of Noise on Deviation Scores

Diabetics scored more deviations than the controls ($p=0.006844$**). Noise did not have a significant effect on the deviation scores.


NUMBER OF DEVIATIONS
1100
1000
900
800
700
0
50
80
NOISE LEVEL dBA
low glucose diabetics
high glucose diabetics
glucose groups
no glucose groups

3.3. Discussion of Blood Glucose and Performance Results

The results presented in the previous section were more complicated than originally anticipated. The blood glucose changes that occurred during the task period were dependent upon the diabetic's initial blood glucose levels. The diabetic subjects could be divided into those with blood glucose levels greater than 180mg./100ml. (the approximate renal threshold) and those with blood glucose levels below 180mg/100ml. The low glucose diabetics who performed the pursuit rotor task in the noisy condition showed the fall in blood glucose levels similar to that observed in Vandenberg's diabetics and Simpson, Cox and Rothschild's glucose preloaded subjects. This decrease in blood glucose was greater in the noisy condition than in the quiet condition. Time on target scores tended to be higher under noise than in the quiet condition although the difference was not significant.

Diabetics with high initial blood glucose levels differed considerably from the hypothesised pattern of results. When working in the noisy condition their blood glucose levels increased significantly. Time on target scores tended to be lower though not significantly lower than in the quiet condition. The different responses of the high and low blood glucose diabetics may be related to the amount of circulating insulin and the amount of glucagon secreted.

Lefebvre and Unger (1972) reviewed the evidence that, relative, and at times absolute, hyperglucagonaemia might be present in persons with insulin requiring diabetes mellitus, thereby exaggerating the metabolic consequences of their insulin deficiency. They also suggested that many of the unexplained manifestations of the diabetic state could well be the consequence of changes in glucagon levels in such people.

There is considerable evidence to suggest that glucagon secretion occurs in response to a variety of stressful situations (Bloom, 1975;

Lindsey and colleagues, 1974). Bloom (1973) referred to glucagon as a 'stress hormone' which 'could play an important role in diabetic control in stress situations'. Bloom and his colleagues (1973) have provided evidence to suggest that glucagon release accompanies the startle response to noise.

In non-diabetic subjects, the hyperglycaemia produced by glucagon secretion in response to stress would, in turn stimulate insulin secretion which would facilitate utilisation of glucose mobilised by glucagon. In the high glucose diabetics, it appeared that there was insufficient insulin to cope with the original level of glucose; consequently if glucagon was released in response to working under noise, sufficient insulin would not be available to utilise the additional glucose by the muscle cells. The low glucose diabetics might have had enough insulin available to partially regulate their blood glucose levels and to utilise the influx of glucagon-released glucose, or to inhibit glucagon release itself.

Unger (1972) suggested that the glucagon producing alpha cell was an insulin requiring cell which in the absence of insulin was incapable of sensing or responding appropriately to the high glucose levels outside the cell. Thus if insulin was not available, which was here likely to be the case with the high glucose diabetics, the release of glucagon under stress would merely exaggerate the present state of hyperglycaemia; the negative feedback control of this process being impaired by insulin deficiency.

Levine (1976) cited studies suggesting that hyperglucagonaemia only caused significant hyperglycaemia in insulin requiring diabetics who were insulin deprived. He concluded that glucagon exerted a diabetogenic action only when there was an insulin deficiency. The low glucose diabetic patients in the present study may be presumed to have had sufficient effective insulin to prevent a hyperglycaemic response to glucagon.

It was surprising that although there were highly significant differences between the blood glucose responses of the high and low glucose diabetic subjects, there was little difference in performance. If performance efficiency under stress is meaningfully related to blood glucose change, as the work of Cox and Simpson (1973; 1974) suggested, it might be expected that the high glucose diabetics who were unable to use their blood glucose adequately would perform at a considerably lower level than the low glucose diabetics, whose blood glucose levels decreased during the task period. However, although the high glucose diabetics' mean time on target score was lower than the low glucose diabetics' (and lower than the non-diabetic groups) in the noisy condition, the difference was not significant. It may be that, if the link between the physiological and behavioural responses suggested by Cox and Simpson's results exists, it was weakened in the diabetics where feedback from physiological changes was often inappropriate and misleading. However, it is also possible that this link observed by Cox and Simpson was not a direct link between performance and blood glucose change.

Some difference was found between the diabetic and control groups in the number of deviations made from the target. The diabetics and particularly the high glucose diabetics made more deviations than the controls (figure 20). One possible explanation for this finding is the high incidence of neuropathy among people with diabetes. This condition is characterised by impaired joint position sense in the digits, loss of vibration sense and muscular weakness. Neuropathy is more common among poorly controlled diabetics who are also likely to have more extreme blood glucose levels.

The non-diabetic control groups in the present study failed to show the same pattern of results as the subjects in the experiments by Cox and Mackay. Several factors were considered which might have accounted for the differences in results between the University and hospital studies, besides the obviously important one of setting:

(a) 18gm. glucose preloading vs 30gm. preloading.

(b) Morning testing sessions vs afternoon.

(c) Younger subjects vs older subjects.

(d) University population vs hospital population.

(e) Homogeneity of populations.

(f) Different experimenters.

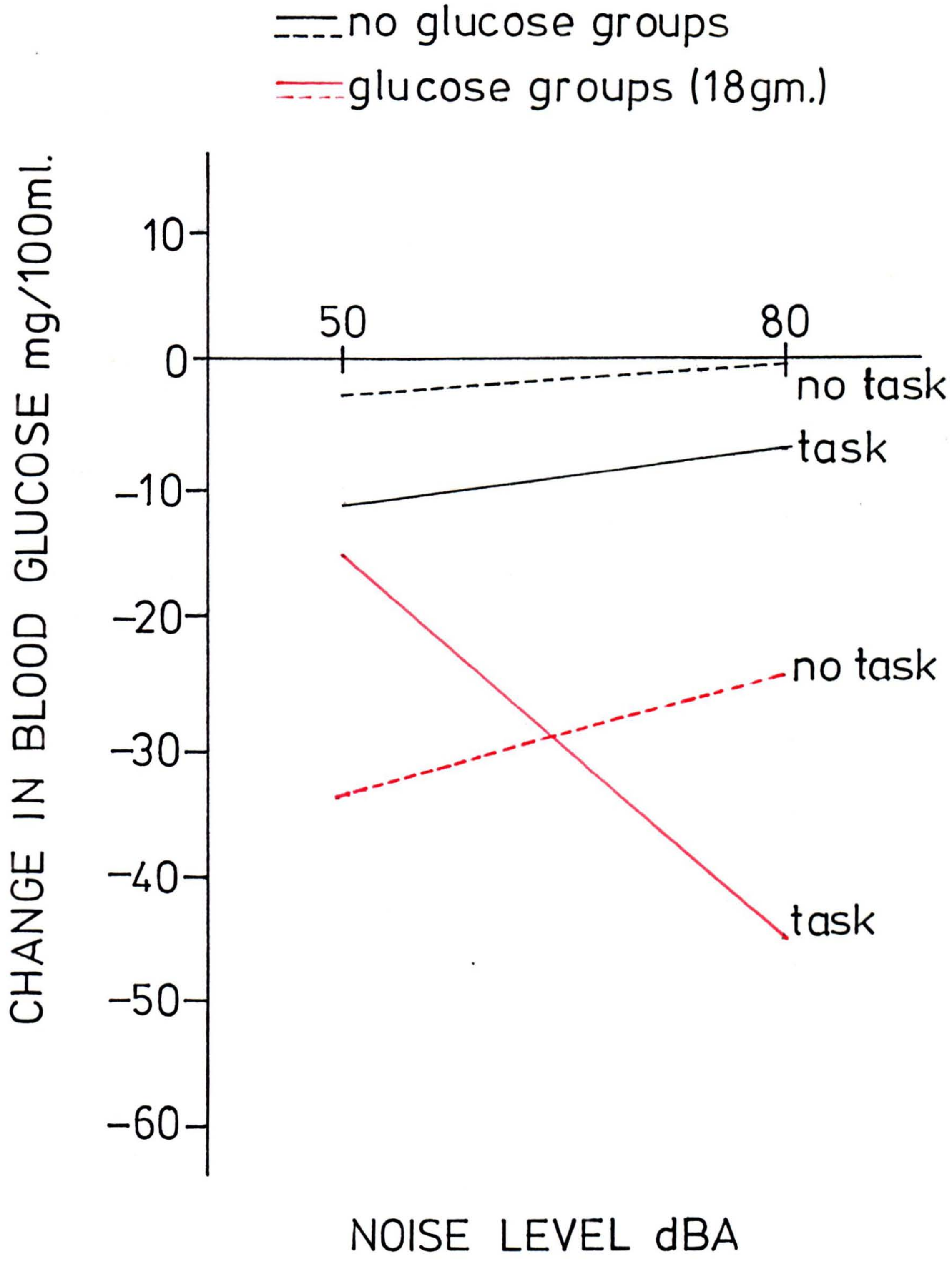
(g) Higher chair vs lower chair.

Figures 21 and 22 describe the non-diabetic blood glucose changes found in the present study and the changes found with the healthy male students in the previous work by Simpson, Cox and Rothschild (1974). The results observed in the no glucose groups are almost identical in the two studies. However, the results of the glucose preloaded groups are quite different. It is therefore possible that the differences in the responses of the preloaded groups were due to the amount of glucose used rather than to the other variables considered. The effects of different amounts of glucose preloading were systematically investigated in the titration experiment which is reported in Chapter 6.

Although the no glucose controls in both studies demonstrated similar blood glucose changes, the performance results were different (Figure 23). Performance scores were lower in the present study. The factor most likely to have caused this difference was thought to be the height of the chair used which differed between the two studies. In the present study the chair was lower than in the previous university study.

Figure 21: Results Obtained by Simpson, Cox and Rothschild (1974) from a Sample of Male Students

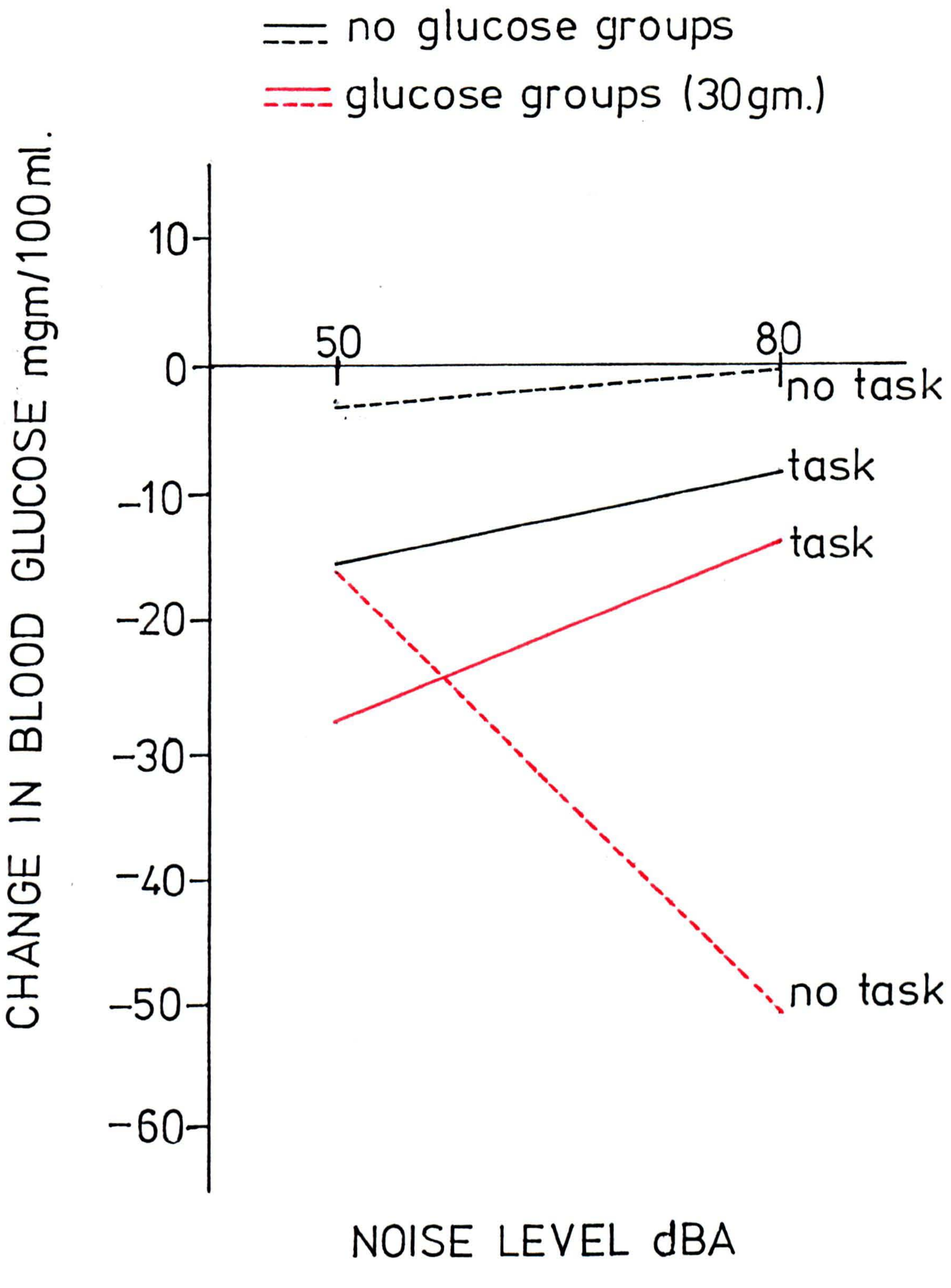
The graph shows the effects of noise, task and glucose preloading on changes in blood glucose levels.



(after Simpson, Cox and Rothschild)

Figure 22: Results Obtained from the Sample of Male Control Subjects from the Hospital Population

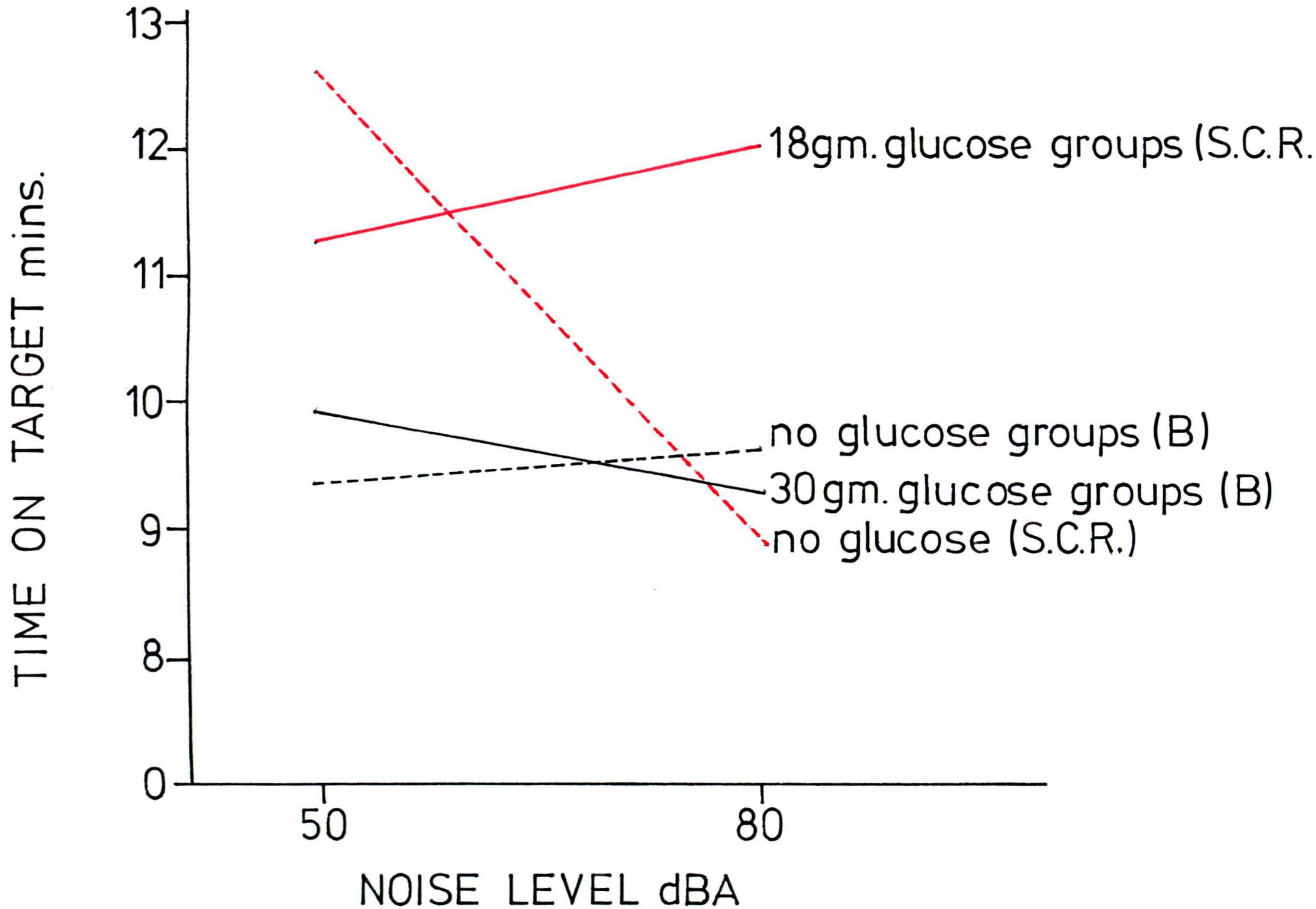
The graph shows the effects of noise, task and glucose preloading on changes in blood glucose levels. (Bradley 1975)



no glucose groups
glucose groups (30gm.)
CHANGE IN BLOOD GLUCOSE mgm/100ml.
10
0
-10
-20
-30
-40
-50
-60
50
80
no task
task
task
no task
NOISE LEVEL dBA

Figure 23: Time on Target Scores.

Results obtained by Simpson, Cox and Rothschild (1974) plotted with those obtained by Bradley (1975).


13
12
11
10
9
8
0
TIME ON TARGET mins.
50
80
NOISE LEVEL dBA
18gm. glucose groups (S.C.R.)
no glucose groups (B)
30gm. glucose groups (B)
no glucose (S.C.R.)

As a consequence of this, the task was more difficult. It was necessary for subjects to raise their arms above the level of the apparatus in order to perform the task and several subjects commented that the effort involved was tiring. Chair height may therefore account for the lower time on target scores in the present study.

Furthermore it is possible that the greater task demand that this caused obscured any differences in performance due to noise stress. Noise did not produce the decrement in performance observed in the no glucose group of Simpson, Cox and Rothschild's study. It is possible that the task was more stressful than the noise in the present study. This possibility is considered in relation to subjective experiences of the experimental conditions. These data are presented and discussed in the following section.

3.4. Subjective Experience of the Task Period: Results and Discussion

Subjective View of Stress

These data were collected by means of the Subjective Experience Questionnaire described in Section 6.1 of Chapter 2. For the purpose of analysis, reports that the 15 minute session was very or slightly stressful were considered together and compared with reports that the situation was not stressful at all. In this way 2x2 contingency tables were drawn up of the frequencies of each of the two categories of response, 'Stress' and 'No Stress' and tables for testing the significance of such results were referred to (Finney and colleagues, 1963). The frequency tables of each of the four groups are presented below.

Table 21: No Glucose Controls

	TASK		NO TASK		TOTALS	
	Stress	No Stress	Stress	No Stress	Stress	No Stress
80dB	7	1	4	4	11	5
50dB	4	4	1	7	5	11
TOTALS	11	5	5	11		

Both the effects of task and noise on the no glucose groups'subjective reports of stress were significant at the 0.05 level. It does indeed appear that performance of the task is in itself a stressful experience equivalent to that of the noise. This finding supports the suggestions made in the previous section.

Table 22: Glucose Preloaded Controls

	TASK		NO TASK		TOTALS	
	Stress	No Stress	Stress	No Stress	Stress	No Stress
80dB	5	3	0	8	5	11
50dB	3	5	5	3	8	8
TOTALS	8	8	5	11		

Neither the effect of task nor the effect of noise on the glucose preloaded groups' subjective report of stress was significant. It is of interest to note that there were more reports of stress by the glucose preloaded group in the quiet, no task condition than there were in the noisy no task condition or in the quiet task condition. It would appear that glucose preloading in the absence of any external demand may itself be stressful.

The glucose preloaded subjects were less inclined to report the noise and task conditions as stressful than the no glucose subjects. However, the glucose preloaded group tended to report the quiet, no task condition as stressful while the no glucose group tended to report this condition as non-stressful.

Table 23: Low Glucose Diabetics

	TASK		NO TASK		TOTALS	
	Stress	No Stress	Stress	No Stress	Stress	No Stress
80dB	4	1	1	2	5	3
50dB	3	1	0	4	3	5
TOTALS	7	2	1	6		

The effect of task was significant at the 0.025 level but noise did not have a significant effect on subjective report of stress by low glucose diabetics. Task performance was also reported to be a more stressful factor than noise by the high glucose diabetics.

Table 24: High Glucose Diabetics

	TASK		NO TASK		TOTALS	
	Stress	No Stress	Stress	No Stress	Stress	No Stress
80dB	4	1	2	5	6	6
50dB	5	1	1	5	6	6
TOTALS	9	2	3	10		

The effect of task was significant at the 0.05 level while noise did not have a significant effect on high glucose diabetic's subjective report of stress.

The results showed that task performance was reported to be stressful by all groups with the exception of the glucose preloaded controls who either did not feel stressed, did not recognise that they felt stressed or did not report that they felt stressed. This apparent lack of stress experienced with task performance was not reflected in improved performance in comparison with the other groups, nor was it reflected in the blood glucose changes. It is interesting that 5 of the 8 glucose preloaded subjects reported feeling stressed in the quiet, no task condition. It is possible that glucose preloading induces a simulated form of adrenalin reaction which may be perceived as stressful in the absence of any external stressor in the form of noise or task. The effects of glucose preloading appeared to be considerably more complex than previous studies have suggested. No measures of subjective experience were attempted in the earlier studies nor were different amounts of glucose preloading compared. Such a study is presented in Chapter 6 with further discussion of the physiological and behavioural effects of, and subjective experience associated with glucose preloading.

It was suggested earlier that experience of the task itself as stressful may be obscuring any effects of noise as a stressor. The above results suggested that the task was found to be more stressful than the noise. It was therefore possible that any noise effects on performance were over-ridden by stress due to difficulties inherent in the task itself. Task inherent stress was not a source of stress that was originally anticipated and no behavioural measures common to both task and no task conditions were available for comparison.

Although task inherent stress might have obscured any effects of noise on performance, noise effects on blood glucose levels were significant. The blood glucose changes may reflect adaptations serving to reduce the experience of noise stress. If such adaptations to task stress did occur they were insufficient to prevent the experience of stress. A mechanism is suggested in Chapter 6 to account for this relationship between noise, blood glucose change, performance and subjective experience of stress.

3.5. Time Estimation

The duration of the task period was estimated shortly after the session by means of the questionnaire described in Section 6, Chapter 2. Studies measuring duration were considered in this section in relation to Ornstein's 'storage size metaphor'.

It was suggested that duration estimates might reflect the degree of arousal, with longer estimates associated with increased arousal. It was originally thought that subjects reporting the task period to be stressful would give longer estimates of duration; stress and arousal were thought to be associated states. However, work by Mackay, Cox and others (Mackay and colleagues, in press; Burrows, Cox and Simpson, 1977; Cox, 1978) towards the development of the Stress-Arousal Checklist (Chapter 2 Section 6.2) suggested that stress and arousal were independent factors. The present results suggested that there was some relationship between stress reports and time estimation but not in the expected direction.

Time Estimation: Results and Discussion

Table 25 presents the mean estimates of duration for the 15 minute task period for each of the four experimental groups. The number of subjects in each group is noted in parentheses. The general tendency to underestimate time is apparent in all groups.

Table 25: Time Estimation Mean Values

	NO GLUCOSE CONTROLS			GLUCOSE PRELOADED CONTROLS		
	Task	No Task	Totals	Task	No Task	Totals
80dB	10.0 (N=8)	13.2 (8)	11.6	11.8 (8)	15.6 (8)	13.7
50dB	9.8 (8)	11.4 (8)	10.6	7.7 (8)	9.6 (8)	8.7
MEAN TOTALS	9.9	12.3	11.1	9.8	12.6	11.2

	LOW GLUCOSE DIABETICS			HIGH GLUCOSE DIABETICS		
	Task	No Task	Totals	Task	No Task	Totals
80dB	7.5 (N=5)	8.3 (3)	7.9	10.3 (5)	8.7 (7)	9.4
50dB	11.6 (4)	11.8 (4)	11.7	7.0 (6)	11.8 (6)	9.4
MEAN TOTALS	9.38	10.3	9.8	8.5	10.1	9.4

Analysis of variance comparing the two control groups showed that both task and noise significantly affected estimates of duration. There was no significant difference between the two groups in terms of their estimates. (Table 26).

Table 26: Summary of Analysis of Variance of Time Estimations by Control Groups

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A G/NG Controls	0.1406	1	0.1406	0.005	56	n.s.
B Task	110.2500	1	110.2500	4.191	56	0.04533*
C Noise	147.0156	1	147.0156	5.589	56	0.02156*
AB	1.0000	1	1.0000	0.038	56	n.s.
AC	66.0156	1	66.0156	2.510	56	0.11877
BC	12.2500	1	12.2500	0.466	56	n.s.
ABC	0.0625	1	0.0625	0.002	56	n.s.
Within	1473.0000	56	1473.0000			
Total	1809.7344	63	1809.7344			

Task significantly decreased time estimation compared with the no task condition, while noise significantly increased time estimation. Glucose preloading had little effect on time estimation.

All four experimental groups were compared with analysis of variance (Table 27).

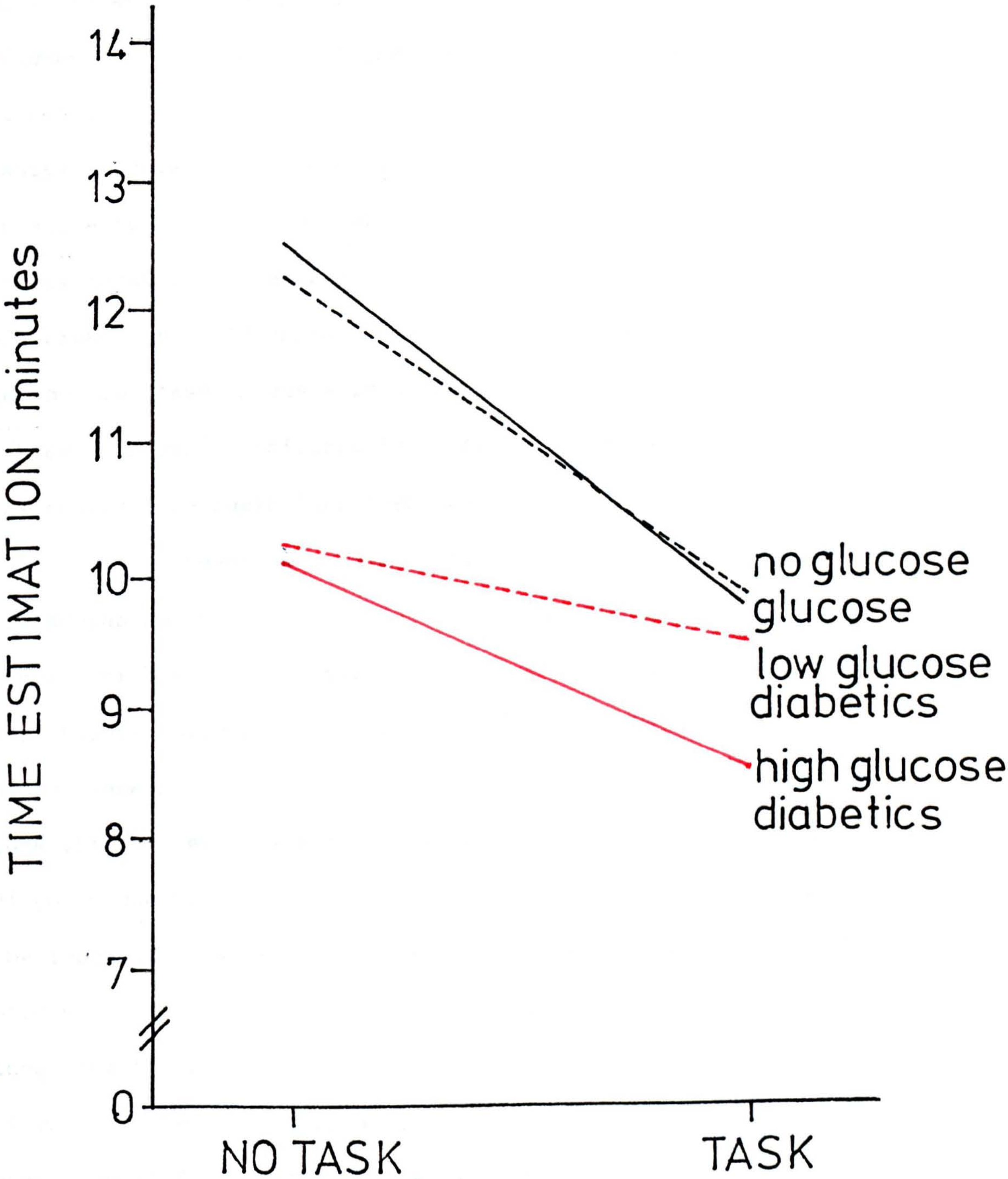
Table 27: Summary of Analysis of Variance of Time Estimation Scores for the Four Experimental Groups

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A 4 GROUPS	73.5289	3	24.5096	1.082	88	0.36089
B TASK	63.3935	1	63.3935	2.799	88	0.09786
C NOISE	14.9488	1	14.9488	0.660	88	n.s.
AB	24.3207	3	8.1069	0.358	88	n.s.
AC	228.225	3	76.0742	3.359	88	0.02234*
BC	0.2426	1	0.2426	0.011	88	n.s.
ABC	45.1136	3	15.0379	0.664	88	n.s.
WITHIN	1992.8661	88	22.6462			
TOTAL	2442.6366	103				

Figure 24 shows the effect of task on time estimation. The duration of time was estimated to be shorter by all four groups when working at the task: longer when they were just sitting at the apparatus. Referring to Ornstein's 'storage size' theory of time estimation, the shorter estimates given while performing the task may be due to the 15 minutes period being perceived as one 'chunk' of information when attention was directed solely towards the task. While sitting at the apparatus without working, subjects may have directed their attention to a variety of stimuli in the cubicle or to their own personal thoughts which might be

Figure 24: The Effects of Task Performance on Time Estimations in the 4 Experimental Groups

Time estimations from all subject groups tended to be shorter after performing the task ($p=0.09786$)


TIME ESTIMATION minutes
14
13
12
11
10
9
8
7
0
NO TASK
TASK
no glucose
glucose
low glucose
diabetics
high glucose
diabetics

stored as a number of information 'chunks' leading to an impression of a longer time period. There was no reason to suppose, however, that subjects were more aroused by the no task condition than by the task condition. If time estimation did reflect arousal levels it also appeared to be affected by other factors: in particular it might have been influenced by the nature of the task that the subject had been occupied with.

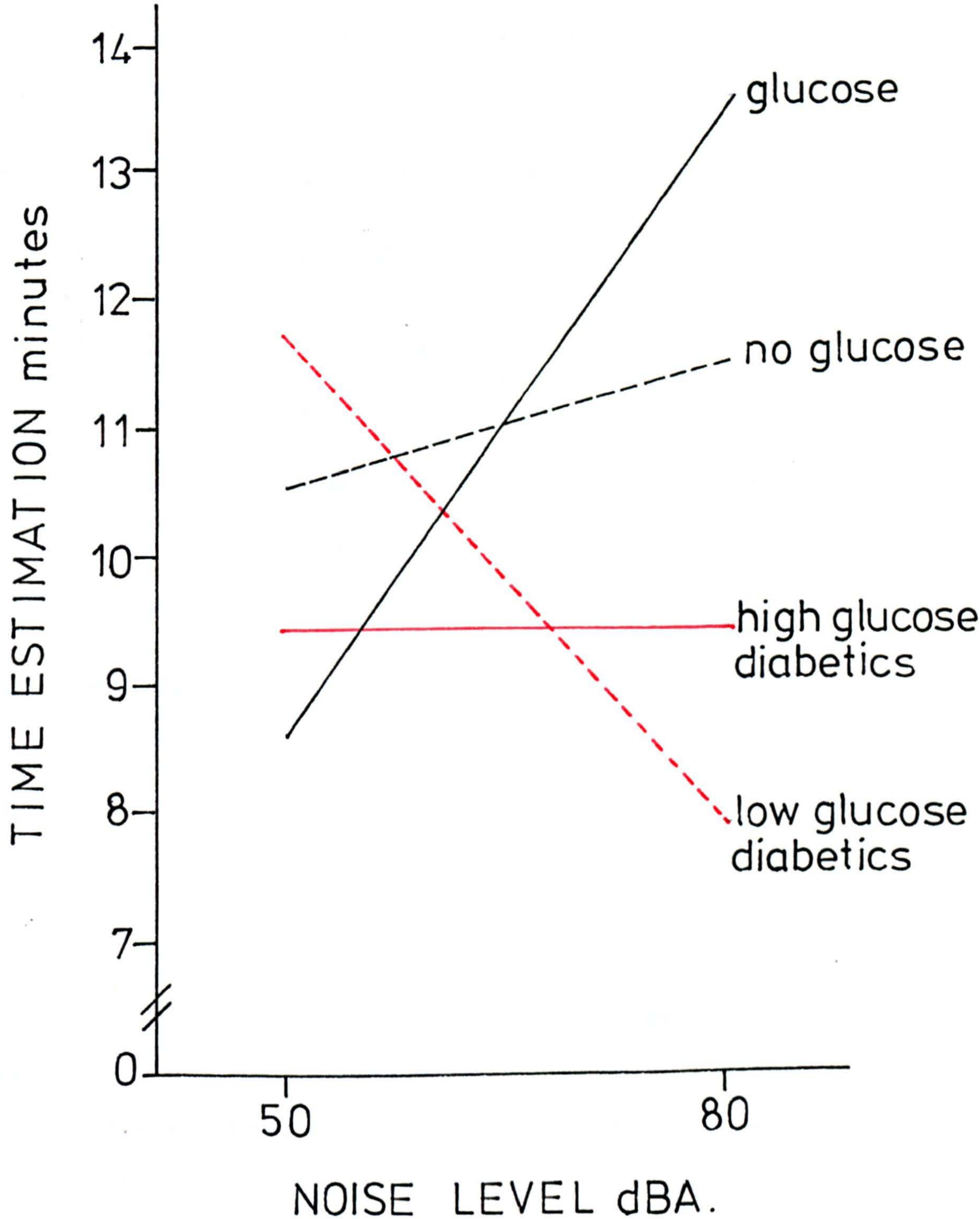
Noise produced significant increases in time estimation by non-diabetic subjects while the diabetic groups produced shorter time estimates in the noisy condition (Figure 25). If time estimation is related to the level of arousal it would appear that noise increased arousal in non-diabetics but decreased arousal in diabetics.

These data were considered in relation to performance measures. Diabetics scored more deviations than the controls particularly in the noisy condition. However correlations between time estimations and deviation scores suggested that those diabetics giving shorter time estimations, which may be associated with lowered arousal levels, scored fewer deviations, (high glucose diabetics, $r= 0.39$, $N=11$, n.s.: low glucose diabetics, $r= 0.19$, $N=9$, n.s.). The controls scored fewer deviations with longer time estimations (suggesting that they were more aroused) (no glucose, $r= -0.23$, $N=16$, n.s.: glucose, $r= -0.14$, $N=16$, n.s.). It may be suggested that the diabetics were more aroused initially than the controls and that this heightened arousal led them to make more deviations from the light.

A more direct measure of arousal such as the arousal scale on the Stress Arousal Checklist would be required to confirm these suggestions. This measure of arousal was used in later work which is reported in Chapter 6 of this thesis.

Figure 25: The Effects of Noise on Time Estimations by Each of the 4 Experimental Groups

The interaction between noise level and experimental group was significant (p=0.02234*)



14
13
12
11
10
9
8
7
0
TIME ESTIMATION minutes
glucose
no glucose
high glucose
diabetics
low glucose
diabetics
50
80
NOISE LEVEL dBA.

3.6. Personality Measures

Extraversion (E) and Neuroticism (N) scores were obtained for all subjects and were considered in relation to the other dependent variables using multiple correlations.

Results and Discussion

Means and standard deviations of E and N scores for each of the four groups are presented in Table 28.

Table 28: Means and standard deviations of E and N scores

	HIGH GLUCOSE DIABETICS		LOW GLUCOSE DIABETICS		GLUCOSE CONTROLS		NO GLUCOSE CONTROLS	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
E	24.17	10.24	22.63	8.94	25.41	8.07	27.13	9.30
N	17.92	10.41	24.87	10.07	23.03	9.80	20.97	11.20

The means and standard deviations of Eysenck's (1959) standardisation groups are given in Table 29 for a 'Normal English quota sample' and for a 'Psychosomatic hospital patient group'

Table 29: Means and Standard Deviations of E and N scores from Eysenck (1959)

	'Normal English sample'		'Psychosomatic sample'	
	Mean	S.D.	Mean	S.D.
E	24.91	9.71	25.38	9.33
N	19.89	11.02	35.69	10.89

The E and N scores of the control groups are very similar to those of Eysenck's 'Normal English sample'.

The observation that high glucose diabetics scored higher on E but lower on N than the low glucose diabetics was of significance in relation to other findings discussed below. Extraversion scores correlated positively with initial blood glucose levels for diabetic subjects. This correlation was highly significant for the high glucose diabetics ($r=0.61$, $N=24$, $p<0.01$**) but not significant for the low glucose diabetics ($r=0.30$, $N=16$, n.s.). The control subjects showed no relationship between E and initial blood glucose levels, (glucose controls $r=0.01$, $N=32$, n.s.: no glucose controls $r= -0.04$, $N=32$, n.s.).

Since the high glucose diabetics had higher E scores and lower N scores it was likely that their very high blood glucose levels were due to their more sociable life styles and tendency to worry less. Such a combination of traits might well lead to a more casual approach to diabetic management. The low glucose diabetics having lower E and higher N scores were probably better able to accept the restrictions of a diabetic regime and would be more anxious to maintain good control of their condition. It seemed that a stable (rather than neurotic) attitude towards life was maladaptive for diabetics. The importance of careful treatment and dietary control needed to be emphasised more strongly to stable, extraverted diabetics. The low glucose diabetics appeared to manage their disorder adequately. To over emphasise the danger of inadequate control to the more introverted and neurotic diabetics might produce excessive anxiety about their disorder.

Certain diabetics who had a good understanding and intelligent approach towards the management of their disorder might benefit from a more flexible approach to their disorder. Such patients could, perhaps be encouraged to take more responsibility for the control of their condition and to alter the amount of insulin and dietary intake to suit inevitable changes in their life styles which might otherwise impair their diabetic control. It is suggested that a more individual approach to diabetic management may lead to more satisfactory control of the disorder.

Further evidence for the relationship between personality measures and management of diabetes was found in the correlations between weight and E scores. There were positive correlations between E and weight for both diabetic groups and the correlation was significant for the low glucose diabetics (high glucose diabetics, r= 0.30, N=24, n.s.: low glucose diabetics, r= 0.59, N=16, P<0.05*). It is likely that this correlation was due to inadequate dieting by extraverted diabetics who may find the restrictions on their diet more difficult to accept and cope with than introverted diabetics. There was no correlation between initial blood glucose levels and weight (high glucose diabetics, r=-0.05, n.s.: low glucose diabetics, r= -0.12, n.s.). These results suggested that the relationship between E and blood glucose was not directly due to their correlations with weight.

There was no evidence to suggest that E was related to body weight in the control subjects (glucose controls, r=0.14, n.s.: no glucose controls, r= 0.06 n.s.).

There tended to be a negative correlation between E and age which was significant in the high glucose diabetic group (r= -0.68, P<0.05*) and in the no glucose group of controls (r= -0.50, P<0.01**). There appeared to be a general tendency for people to socialise less as they became older, to be less impulsive and to be less inclined to seek stimulation. Eysenck made no reference to a relationship between E and age in the MPI manual (1959). Although he noted a significant trend for E to decline with age in the manual of the EPI (1964), he merely stated that 'the reasons for this are speculative'.

There was little evidence of any relationship between E, N and measures of performance or blood glucose changes during the task period. One notable exception was a significant correlation between E and deviation scores for the high glucose diabetics (r= 0.73,< P 0.05*). Low glucose diabetics showed a small negative correlation between these measures (r= -0.28, n.s.). The control groups also showed small negative correlations (glucose controls, r= -0.14 n.s.: no glucose controls, r= -0.39). It was tempting to speculate on the exception although it was accepted that among so many correlations, a significant result might be spurious. However, age and initial blood glucose levels also correlated significantly with deviation scores in the high glucose diabetic group (Age; r= -0.81 P<0.01**: BSI: r= -0.64, P<0.05*). No such significant correlations were found with low glucose diabetics or with the control groups. It therefore appeared that in high glucose diabetics, deviation scores were higher among extraverted diabetics. E decreased with age and BSI and deviation scores also decreased with age. The high glucose diabetic subjects tended to be younger (mean age 37.8 years) than the low glucose diabetics (mean age 44.6 years) and younger than the control subjects (glucose controls; mean age 42.0: no glucose controls: mean age 43.8 years). The younger diabetics tended to have higher blood glucose levels and were more extraverted than the older groups. The young, extraverted, high glucose diabetics also tended to score more deviations at the experimental task. It appeared to be a combination of these characteristics that associated them with higher deviation scores since deviations were not significantly correlated with these variables in the other groups. It was possible that these characteristics were associated with heightened arousal levels which in turn were associated with more deviations from the light.

4. Laboratory Studies: Summary and Conclusions

The first experiment reported in this chapter was a single subject diabetic study examining the effects of noise and task on blood glucose changes, and the effects of noise on performance. The subject was a stable, extraverted insulin requiring male diabetic student who sustained considerable variation in his blood glucose levels as a result of a rather casual approach to the management of his disorder. There were no significant effects of noise or task on blood glucose changes. Performance measures were influenced more by practice than by the presence or absence of noisy conditions. The 80dB noise condition initially impaired performance but the subject soon habituated to the noisy condition and no overall effects of noise on performance measures were observed.

The second experiment with insulin requiring diabetic males investigated the effects of noise on task acquisition in a multi-subject study. It was hoped that diabetics from the out-patient clinic would have more satisfactory control of their blood glucose levels. However, it was apparent that more than half of the subjects had blood glucose levels which exceeded the renal threshold (the high glucose diabetics) and under noisy conditions these subjects demonstrated significantly different blood glucose changes from the low glucose diabetics. The high glucose group of diabetics was characterised by more subjects with stable, extraverted personality styles similar to that of the subject in the single-subject study.

The two diabetic groups were compared with two control groups of non-diabetic subjects. One of the non-diabetic groups was preloaded with 30gm. glucose.

The first hypothesis was not upheld by the results. There was no evidence that the glucose preloaded group obtained higher time on target scores in the noisy condition than in the quiet condition. The related hypothesis, that the glucose group would show greater decreases in blood glucose in the noisy condition when performance was expected to improve, was not supported. Larger decreases in blood glucose were, however, associated with the slightly improved performance which occurred in the quiet condition. It was suggested that the findings of the present study differed from those of Simpson, Cox and Rothschild (1974) because of differences in the experimental situation and populations, in particular differences in amount of glucose preloading. The titration experiment described in Chapter 6 was designed to test this hypothesis.

It was hypothesised from Vandenberg's studies of diabetics' blood glucose changes under stress that the diabetic subjects in the present study would show greater decreases in blood glucose levels in the noisy condition; it was further hypothesised that this decrease would be associated with improved performance. The low glucose diabetics showed such a pattern of results. When working under 80dB noise their blood glucose levels decreased more than with 50dB noise. However, when they were not working at the task but were in the noisy condition, blood glucose levels tended to rise slightly. The greater fall in blood glucose levels was associated with improved time on target scores but this association was not statistically significant.

High glucose diabetics responded quite differently. Significant increases in blood glucose levels occurred when working in the noisy condition. It was suggested that glucagon secretion in response to noise acted to mobilise glucose resources. In the high glucose diabetics, it was likely that no insulin was available to utilise the glucagon mobilised glucose or to control the secretion of glucagon from the pancreatic alpha cells which require the presence of insulin in order to detect the surrounding blood glucose level. The glucagon rise in response to stress, it was suggested, would be unimpeded in such poorly controlled patients, resulting in a maladaptive response to stressful conditions. Exposure to stress may thus exaggerate the difficulties of diabetic control in such patients.

While the low glucose diabetics differed little from the no glucose controls in terms of their blodd glucose changes, the high glucose diabetics showed a significantly different response from the other three groups. There was, however, surprisingly little difference in the performance of the four groups. Diabetics scored more deviations than the controls but time on target scores were similar. It was suggested that frequent deviations from the target might be associated with the high incidence of neuropathy found among insulin requiring diabetics. Alternatively it was suggested from the time estimation data that the diabetics might have been more aroused than the controls and this heightened arousal may have led to more deviations from the light. Deviation scores were lower in those diabetics who gave shorter duration estimates which might indicate lowered arousal. These speculations may only be confirmed with more reliable measures of arousal which were not employed at the start of this study. The Stress Arousal Checklist was used in later studies reported in Chapter 6.

The Subjective experience of stress data indicated that the task itself was reported to be stressful by most of the subjects. It was suggested that this task inherent stress was greater in the present study than in the previous experiments by Cox and Simpson because of differences in the ergonomics of the task situation which increased the difficulty of the task. However, subjective estimates were not measured in the earlier work by Cox and Simpson.

Task inherent stress was reported to be more stressful than the stress induced by noise in the present study. The experience of the task itself as stressful may have obscured significant effects of noise on performance in this study.

Personality measures were shown to be related to blood glucose control in diabetics. Young, extraverted diabetics had the highest blood glucose levels. These subjects also showed the unusual blood glucose response to noise.

It was suggested that greater emphasis should be put on the need for stricter control of treatment for such patients. It might, however, be more appropriate for certain patients with a good understanding of the principles of diabetic control, to encourage a more flexible approach to their treatment regime. Such an approach might be particularly appropriate for those diabetics leading irregular lives involving, for example, changes in the pressure of work or changes in working hours. An obvious example is that of the accountant who is under greater pressure towards the end of the tax year. To encourage such patients to adapt the amount of insulin and dietary intake within reasonable limits to cope with environmental and personal changes might result in more satisfactory management of their condition.

CHAPTER 4.

DIABETES MELLITUS: STUDIES OF LIFE EVENTS.

The results of the laboratory studies on diabetic subjects suggested that diabetics with poor control of their disorder reacted to noise stress with marked increases in their already elevated blood glucose levels. It appeared that their neuroendocrine activity in response to stress further disrupted the fragile balance of glucose homeostasis. It was reported in Chapter 3 that stable extraverted diabetics experienced greater difficulty in maintaining satisfactory control of their condition and that these subjects demonstrated an overall rise in blood glucose levels in response to stress.

It was thought probable that the experience of life events would have disturbing effects on diabetic control similar to those shown in response to noise stress: some evidence for this suggestion was presented in Chapter 1. The following study was designed to investigate the relationship between physiological measures of diabetic control and the experience of life events over a twelve month period.

1. Experiment 3: The Effects of Life Events on the Management of Diabetes.

In this experiment, retrospective measures of life change experience were compared with physiological measures of diabetic control over a twelve month period. It was hypothesised that the experience of stress in the form of life change would lead to problems in the management of diabetes which would be reflected in poorly controlled blood glucose levels, episodes of glycosuria and changes in treatment requirements. Diabetics' ratings of life events were compared with control subjects' ratings to examine any differences in reported experience of upset caused by life events and in the amount of adjustment that such events are supposed to entail.

1.1. Method

This study was carried out with the assistance of Ian Minto, a final year psychology student who graduated from the University of Nottingham in 1976.

Subjects 114 diabetic patients from the outpatient clinic at the Nottingham City Hospital participated in this study. The subjects were divided by sex and treatment into four groups (see Table 30)

Table 30: Numbers of diabetic subjects participating in the study

		SEX	
		Male	Female
TREATMENT	Insulin	45	32
	Tablet	18	19

The number of diabetics who were treated by means of diet alone was too small to allow this group to be included in the analysis.

The diabetic subjects in this experiment ranged in age from 16 to 81 years and had a variety of occupational backgrounds; the sample included all categories of workers from professional through to unskilled as well as housewives and those who had retired from work.

Sixty control subjects were studied: 30 males and 30 females. The control sample was drawn from the hospital staff and included porters, cleaners and laboratory staff as well as doctors and nurses. In addition, adult education students formed a substantial proportion of the control group in order to balance for the number of housewives and retired people in the diabetic population. The control subjects ranged in age from 18 to 67 years.

The Questionnaire An information sheet was used to collect details of name, sex, age, height, weight, occupation and treatment. This was followed by an instruction sheet an example of which is included in the Appendix. Instructions were given for completing the questionnaire either for the concept of 'upsetting' or for 'adjustment'. The Life Events Inventory was rated for 'upsetting' or 'adjustment' using analogue scales, (see Appendix). At the end of the list of life events, subjects were asked to go back over the list and to tick those events they had experienced during the past year. Finally, subjects were asked to complete a Maudsley Personality Inventory, (Chapter 2, Section 5).

The questionnaire for control subjects contained a modified information sheet including details of name, sex, age, height, weight, occupation and details of any illness that had occurred during the previous year. The instruction sheet, Life Events Inventory and MPI were the same for diabetic and control subjects.

Procedure The experimenter talked to the diabetic subjects individually while they waited in the outpatient clinic. The nature of the questionnaire was briefly described. The majority of the patients agreed to participate. The experimenter went through the questionnaire with each subject to ensure that the requirements were understood. Most patients were then left to read through the written instructions and to complete the booklet. Further explanation was given where necessary. Some of the patients with poor eyesight or limited reading ability were able to complete the form by reporting verbally to the experimenter. However, this procedure was time consuming and could not be arranged in every case.

The questionnaires were distributed and collected during the clinic sessions which were held between 1400 and 1700 hours. After giving blood samples in the hospital laboratory the subjects waited while the samples were analysed. Most patients had sufficient time to complete the questionnaires before their appointments with the doctors. Some completed their questionnaires after the doctors' interviews, before leaving the hospital.

Information concerning the patients' treatment and condition was gathered from the patients' medical records.

Questionnaires were distributed to control subjects in the hospital and to subjects in the adult education classes. The experimenter explained the instructions either in individual or group sessions according to the circumstances.

Data Analysis The possibility of differences dependent upon the sex of the subjects was considered as well as differences due to the two versions of the questionnaire using the concepts 'upsetting' or 'adjustment'.

The data from the diabetic subjects were factor analysed with principal component analysis (leaving unity in the diagonals) using varimax rotation procedure.

The dependent variables for the insulin treated groups were as follows:

a. Mean rating of all life change items.

b. Sum of ratings of experienced events.

c. Number of experienced events.

d. Age.

e. Neuroticism.

f. Extraversion.

g. Blood glucose level on the day.

h. Mean blood glucose level (over 12 month period).

i. Variance of blood glucose levels.

j. Urine glucose (number of times present).

k. Weight (difference between actual and ideal weight).

l. Number of changes of insulin prescription.

m. Number of insulin units taken (on day).

n. Number of clinic attendances (over 12 month period).

Variables for the tablet treated groups were as above with the exception of the insulin data (l and m). The number of changes of tablet prescription was substituted for insulin changes. For the purpose of analysis '0's replaced insulin unit data.

The data from all 114 subjects were factor analysed. Separate analyses were carried out to examine differences due to sex, treatment, and type of questionnaire (upsetting or adjustment). When the results from subjects' rating for upsetting were combined for analysis with the results of subjects' rating for adjustment data dependent upon these variables were excluded. Thus mean ratings of the life change items and the sum of ratings of experienced events were not included in these analyses.

1.2. Factor Analysis: Results and Discussion

Four overall factors were obtained from the combined data (Eigen values >1). The factors are presented below with those variables which loaded highly (>0.5) on each factor. Variables in parentheses are those which did not quite reach the level of 0.5. Negatively correlated variables are designated as such (-).

Factor 1

Number of experienced events

Urine Glucose

prescription changes

Number of attendances

'Disturbance measures'.

Factor 2

Blood glucose on day

Mean blood glucose

Variance of blood glucose

(Urine glucose)

'Glucose measures'.

Factor 3

N — 'Neuroticism'

Weight

Factor 4

Age (-)

E — 'Extraversion'

Factor 1 showed that the number of life events experienced during the year was positively related to the number of incidences of glycosuria, changes of insulin or tablet prescription and the number of clinic attendances. The relationship of these variables provided support for the hypothesis that the occurrence of life events is associated with difficulties in diabetic management. This factor has been labelled 'disturbance measures'.

The factor analysis suggested that the experience of life events was not associated with measures of blood glucose which loaded on a separate factor. Rather the disruptive effects of life events were reflected in the spillage of glucose into the urine. The measure of urine glucose loaded almost as heavily on Factor 2 (factor score = 0.48838) as on Factor 1 (factor score = 0.50611). Higher blood glucose levels were associated with greater incidence of glycosuria. Increases in blood glucose associated with life events appeared to be channelled into the urine.

Factor 3 consisted of the variables N and weight. The more neurotic the diabetic patient, the heavier was their body weight.

Age was negatively associated with E to form Factor 4. Extraversion was not found to be significantly related to measures of diabetic control. In Chapter 3 it was reported that stable extraverted insulin requiring diabetics tended to have higher blood glucose levels. However, the present sample was drawn from tablet as well as insulin requiring diabetics and female diabetics were also included. The reasons for the differences between the earlier findings and the findings from the wider sample presented here are considered in the discussion of the results of the analysis of variance of factor 4 scores.

1.3. Analyses of Variance: Results and Discussion

In order to examine quantitative differences between sex and treatment groups, factor scores were computed for each subject for each of the four factors which emerged from the overall factor analysis of all 114 subjects combined. Two way analyses of variance were then carried out on each of the four sets of factor scores. Upsetting and Adjustment data were combined since in the overall factor analysis, variables which depended on the Upsetting/adjustment distinction were excluded. Sex and treatment differences were examined.

Factor 1: Disturbance Measures

Analysis of variance showed that differences between the sexes were not significant. However, insulin and tablet groups differed significantly in the extent to which their scores loaded on this factor. Table 31 summarises the results of the analysis of variance.

Table 31: Summary of Analysis of Variance of Factor 1 Scores

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Sex	0.0436	1	0.0436	0.049	110	n.s.
B Treatment	12.9157	1	12.9157	14.386	110	0.00024***
AB	1.5226	1	1.5226	1.696	110	0.19554
Within	98.7609	110	0.8978			
Total	113.2428	113				

Observation of the raw data means showed that insulin requiring diabetics reported that they had experienced life change slightly more often than tablet treated diabetics. They also manifested a greater incidence of glycosuria, their prescriptions were changed more frequently and they attended the clinic more often than the tablet treated diabetics. Table 32 presents the mean values of each variable.

Table 32: Mean Factor Scores for Variables Loading on Factor 1

	Insulin		Tablet	
	Males	Females	Males	Females
No. Exp. Events	2.2	2.3	2.9	1.1
Urine Glucose	2.3	2.8	1.7	1.2
Prescription Change	1.7	2.4	0.7	0.5
No. Attendances	4.6	5.1	3.6	3.8

Although the insulin requiring diabetics did not differ greatly from the tablet treated diabetics in terms of the number of events they reported, they were more prone to the physiological disruption of their diabetic control which was associated with life change.

Factor 2: Glucose Measures

There were no significant differences in glucose measures due either to sex (F = 2.333, DF 1,110, P = 0.12949, n.s.) or to treatment (F = 2.208, DF 1,110, P = 0.14016, n.s.). Data means are presented in table 33.

Table 33: Mean Factor Scores for Variables Loading on Factor 2

	Insulin		Tablet	
	males	females	males	females
Blood glucose means	202.8	224.7	218.7	197.6
Blood glucose var.	68.6	77.8	57.7	38.3
Blood glucose on day	119.0	233.2	216.2	217.9
Urine glucose	2.3	2.8	1.2	1.7

Differences due to treatment were reflected in urine glucose measures and blood glucose variability with insulin requiring diabetics showing a higher incidence of glycosuria and greater variability in blood glucose levels. Measures of absolute blood glucose level were not affected by treatment differences. Female insulin requiring diabetics tended to have higher scores on all blood glucose measures and greater incidence of glycosuria than the male insulin requiring diabetics. No such sex differences were apparent in the tablet treated groups.

Mean blood glucose levels for all groups exceeded the normal renal threshold. The measure of physiological disturbance which was associated with life change was the incidence of glycosuria rather than the measures of blood glucose. Any further increase in the already high blood glucose levels was registered as greater spillage of glucose into the urine.

Factor 3: Neuroticism and Weight

There was a significant effect of sex on factor 3 scores but no significant effect of treatment (Table 34).

Table 34: Summary of Analysis of Variance of Factor 3 Scores

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Sex	14.0283	1	14.0283	15.636	110	0.0001***
B Treatment	0.6549	1	0.6549	0.730	110	n.s.
AB	1.5235	1	1.5235	1.698	110	0.19525
Within	98.6868	110	0.8972			
Total	114.8935	113				

Mean scores for weight and N are given in Table 35 for each of the four groups.

Table 35: Mean Factor Scores for Variables Loading on Factor 3

	Insulin		Tablet	
	males	females	males	females
N	21.6	29.5	17.2	28.5
Weight	1.8	13.6	4.9	19.8

Female diabetics had higher scores for Neuroticism and were more overweight than the male diabetics. The difference was most apparent in the tablet treated diabetics but also applied to the insulin treated groups. The reason why female diabetics were more neurotic and overweight than males was unclear. Furthermore the association between N and weight was not anticipated. It could be that the danger of becoming hypoglycaemic caused excessive anxiety in the more neurotic diabetics. They may eat more in order to ensure that hypoglycaemia (which is probably the most worrying problem for diabetics) will not occur. There was no evidence from the analysis of Factor 2 scores to suggest that female diabetics had higher blood glucose levels than males although they did experience more occurrences of glycosuria which, in overweight diabetics, would reflect excessive food intake.

Factor 4: Extraversion and Age

There was some effect of sex on the scores for this factor but little effect of treatment, (Table 36).

Table 36: Summary of Analysis of Variance of Factor 4 scores

SOURCE	SUM OF SQUARES	DFI	VAR. EST.	F	DF2	P
A Sex	2.9803	1	2.9803	3.052	110	0.08345
B Treatment	1.9797	1	1.9797	2.027	110	0.15735
AB	1.2624	1	1.2624	1.293	110	0.25803
Within	107.4295	110	0.9766			
Total	113.6520	113				

Observation of data means showed that the male population tended to be slightly younger than the female population and the male population was also more extraverted (Table 37).

Table 37: Mean Factor Scores for Variables Loading on Factor 4

	Insulin		Tablet	
	males	females	males	females
Age	39.2	41.6	53.6	56.4
E	24.9	24.2	29.3	22.7

The present data did not support the finding reported in Chapter 3 that Extraversion scores were positively correlated with blood glucose levels. However, the high correlation found in that previous experiment was derived from the analysis of the group of high blood glucose diabetics. The mean and standard deviation scores of the group of 24 high glucose diabetics studied (Chapter 3, Section 3) were considerably higher (mean 272.79; s.d. 100.64) than the on day blood glucose measures of the group of 45 male insulin requiring diabetics in the present study (mean 199.02; s.d. 92.0954). The relationship between E and blood glucose levels appeared to occuronly among those diabetics with extremely high blood glucose levels.

1.4. Comparison of Diabetic and Control Subjects'Ratings of Life Change

The ratings of life change by the diabetic subjects were compared with those of the control subjects. The three measures of life change, mean life change rating, sum of ratings of experienced events and number of experienced events, are considered in turn below.

Mean Rating of Life Change

Three way analysis of variance was used to compare mean ratings of upsetting and adjustment for male and female subjects from the three sample populations, insulin and tablet treated diabetics and the controls, (Table 38).

Table 38: Summary of Analysis of Variance for Mean Life Change Ratings

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Ups./Adj.	15.5206	1	15.5206	0.148	163	n.s.
B Male/Female	804.3312	1	804.3312	7.678	163	0.00624**
C Cont/Ins/Tab.	200.3305	2	100.1652	0.956	163	n.s.
AB	276.9649	1	276.9649	2.644	163	0.10588
AC	14.7380	2	7.3690	0.070	163	n.s.
BC	315.6916	2	157.8458	1.507	163	0.22468
ABC	54.7232	2	27.3616	0.261	163	n.s.
Within	17074.8599	163	104.7537			
Total	18757.1662	174				

The main difference between the scores was due to the sex difference: female subjects rated life change as more upsetting or as requiring more adjustment than male subjects. Figure 26 shows that the sex difference was most apparent for the control subjects and for the tablet treated diabetics but not for the insulin requiring diabetics. However the interaction between sex and treatment was not shown to be significant here.

Sum of Ratings of Experienced Life Change

Here the effects of treatment were more dramatic and the interaction between sex and treatment was highly significant, (Table 39).

Figure 26: Mean Life Change Ratings by diabetic and control subjects

The sex difference in ratings was highly significant ($P = 0.00624^{**}$)

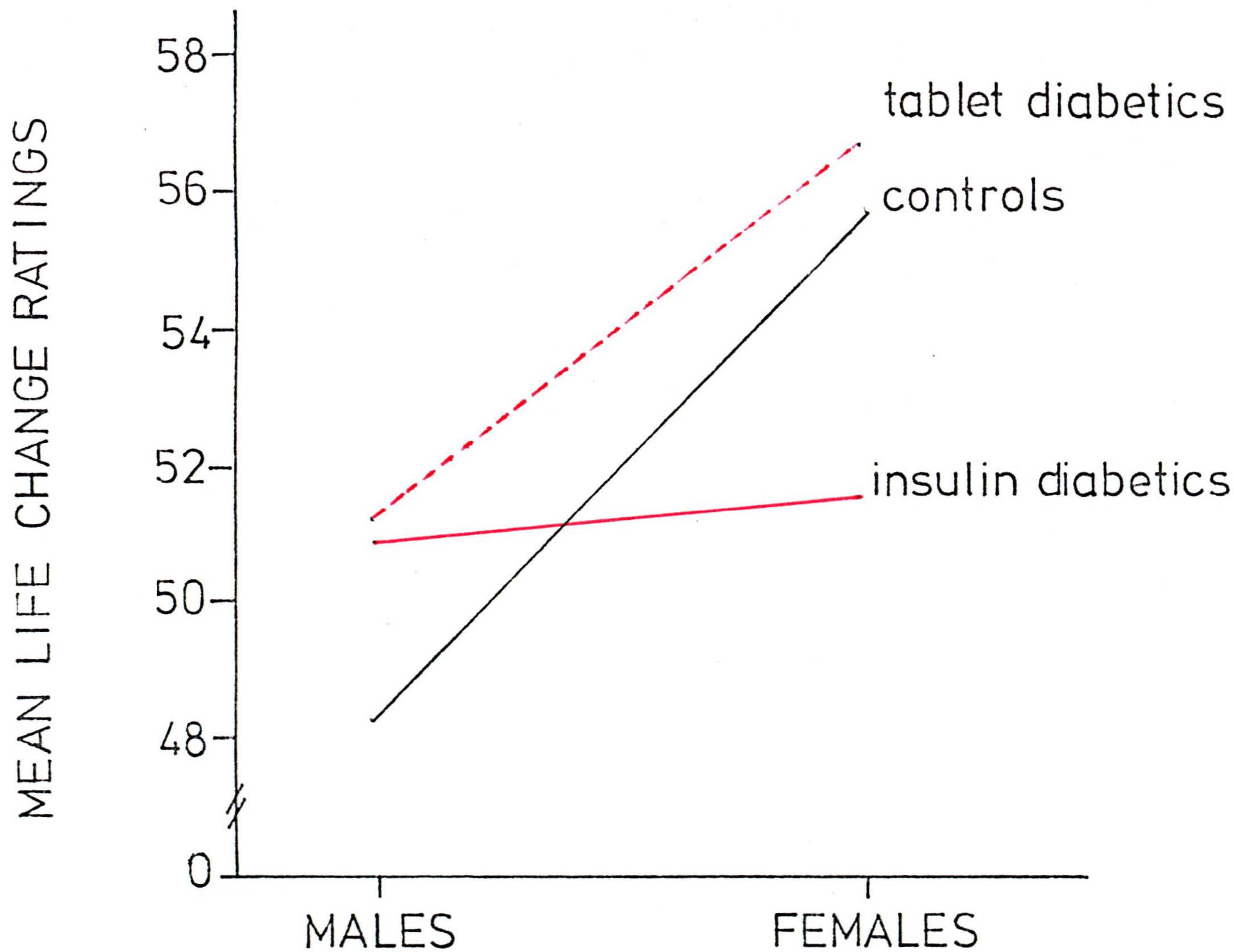

MEAN LIFE CHANGE RATINGS
58
56
54
52
50
48
0
tablet diabetics
controls
insulin diabetics
MALES
FEMALES

Table 39: Summary of Analysis of Variance of Sum of Ratings of Experienced Life Change

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Ups./Adjust.	12282.9766	1	12282.9766	0.401	163	n.s.
B Male/Female	69549.8077	1	69549.8077	2.270	163	0.13385
C Cont./Ins./Tab.	2.8634_{10}+05	2	1.4317_{10}+05	4.673	163	0.01064*
AB	20084.1120	1	20084.1120	0.655	163	n.s.
AC	24129.2866	2	12064.6433	0.394	163	n.s.
BC	3.2854_{10}+05	2	1.6427_{10}+05	5.361	163	0.00556**
ABC	1.0859_{10}+05	2	54293.8070	1.772	163	0.17326
Within	4.9945_{10}+06	163	30641.0093			
Total	5.8440_{10}+06	174				

There was little difference between the groups of male subjects in their ratings of experienced events. The interaction between sex and treatment resulted from differences in the ratings of the female groups. Female controls rated experienced events as considerably more upsetting and requiring more adjustment than males. The diabetic females on the other hand rated the events in a similar manner to the male groups (Figure 27). Ratings for upset and adjustment were similar for all groups.

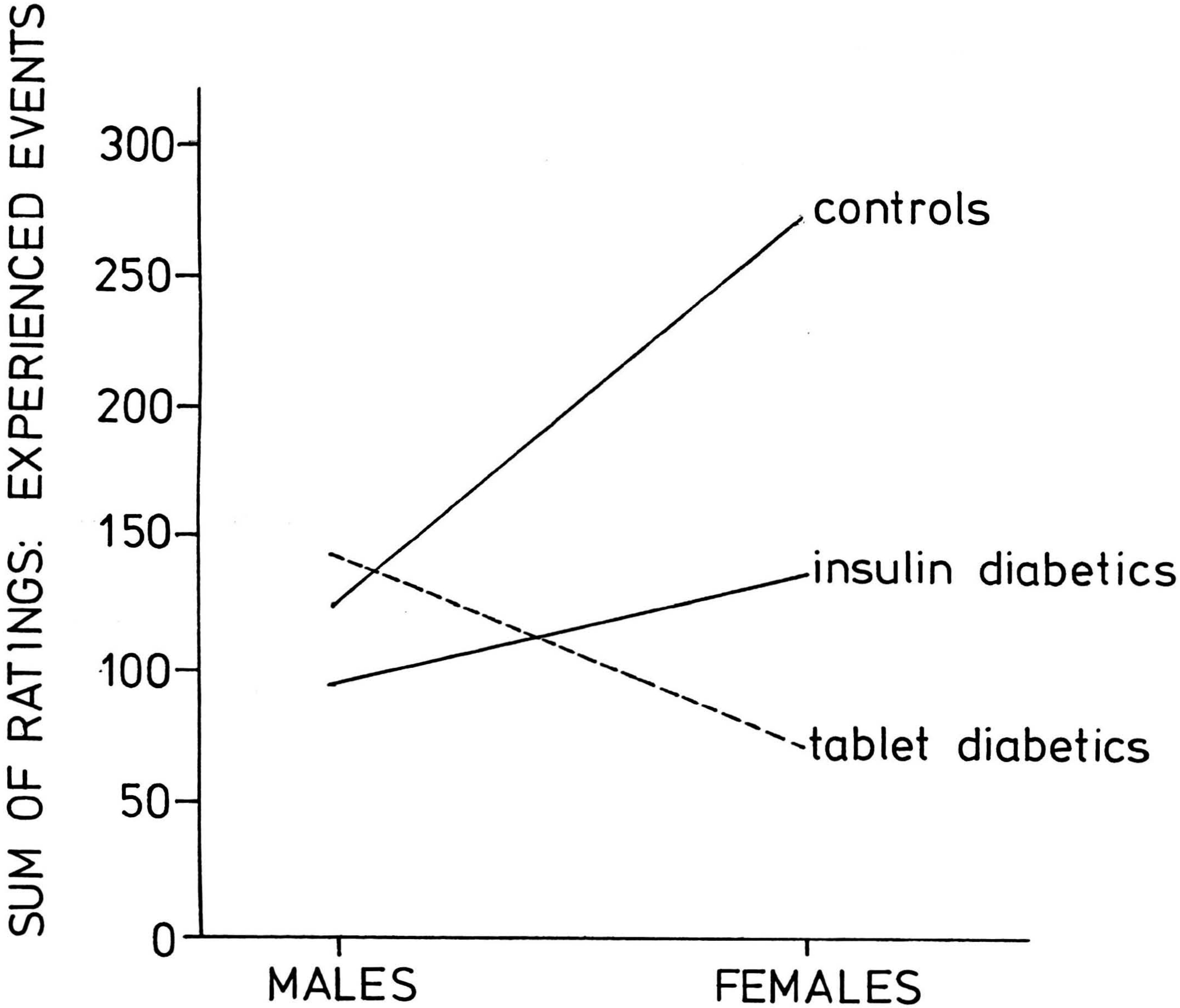
Number of Experienced Life Events

The different treatment groups were significantly associated with different numbers of reported life events. Treatment also interacted with sex producing a similar pattern of results to that obtained

Figure 27: Sum of ratings of experienced life events by diabetic groups and controls

The three groups differed significantly in these ratings ($P = 0.01064$*)

The interaction between experimental group and sex was highly significant ($P = 0.00556$**)


SUM OF RATINGS: EXPERIENCED EVENTS
300
250
200
150
100
50
0
MALES
FEMALES
controls
insulin diabetics
tablet diabetics

with the related measure of the sum of ratings of experienced life events, (Table 40).

Table 40: Summary of Analysis of Variance of Number of Experienced Life Events

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A Ups./Adjust.	2.2885	1	2.2885	0.200	163	n.s.
B Male/Female	1.1185	1	1.1185	0.098	163	n.s.
C Cont./Ins./Tab.	212.1062	2	106.0531	9.267	163	0.00015***
AB	20.7635	1	20.7635	1.814	163	0.17986
AC	21.8430	2	10.9215	0.954	163	n.s.
BC	63.6365	2	31.8183	2.780	163	0.06497
ABC	13.2289	2	6.6145	0.578	163	n.s.
Within	1865.4254	163	11.4443			
Total	2200.4105	174				

Subjects in the control groups reported significantly more life events than the diabetic subjects and this difference resulted again from differences between the female groups. The sex difference, apparent in the control groups, was not apparent in the diabetic groups. Indeed female tablet treated diabetics tended to report fewer life events than male tablet treated diabetics, (Figure 28).

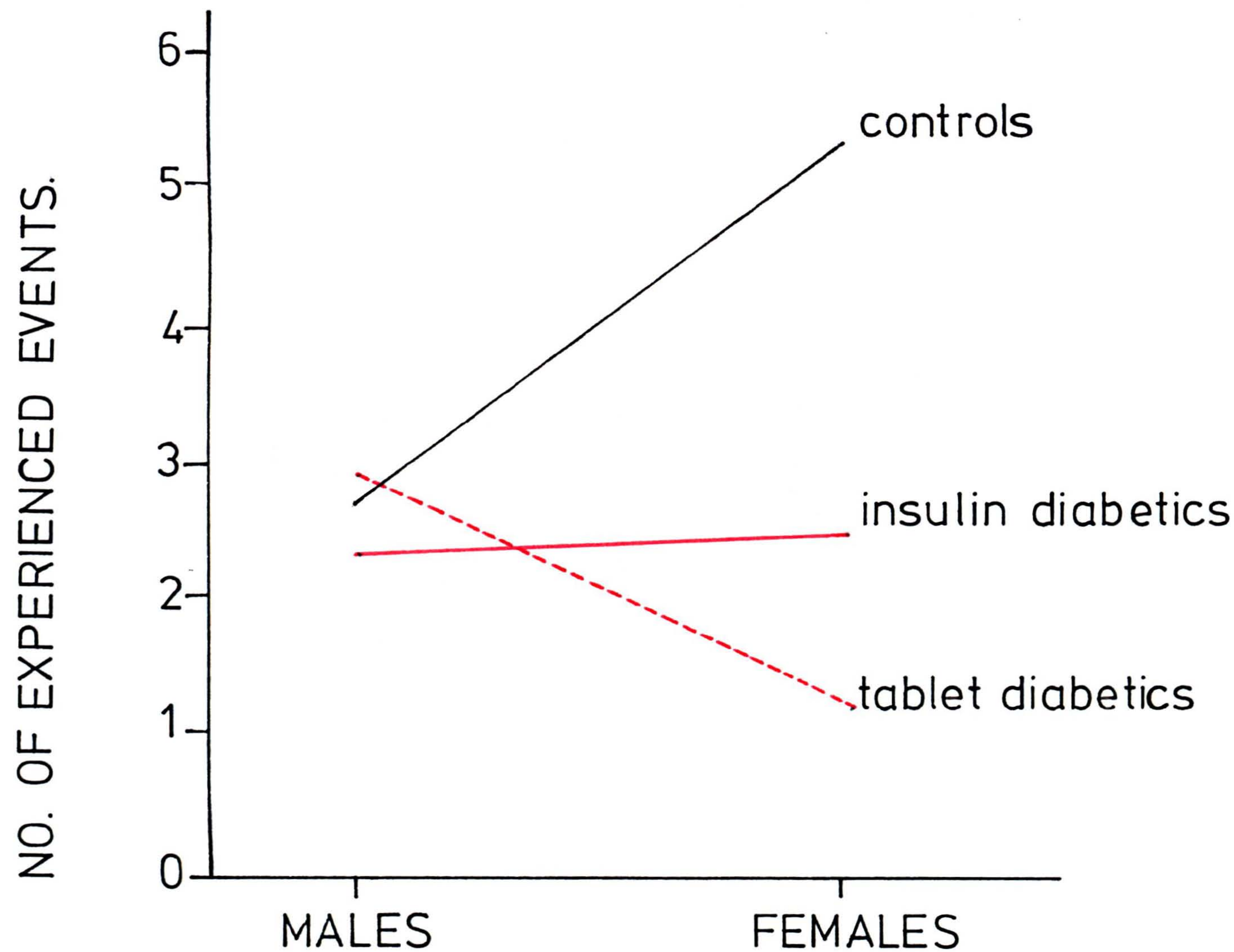
1.5. Discussion of Life Events' Ratings

The sex differences found among the control subjects, where

Figure 28: Number of experienced life events reported by the diabetic groups and the controls

The number of events reported differed significantly between the 3 groups ($P = 0.00015$***).

The interaction between experimental group and sex approached significance ($P = 0.06497$)


NO. OF EXPERIENCED EVENTS.
0
1
2
3
4
5
6
controls
insulin diabetics
tablet diabetics
MALES
FEMALES

females rated life events as more upsetting and requiring more adjustment and reported more experienced life events than males, are interesting in relation to the findings of other researchers who have observed sex differences in response to stress. Frankenhaeuser, Johansson and their colleagues studied sex differences in adrenalin excretion under stressful conditions and found that women, unlike men, showed little increase in adrenalin excretion under stress, (Frankenhaeuser, 1973; Johansson, 1972; Johansson and Post, 1972;). In the courses of these studies Frankenhaeuser (Personal communication, 1977) noted that women were far more inclined than men to verbalise their experience of stress. Thus, while men responded physiologically with little overt expression of their feelings, women tended to respond verbally with little physiological change.

In the present study, the female controls both reported that they had experienced more life events than the males and rated life events in general as more upsetting and requiring more adjustment. The female diabetics, and particularly those requiring insulin, responded in a similar manner to the male groups, reporting less upset and adjustment to life events and fewer experienced events than the female controls. In addition, the physiological disturbance associated with life events (increased incidence of glycosuria and prescription change) was similar in both male and female diabetics (see analysis of variance of factor 1).

It could be suggested that men generally were less likely to verbalise their experiences of stress than women because of the social constraints imposed upon them. It tends to be socially unacceptable for British males to admit to discomfort or to express openly symptoms of distress. However, these social mores would not account for the lower male-like ratings by female diabetics. It is possible that women in general tend to be more sensitive to the physiological changes associated with emotion than men and, because it is socially acceptable for women to do so, they are more likely to express their experiences of emotion overtly. Diabetic women, however, may be less capable than healthy women of gauging their physiological emotional responses since much of the feedback is not related to their emotional state but to faulty metabolic control. Hence, physiological changes associated with emotional response may be interpreted in terms of their disorder.

Other explanations for the differences in ratings of diabetic and non-diabetic women may be considered. Since experience of stressful life change in diabetics was associated with problems of diabetic management, diabetic women may be attempting to reduce the disturbing effects of life change by ignoring such events. Alternatively, diabetic women may be measuring the emotional effects of life change in terms of the problems that arose in the control of their diabetes rather than considering the wider implications of such events. Thus an event might only be considered to be upsetting or requiring adjustment if it was associated with physiological disturbance of their condition. Thus life events in general may be rated lower by diabetic women than by the controls. It could be suggested that events which were not considered upsetting or needing adjustment would not be recalled which may account for the lower number of reported life events by diabetics. On the other hand diabetics may avoid life events that they fear may disturb their control and thus may actually experience fewer events.

The possibility that the diabetics were using the terms 'upsetting' and 'adjustment' differently from the controls was examined in the following study.

2. Experiment 4: Semantic Differential Study of the Use of the Concepts Upsetting and Adjustment by Diabetic and Control Subjects

The construction of the semantic differential rating scales was described in Chapter 2 Section 12. This technique was used to examine any qualitative differences between diabetics and controls in their understanding of the concepts 'upsetting' and 'adjustment'. Quantitative differences in the ratings of 'upsetting' and 'adjustment' were also investigated.

Five other concepts from the Atlas of Semantic Profiles (Jenkins and colleagues, 1958) were rated by the subjects in order to compare the results of the present work with the results obtained from Jenkins' extensive study of 580 subjects. Analysis of the concept 'trouble' is described and discussed in this chapter in relation to the concepts 'upsetting' and 'adjustment'.

2.1. Method

Subjects A sample of 25 diabetic subjects including males and females and insulin and tablet treated patients participated in the study. Subjects were recruited in the manner described in Experiment 3 from the outpatient department of the Nottingham City Hospital. Eighteen control subjects (males and females) were drawn, as before, from the hospital staff and from adult education classes.

Procedure Questionnaires were given to the diabetic subjects who completed them while waiting for their routine appointments. The experimenter went through the instruction sheet with each subject and ensured that the example given in the instructions had been understood. The subject was then left to complete the questionnaire unaided unless further clarification was asked for. The experimenter also went through the instructions with the control subjects, either individually or as a group as the occasion demanded. The majority of subjects were able to understand the requirements.

Analysis of Results Completed questionnaires were scored in the manner described in Chapter 2 Section 12.2. The mean value allotted to each scale for each concept by the different groups was calculated and semantic profiles were constructed which described quantitative differences in rating styles.

Qualitative differences were more easily investigated using factor analysis of the 24 scales, (Chapter 2, Section 12.2).

2.2. Results and Discussion

Preliminary factor analysis distinguished 6, 7 or 8 factors for each group for each concept (adjustment, upsetting and trouble) (Eigen values >1). The factors were unclear and confusing. The relatively small number of subjects in each group probably accounted for many of the apparently random groupings. Most of the variance was accounted for by the first two factors.

The data were therefore analysed for two factors only for each group separately and for the groups combined (including the myocardial infarcation patients and hospital control patients discussed in Chapter 5). Factor 1 consisted primarily of evaluative scales while factor 2 was a mixture of activity and potency scales. This distinction between the factors was more appropriate for the concepts upsetting and trouble than for adjustment where several evaluative scales loaded on factor 2. The potency scales masculine-feminine, strong-weak, and hard-soft did not load on either factor for adjustment although fast-slow and active-passive did load on factor 2.

Even when 7 factors were separated out, activity and potency scales were loaded together on the same factors for the concepts upsetting and adjustment. It therefore appeared that such a grouping of items could more appropriately be labelled with one term such as 'pressure' or 'effort'.

There were no obviously consistent differences in the pattern of scale groupings between the diabetic and control populations. It was therefore assumed that there was little qualitative difference in the understanding of the concepts.

The semantic profiles suggested that there were quantitative differences in rating between the diabetic and control subjects. Analysis of variance was carried out on the two sets of factor scores for each of the 3 concepts. This analysis was used to examine differences in the degree of 'evaluation' and in the amount of 'pressure' ascribed to each word.

The scales which loaded on the two factors for each of the 3 words are listed below (Table 41). One end of the scale is listed indicating the relationships between the scales. Scales in parentheses did not quite reach the level of 0.5.

Analysis of variance results for each of the 3 concepts are considered in turn in the text that follows.

Table 41: Scales Loading on the Two Factors for each of the Three Concepts

Factor 1: Evaluation

Upsetting	Trouble	Adjustment
timely	timely	timely
relaxed	relaxed	relaxed
pleasant	pleasant	pleasant
calm	calm	calm
cheerful	cheerful	cheerful
good	good	good
relief		relief
loose	loose	
peaceful	peaceful	
settled	settled	
(positive)	positive	
controllable		controllable
attractive	attractive	
unemotional		
understandable		

Factor 2: Pressure

(Activity/Potency)	(Activity/Potency)	(Activity/Evaluation)
Upsetting	Trouble	Adjustment
fast	fast	fast
active	active	active
interesting	(interesting)	interesting
masculine	masculine	
strong	strong	
hard	(hard)	
(important)	important	
(positive)		positive
	emotional	unemotional
	worry	
		peaceful
		attractive
		loose
		settled

'Adjustment'

There were no significant differences between either sets of factor scores describing the ratings of adjustment by diabetic and control subjects, (figure 29). Observation of the semantic profile for adjustment (figure 30) showed that this concept was seen in a positive way by both diabetics and controls. It would appear that subjects were considering the process of adjustment rather than the need to adjust to an event. The ability to adjust was evaluated positively as a 'good', 'active', 'important' process by both groups. They appeared to have accepted the need to adjust as given and rated the process of adjusting as a positive response to such a need. The concept of adjustment appeared therefore, to be understood rather differently when it appeared out of context on the semantic differential rating scales.

'Upsetting'

The most significant differences between the groups were apparent for the concept 'upsetting'. Diabetics and controls showed highly significant differences in their evaluation of the concept ($F = 7.835$, DF 1,41, $P = 0.0078$**). The controls were more negative in their evaluation of the concept upsetting than the diabetics. Thus, controls rated the term as more 'tense', 'unpleasant' and 'emotional' than the diabetics. Although an upsetting event may disturb a diabetic's control of his condition, this factor did not appear to influence his evaluation of the term. On the contrary, diabetics were less negative in their evaluation than the controls.

Analysis of variance of factor 2 scores showed that the difference between the groups on this factor was not statistically significant,

<u>Figure 29: Mean factor scores for the concept 'adjustment' rated by diabetic and control subjects</u>

Differences in factor scores between the groups were not significant.

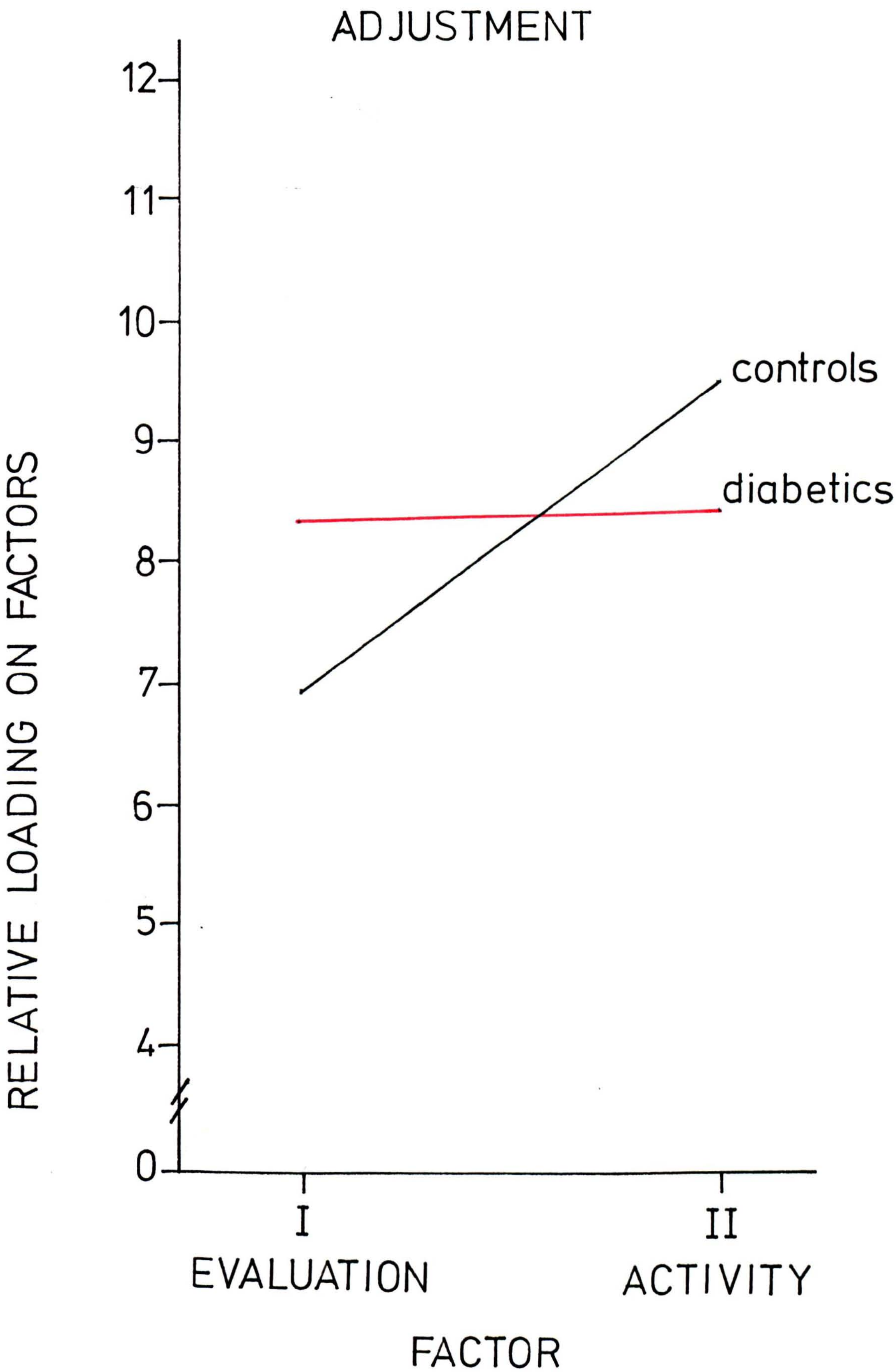
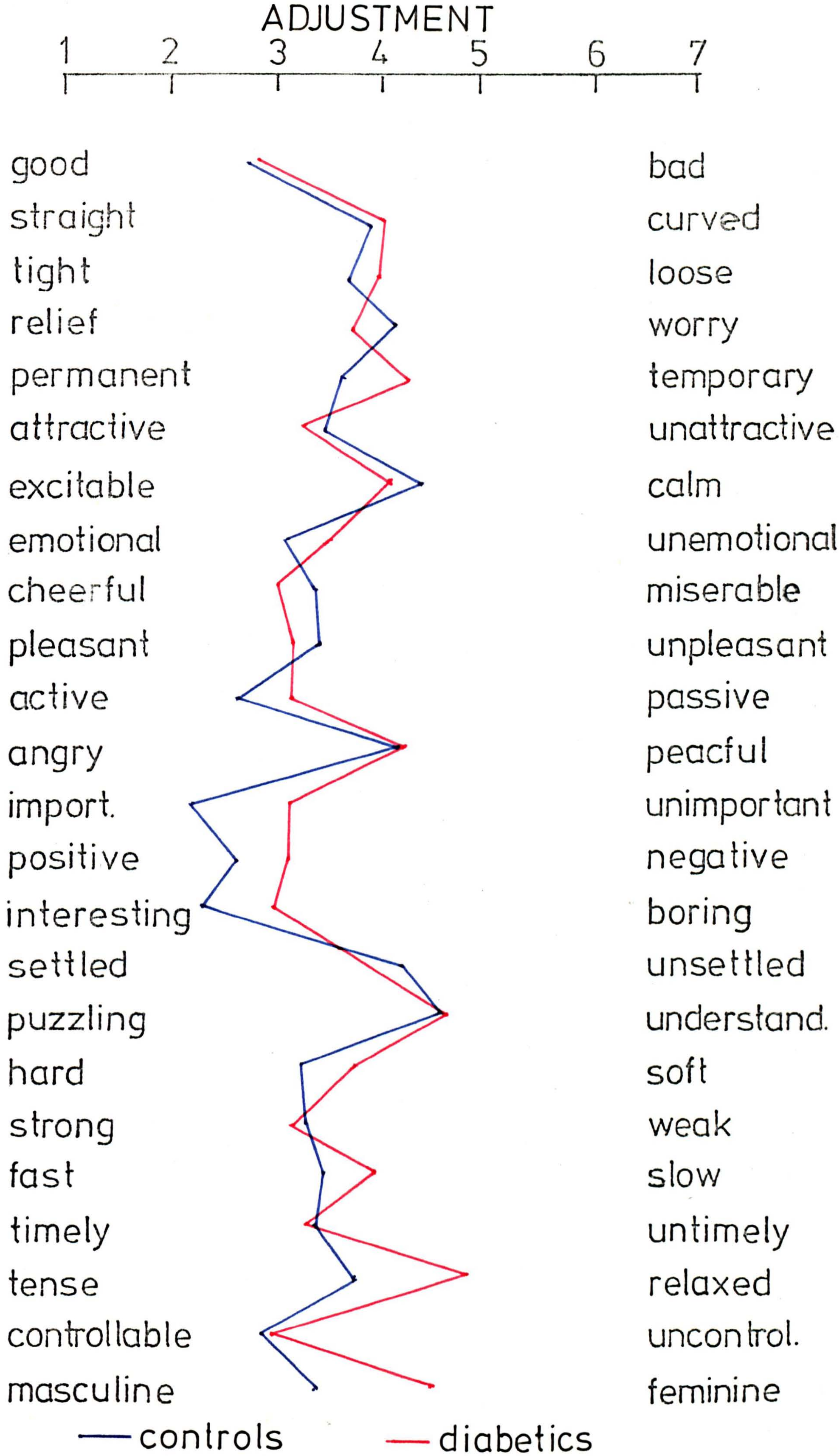

ADJUSTMENT
RELATIVE LOADING ON FACTORS
12
11
10
9
8
7
6
5
4
0
controls
diabetics
I
EVALUATION
II
ACTIVITY
FACTOR

Figure 30: Semantic profile showing mean scale ratings of the concept 'adjustment' by diabetic and control subjects


ADJUSTMENT
1
2
3
4
5
6
7
good
bad
straight
curved
tight
loose
relief
worry
permanent
temporary
attractive
unattractive
excitable
calm
emotional
unemotional
cheerful
miserable
pleasant
unpleasant
active
passive
angry
peacful
import.
unimportant
positive
negative
interesting
boring
settled
unsettled
puzzling
understand.
hard
soft
strong
weak
fast
slow
timely
untimely
tense
relaxed
controllable
uncontrol.
masculine
feminine
controls
diabetics

(F = 2.332, DF1, 41, P = 0.13438 n.s.). Figure 31 shows that diabetics tended to see upsetting as less active and less potent than the controls. Again diabetics were minimising the impact of upset by denying its 'pressure'. The semantic profile (figure 32) shows that controls were more extreme in their ratings of upsetting than the diabetics. This pattern of response was also apparent in the ratings of the concept 'trouble'.

'Trouble'

Trouble also tended to be evaluated less negatively by diabetics although this result did not attain statistical significance (F = 3.031, DF 1,41 P = 0.08921 n.s.). The smaller degree of 'pressure' ascribed to trouble by diabetics was significantly different from that of the controls (F = 10.679, DF 1,41, P = 0.00220**). The differences are shown graphically in figure 33.

Again diabetics appeared to be denying the impact that trouble might have. The results obtained by Jenkins from his 580 subjects rating this concept are included on the semantic profile (figure 34) for those scales which were used in both studies. It can be seen that the results of the present control group were very similar to those obtained by Jenkins from his healthy sample suggesting that the results were reliable in spite of the considerably smaller sample size in the present study.

2.3. Discussion of Semantic Differential Results

The consistent finding that diabetics minimised the impact of upset and trouble was interesting particularly in relation to work by other researchers on emotional response in various 'psychosomatic'

Figure 31: Mean factor scores for the concept 'upsetting' rated by diabetic and control subjects

The two groups differed significantly in their evaluation of 'upsetting' (P = 0.0078**). The difference between the groups was not significant for factor 2.

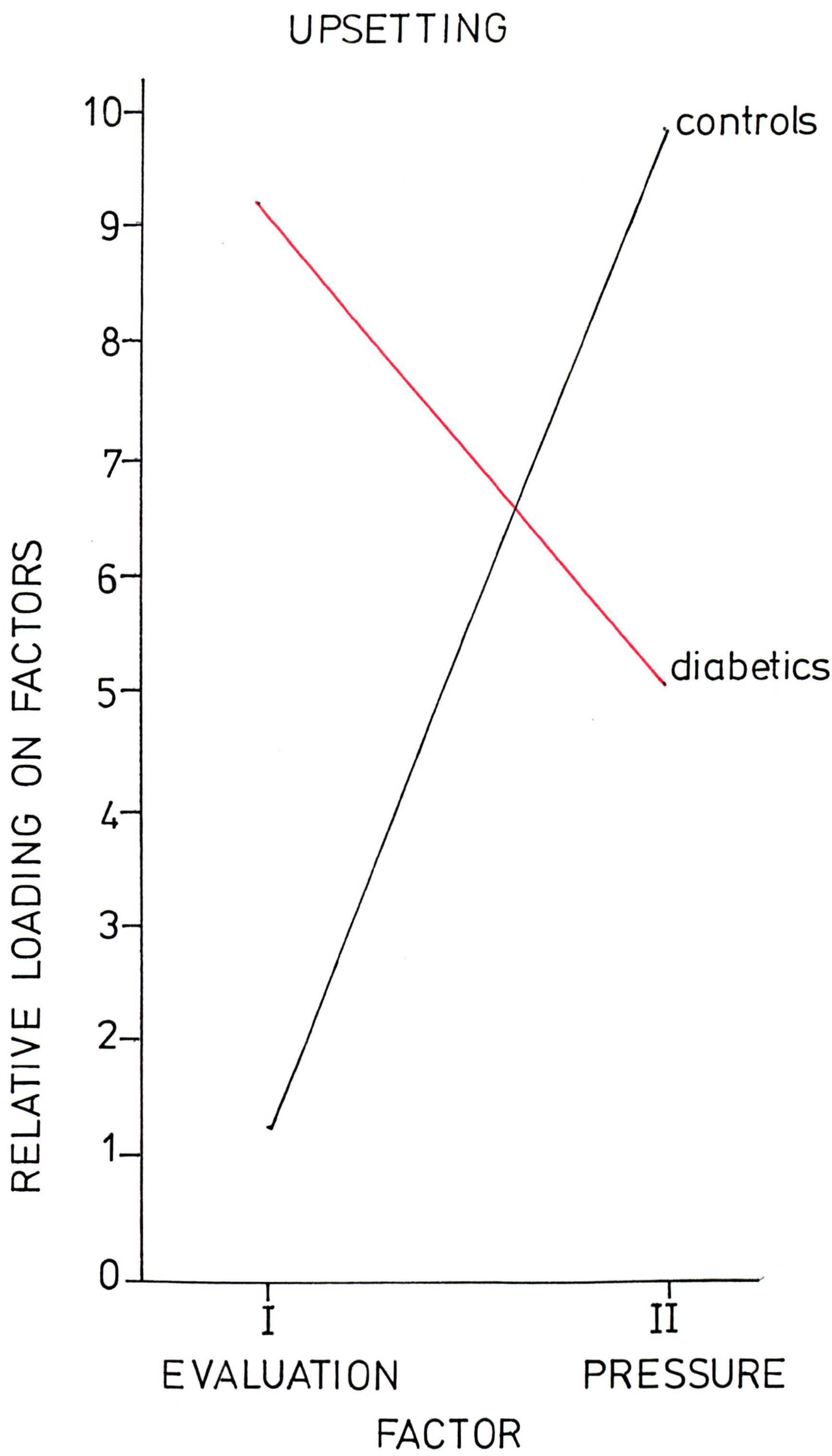

UPSETTING
RELATIVE LOADING ON FACTORS
0
1
2
3
4
5
6
7
8
9
10
controls
diabetics
I
EVALUATION
II
PRESSURE
FACTOR

Figure 32: Semantic profile showing mean scale ratings of the concept 'upsetting' by diabetic and control subjects

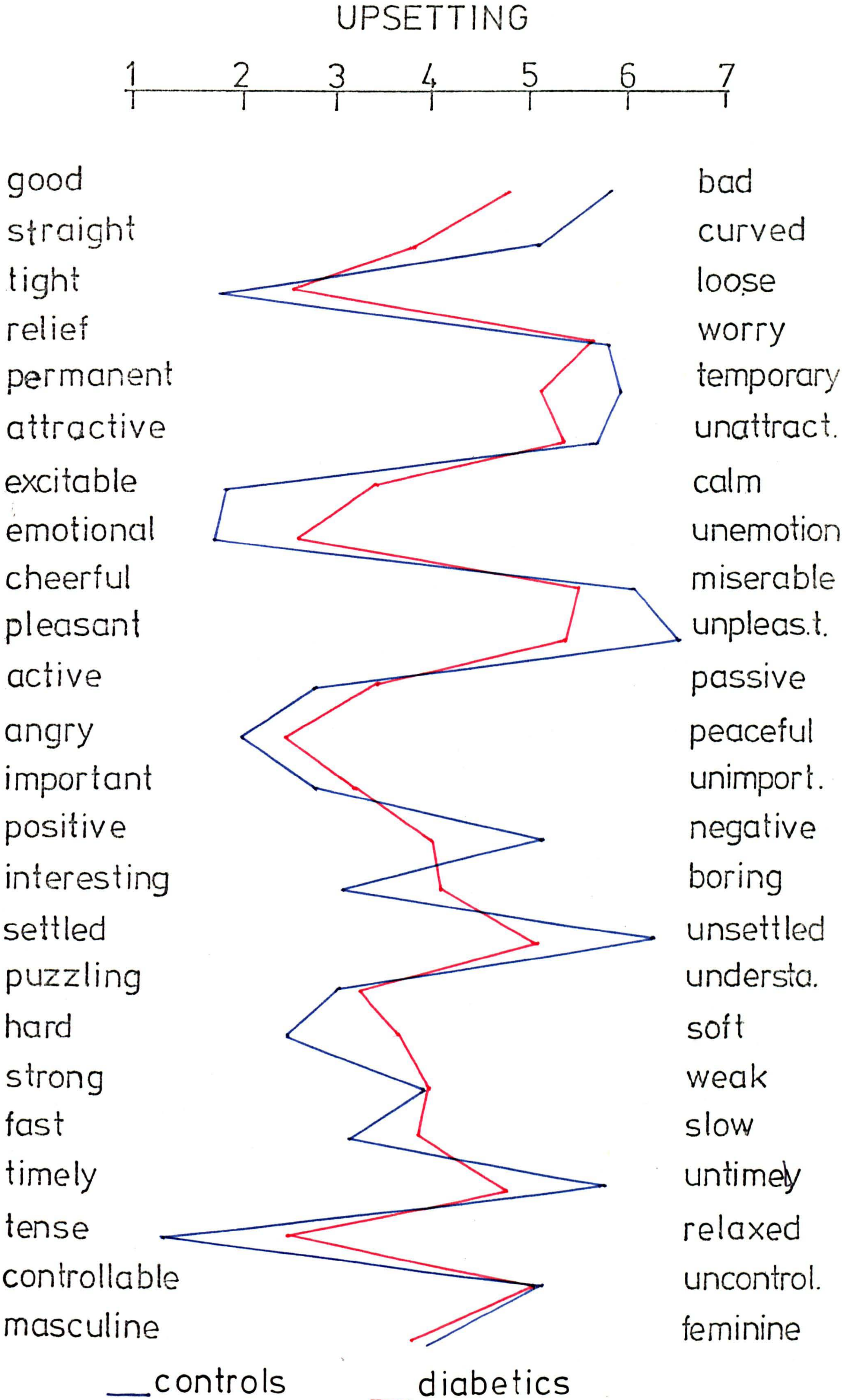
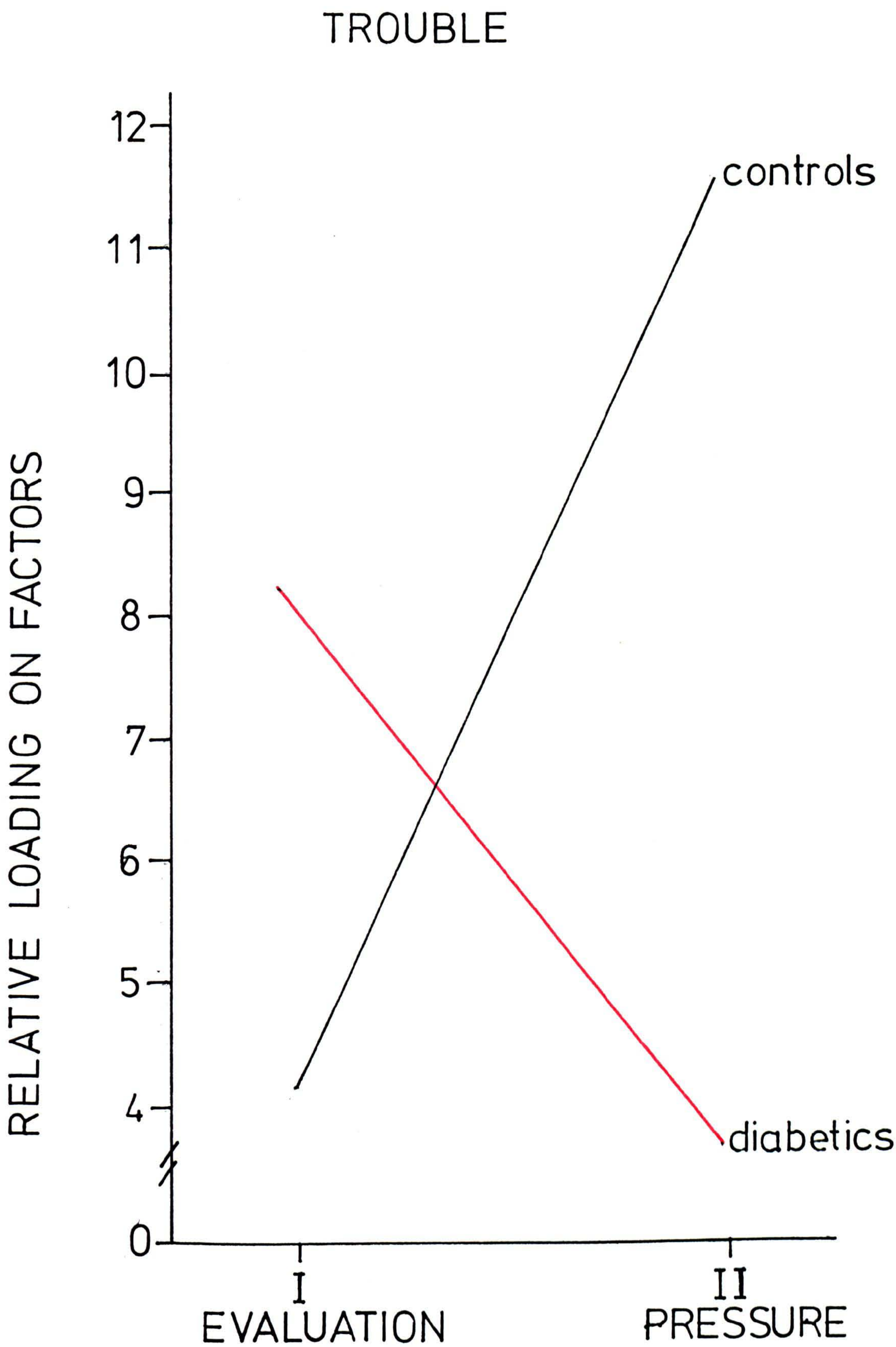

UPSETTING
1
2
3
4
5
6
7
good
straight
tight
relief
permanent
attractive
excitable
emotional
cheerful
pleasant
active
angry
important
positive
interesting
settled
puzzling
hard
strong
fast
timely
tense
controllable
masculine
bad
curved
loose
worry
temporary
unattract.
calm
unemotion
miserable
unpleas.t.
passive
peaceful
unimport.
negative
boring
unsettled
understa.
soft
weak
slow
untimely
relaxed
uncontrol.
feminine
controls
diabetics

Figure 33: Mean factor scores for the concept 'trouble' by diabetic and control subjects

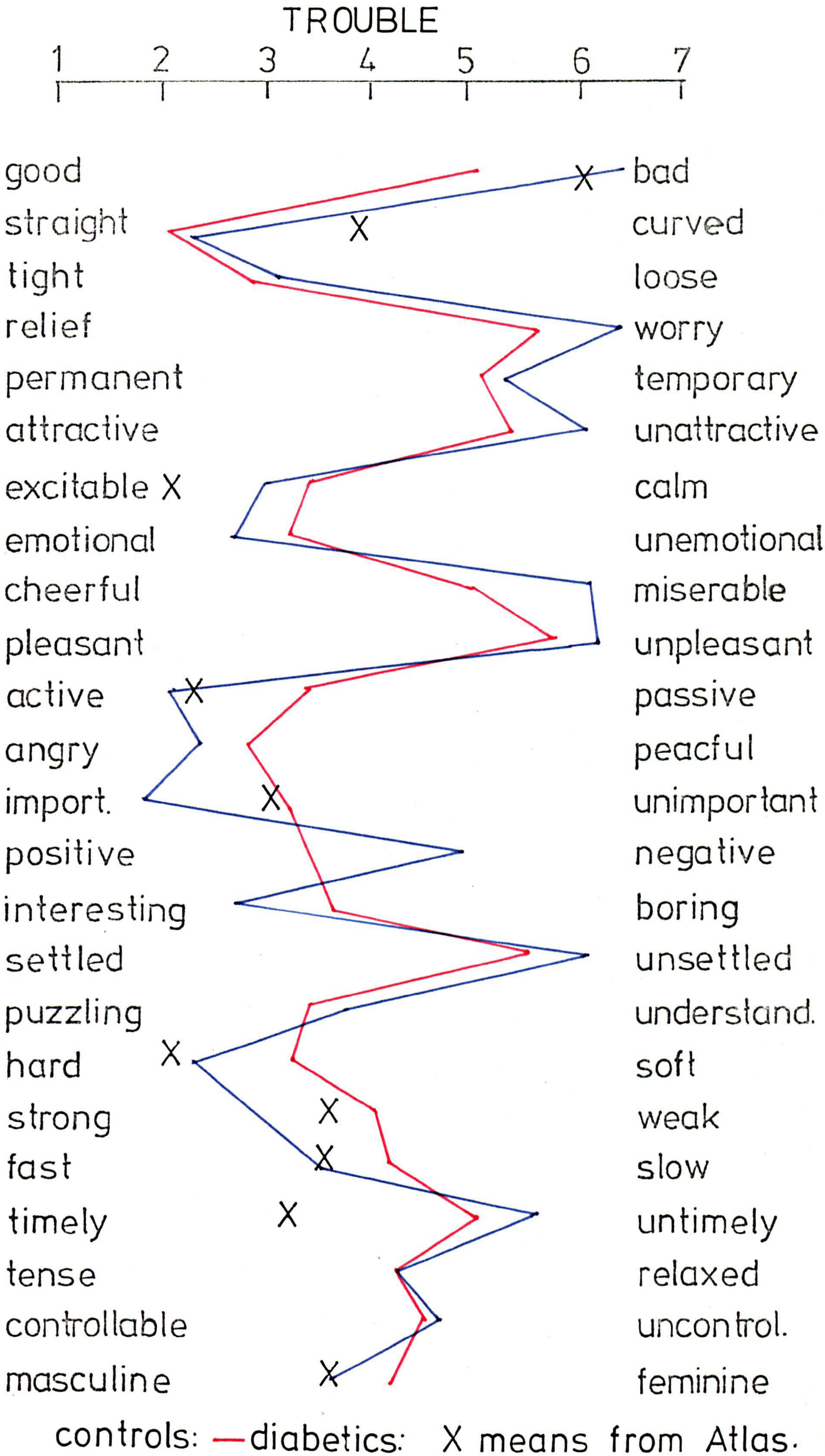
Diabetics tended to evaluate the concept more than controls but this difference was not significant. The difference between the factor 2 scores of the two groups was significant (P = 0.00220**)



TROUBLE
RELATIVE LOADING ON FACTORS
12
11
10
9
8
7
6
5
4
0
controls
diabetics
I
EVALUATION
II
PRESSURE
FACTOR

Figure 34: Semantic profile showing mean scale ratings of the concept 'trouble' by diabetic and control subjects

The mean values obtained by Jenkins are included for comparison (X)


TROUBLE
1
2
3
4
5
6
7
good
bad
straight
curved
tight
loose
relief
worry
permanent
temporary
attractive
unattractive
excitable
calm
emotional
unemotional
cheerful
miserable
pleasant
unpleasant
active
passive
angry
peacful
import.
unimportant
positive
negative
interesting
boring
settled
unsettled
puzzling
understand.
hard
soft
strong
weak
fast
slow
timely
untimely
tense
relaxed
controllable
uncontrol.
masculine
feminine
controls: — diabetics: X means from Atlas.

patients. Nemiah and Sifneos (1970) observed that patients with psychosomatic disorders were unable to describe their feelings and that

> 'their thought content was characterised by a preoccupation with the minutiae of their environment and by an absence of fantasies determined by feelings and drives.'

This observation was made initially by Marty and de M'Uzan (1963) and described by them as 'pensée opératoire'. Nemiah and Sifneos used the term 'alexithymia' (from the Greek stems meaning without words for feelings) in an equivalent way.

McDougal (1974) summarised the theoretical approach of the French researchers. They suggested that individuals with psychosomatic disorders fail to develop the ability to experience feelings or to achieve the capacity of fantasy as a means of temporarily gratifying instinctual drives as a result of disturbances in early mother-child relationships. The individual becomes preoccupied with his environment and makes a 'super-adaptation to external reality' which is associated with alexithymic disturbances of affect and fantasy. They claim that 'instinctual energy, by-passing the psyche, thus affects the soma directly with catastrophic results.'

Starting from similar clinical observations Nemiah and Sifneos (1976) proposed a model based on physiological concepts.

> 'Either because of genetic factors or from developmental arrests in infancy, there is a lack of adequate neuronal connections between those areas of the brain subserving drives and affects (the limbic system) and those areas in the neocortex underlying the conscious representation of feeling and fantasies. As a result the neuronal activity related to drive arousal cannot be processed through the elaborate cortical pathways but is short-circuited to the hypothalamus, which results in excessively strong and lasting discharges in the autonomic nervous system. In most respects our model is similar to that of the French group, postulating as it does a failure

> in the elaboration of drives and a pathogenic short-circuiting of the energy involved, but in our model we have substituted neuronal activity for "instinctual energy", which, unlike the concept of neurophysiological processes, is an intellectual construct, incapable of direct observation and measurement.'

Unfortunately Nemiah and Sifneos were unable to elaborate on the details of the postulated link between brain mechanisms and psychosomatic symptom formation. They emphasise that the correlation of alexithymic characteristics with brain function is highly speculative. Nemiah and Sifneos conclude

> 'It is an interesting possibility that remains to be tested whether the patient can be "taught" to fantasise, can be led to develop a vocabulary for feelings, and can be induced to begin to experience affect under the guidance and influence of a physician who, by openly employing fantasy himself, by using richly emotive language and by actively encouraging the patient to do likewise, allows him to develop modes of experience previously unavailable to him.'

The concept of alexithymia may not be directly applied to the present results from diabetic groups. The words used to describe the 3 concepts were offered to the subjects and there is no evidence to suggest that the diabetics either could or could not elicit such descriptions spontaneously. However, the diabetic patients did appear to minimise the stress that would be caused by upset and trouble and in this sense they were behaving in a manner that could be termed 'alexithymic'. Nemiah and Sifneos suggested that this phenomenon may be due to inadequate neuronal connections between the limbic system and the neocortex concerned with conscious representation of feelings. A more feasible explanation for this phenomenon in diabetic patients is the lack of accurate feedback of physiological changes associated with emotion. In diabetic patients, physiological changes such as blood glucose changes, sweating, blurring of vision, and heart rate changes were often due to problems of diabetic control that were physical in origin. Thus physiological changes associated with emotion may be dissociated from cognitive appraisal of feelings and may result in a diminished appreciation of the extent of emotional reactions. This explanation would account for the less extreme ratings of the emotive concepts, 'Upsetting' and 'Trouble' and the lower ratings of stressful life events in comparison with those of the non-diabetic controls.

3. Summary and Conclusions

The results of the factor analysis supported the hypothesis that the experience of stressful life events was associated with disturbances of diabetic control. Increases in the incidence of glycosuria, changes in prescriptions and clinic attendances were associated with increases in the reported occurrence of life events. The experience of life events was not reflected in blood glucose measures. Any increases in blood glucose appeared to be registered as glycosuria. Analysis of variance showed that the relationship between the 'disturbance measures' was more marked in the insulin treated groups than in the tablet treated groups. Insulin requiring diabetics were more inclined to have problems with their diabetic management in association with life events than the tablet treated diabetics.

The insulin and tablet groups did not, however, differ in terms of their blood glucose measures. Any increase in blood glucose levels was manifested in the form of glycosuria.

Diabetic subjects' ratings of life events were compared with the ratings by control subjects. Female controls and female tablet treated diabetics rated life events in general as more stressful than did males. This sex difference was not apparent for the insulin requiring diabetics. In this insulin requiring group the females gave lower ratings which were similar to those of the males.

Ratings of experienced events were significantly higher for the female controls than for the males or the diabetics of either sex. Reports of the number of events experienced followed a similar pattern.

The sex difference in ratings by control subjects was discussed in relation to work by other researchers which supported the findings. Suggestions were made to account for the absence of such sex differences among diabetic subjects.

The understanding of the meaning of the concepts 'upsetting' and 'adjustment' was examined using the semantic differential rating scales. There was no significant difference between diabetic and control subjects in their understanding of the concept 'adjustment'. However, the subjects in both groups appeared to be using the term adjustment in a more positive way in the semantic differential rating scales than in the life events questionnaire. In the life change questionnaires the instructions tended to suggest negative implications by focusing on the need to adjust to the life events rather than on the more positive process of adjustment itself.

The diabetic subjects differed significantly from the control subjects in their semantic differential ratings of the concept 'upsetting'. The diabetics minimised the impact of this concept. Nemiah and Sifneos' concept of alexithymia was discussed and it was suggested that diabetics might disclaim the effects of events which were upsetting as a result of the lack of accurate feedback from physiological changes associated with emotional reactions. Such physiological changes in diabetics are often physical rather than psychological in origin. Thus in making cognitive appraisals of stressful events diabetics may overlook physiological information concerning their emotional state. This restricted form of appraisal may account for the lower ratings of 'upsetting' and 'adjustment' by diabetic subjects.

CHAPTER 5:

ISCHAEMIC HEART DISEASE : STUDIES OF NOISE AND LIFE STRESS

This chapter describes a secondary line of research which closely followed the approaches used in the study of diabetic patients. Section 5 of Chapter 1 reviewed some of the extensive research which has strongly implicated stress in the etiology and course of IHD (ischaemic heart disease). The relationship between IHD and diabetes was also considered in that section.

The first experiment described in this chapter is an extension of the laboratory study of diabetic and control subjects. Patients exhibiting symptoms of IHD were compared under the same experimental conditions to examine the effects of noise and task performance on the physiological and psychological variables investigated.

The studies of patients with histories of myocardial infarction (MI) which follow, examined their perception of and reported responses to life events. The first of these later investigations attempted to replicate the study by Lundberg, Theorell and Lind (1975) who investigated men with MI histories in Sweden. This study was followed by an experiment which used the semantic differential rating scales to examine the patients' perception of the meaning of the concepts 'adjustment' and 'upsetting'.

1. Experiment 5: A laboratory study of the psychophysiological effects of noise in patients with Ischaemic Heart Disease

This study compared measures of performance, blood glucose, personality and subjective experience of patients manifesting symptoms of IHD under the two levels of white noise. The responses of these patients were compared with those of the control subjects already reported in Experiment 2, Chapter 3 where their responses were described and compared with the responses of diabetic patients.

It was hypothesised that IHD patients would demonstrate an exaggerated reaction to noise stress. Earlier research had suggested that IHD was associated with enhanced sympathetic activity in response to stress (e.g. Raab, 1968; Williams, 1975). It was therefore supposed that IHD patients would experience greater sympathetic response to noise than controls and that this response would be reflected in greater initial elevations of blood glucose. If IHD patients' blood glucose levels increased significantly more than the control subjects' in response to noise, it may be hypothesised that the decrease in blood glucose during the task period, which would be expected as a result of subsequent insulin release, would be less marked in the IHD patients. Differences between IHD and control subjects due to abnormalities of insulin release were not anticipated in this study. The hyper-insulinism noted by several authors (Stout and Valance-Owen, 1969; Szanto and Yudkin, 1969) and associated with IHD was stimulated by carbohydrate intake. None of the IHD subjects in the present study were preloaded with glucose and there was no evidence to suggest that people with IHD showed excessive insulin secretion in response to raised blood glucose levels resulting from adrenalin release.

Associated with the enhanced sympathetic activity expected to occur in IHD patients it was hypothesised that, when compared with control subjects, IHD patients would more often report the task period to be stressful.

The level of performance efficiency associated with these hypothesised reactions to noise stress was considered in relation to the studies by Cox and Simpson and their colleagues (1973, 1974) and to studies of adrenalin secretion and performance by Frankenhaeuser and her colleagues (eg 1971).

If performance efficiency under stress was related to the availability and uptake of glucose by the body cells as Simpson, Cox and Rothschild suggested in their 1974 paper there would be no reason to suppose that performance of IHD patients would in any way be inferior to that of the controls. On the contrary, increased adrenalin secretion in IHD patients would mobilise more glucose and it may be suggested that performance would improve under stress as a result.

On the other hand, Frankenhaeuser, Nordheden, Myrsten and Post (1971) found that while individuals who secreted relatively more adrenalin tended to perform better when working under conditions of 'low or moderate activation' (i.e. a vigilance task representing 'understimulation'), their performance tended to be inferior under conditions of 'high activation' (i.e. a complex sensorimotor task representing 'overstimulation'). These results were interpreted in terms of the inverted U relation between behavioural efficiency and physiological arousal. Frankenhaeuser (1975) suggested that these findings were supported by the results of earlier experiments with catecholamine infusions. Frankenhaeuser and Jarpe (1963) had shown that the infusion of small or moderate doses of adrenalin may have a beneficial effect on performance in cognitive tasks requiring sustained attention. Presumably these cognitive tasks were considered to be 'understimulating'. In the light of these studies, it was difficult to predict the effects of enhanced adrenalin secretion on performance of the pursuit rotor task. The noisy condition may be considered to be 'activating' or 'overstimulating' and it would therefore be expected, from Frankenhaeuser's interpretations, that IHD patients' performance would be impaired by noise.

It may be predicted either from Simpson, Cox and Rothschild (1974) that performance of the IHD patients would improve with noise or, from Frankenhaeuser's work, that their performance would be impaired by noise. If noise was shown to affect performance efficiency, one of the two lines of reasoning would be supported and some indication of the mechanism behind the postulated relationship between blood glucose change and performance could be given.

1.1. Method

Subjects 32 male patients with symptoms of IHD were studied. 17 of these subjects were outpatients attending the cardiac clinic at the Nottingham City Hospital with conditions which included angina, high blood pressure or shortness of breath which had been diagnosed as symptomatic of IHD. The remaining 15 subjects were inpatients at the hospital due for discharge following recovery from acute MI or inpatients with a history of IHD who had been admitted for observation with suspected MI. All patients were considered by the physician in charge and by the experimenter to be sufficiently recovered to participate in the experiment. The volunteers, who themselves felt able to participate, were initially approached by the consultant physician Dr D C Banks or one of his colleagues. It was emphasised to patients that they would be taking part in the study on a voluntary basis.

It was not possible to control the drug treatments of these patients. Sufficient numbers of diabetic patients had been available to make it possible to select only those patients treated with insulin. In the case of IHD patients, a great variety of drugs was used in treatment and the numbers were too few to allow for selection of a homogeneous group. Only 7 of the 32 patients were not receiving any form of drug therapy. The drugs used among the other 25 patients are listed below with the numbers of patients taking each drug.

Beta receptor blockers (propranolol, practolol)	6
Antiarrythmic drug (procainamide)	1
Noradrenalin inhibitor (bethanedine)	1
Atropine	1
Cardiac glycosides (digoxin)	8
Minor tranquillisers (diazepam)	2
Major tranquillisers (prochlorperazine)	1
Anticoagulants (warfarin)	5
Diuretics (frusemide, bendroflurazide, cyclopenthiazide)	8
Potassium supplements (potassium chloride)	7
Vasodilators (glyceryl trinitrate, peritrate)	5
Tricyclic antidepressants (amitryptyline)	1

Subjects ranged in age from 41 to 76 years and thus constituted a rather older group than the diabetic and non-diabetic control groups studied. The subjects were tested as before, in the afternoons between 1400 and 1700 hours. The results obtained with the IHD patients were tentatively compared with the results of the control group reported in Chapter 3. Consideration was given to the possible effects of differences between the populations in the discussion of the results.

Design The design of the study was identical to that used with the three experimental groups in Chapter 3, and is summarised in Table 42.

Table 42: Summary of Experimental Design

	Noise Level dBA	
	50	80
Task	N=8	
No Task		

All subjects were given 100ml. water to drink in order to allow comparison between these results and those obtained with the diabetic and control subjects.

Procedure The experimental procedure followed has been described in Experiment 2 of Chapter 3.

1.2. Results Analysis of variance showed no significant effects of noise (F=0.002; DF 1,28,n.s.) or task (F=0.092; DF 1,28,n.s.) on changes in the blood glucose levels of IHD patients during the 15 minute task period.

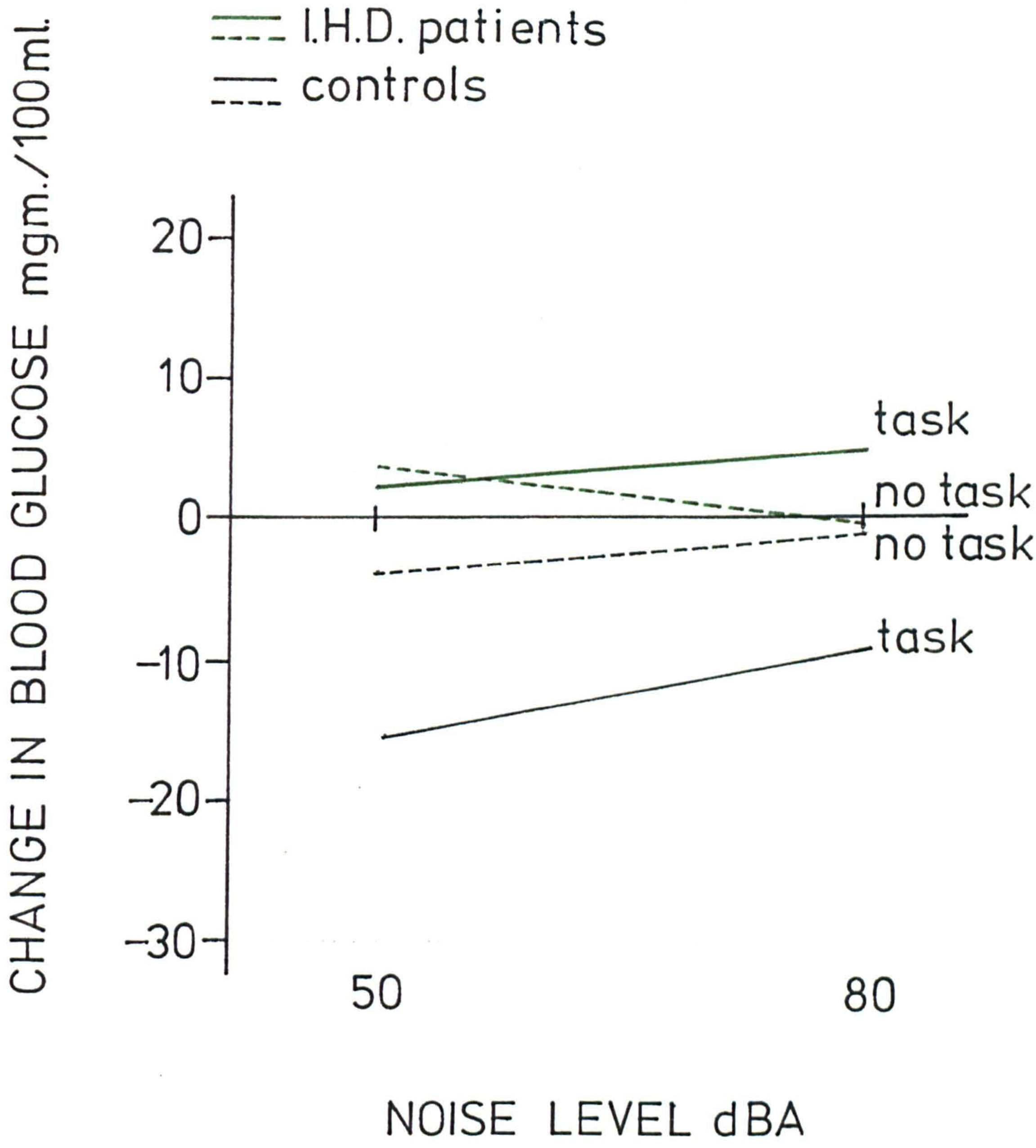
The blood glucose changes of IHD patients were different from those of the (no glucose) controls. It can be seen from figure 35 that the controls showed overall decreases in blood glucose levels during the task period while the IHD patients tended to show increases. (F=3.638 DF 1,56 P=0.06161).

There was some indication from the analysis of variance of an interaction between subject group and the task/no task conditions on the change in blood glucose. A greater rise in blood glucose was shown by IHD patients in the task condition while a greater fall occurred in the control subjects. (F=1.797, DF 1,56, P=0.18548).

The data were reanalysed omitting the results from the eight subjects using beta blocking drugs and tranquillisers since the effect of these drugs might have inhibited sympathetic activity in response to the experimental conditions. Analysis of variance showed that the interaction between subject group and task was significant when the eight subjects were omitted. (Table 43) The results are shown in figure 36. The inclusion of 3 patients treated with these drugs in the 50dB task condition had suppressed the mean increase in blood glucose levels in this condition. Time on target and the number of deviations made remained unchanged when these subjects were excluded from the 50dB

Figure 35: Blood Glucose Changes in IHD Patients and No Glucose Control Subjects

The difference between the two groups did not quite reach statistical significance ($p=0.06$). Noise and Task factors did not significantly affect the blood glucose changes.



I.H.D. patients
controls
CHANGE IN BLOOD GLUCOSE mgm./100ml.
20
10
0
-10
-20
-30
task
no task
no task
task
50
80
NOISE LEVEL dBA

Figure 36: Blood Glucose Changes in IHD Patients Omitting the Results of 8 Patients Taking Tranquillisers or B Blocking Drugs Compared with the Blood Glucose Changes in Control Subjects

The interaction between subject group and task was significant ($p=0.05^*$)

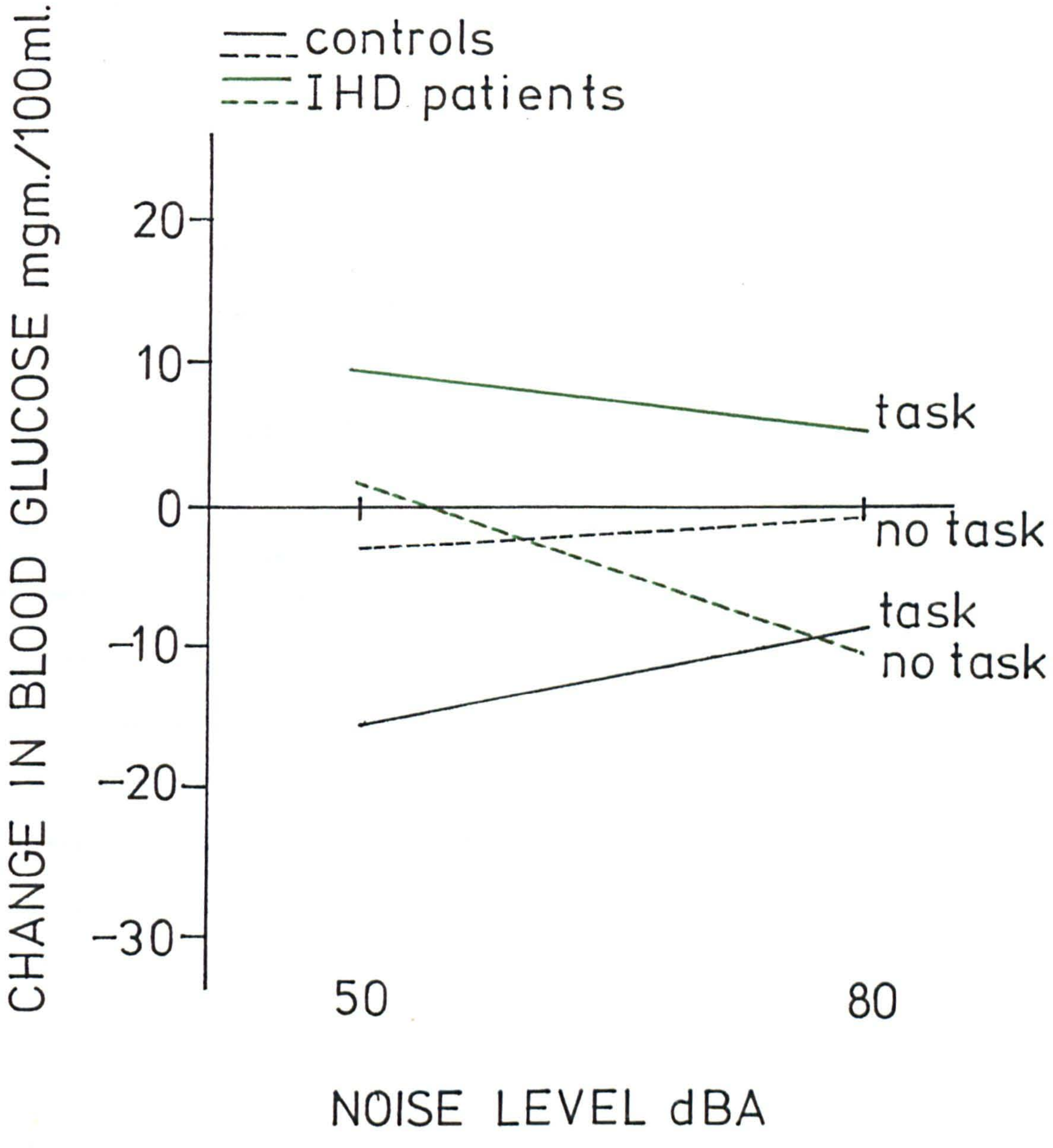

controls
IHD patients
CHANGE IN BLOOD GLUCOSE mgm./100ml.
20
10
0
−10
−20
−30
task
no task
task
no task
50
80
NOISE LEVEL dBA

Table 43: Summary of Analysis of Variance of Blood Glucose Changes in the IHD Patients not Taking Tranquillisers or Beta Blocking Drugs, and in the Control Subjects

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A.IHD/Controls	1140.2886	1	1140.2886	3.111	48	0.08414
B.Task/No Task	4.6837	1	4.6837	0.013	48	n.s.
C.Noise 50/80	157.4446	1	157.4446	0.430	48	n.s.
AB	1470.6033	1	1470.6033	4.012	48	0.05085*
AC	23.3723	1	23.3723	0.064	48	n.s.
BC	46.2323	1	46.2323	0.126	48	n.s.
ABC	204.1527	1	204.1527	0.557	48	n.s.
Within	17595.0698	48	366.5640			
Total	20641.8474	55				

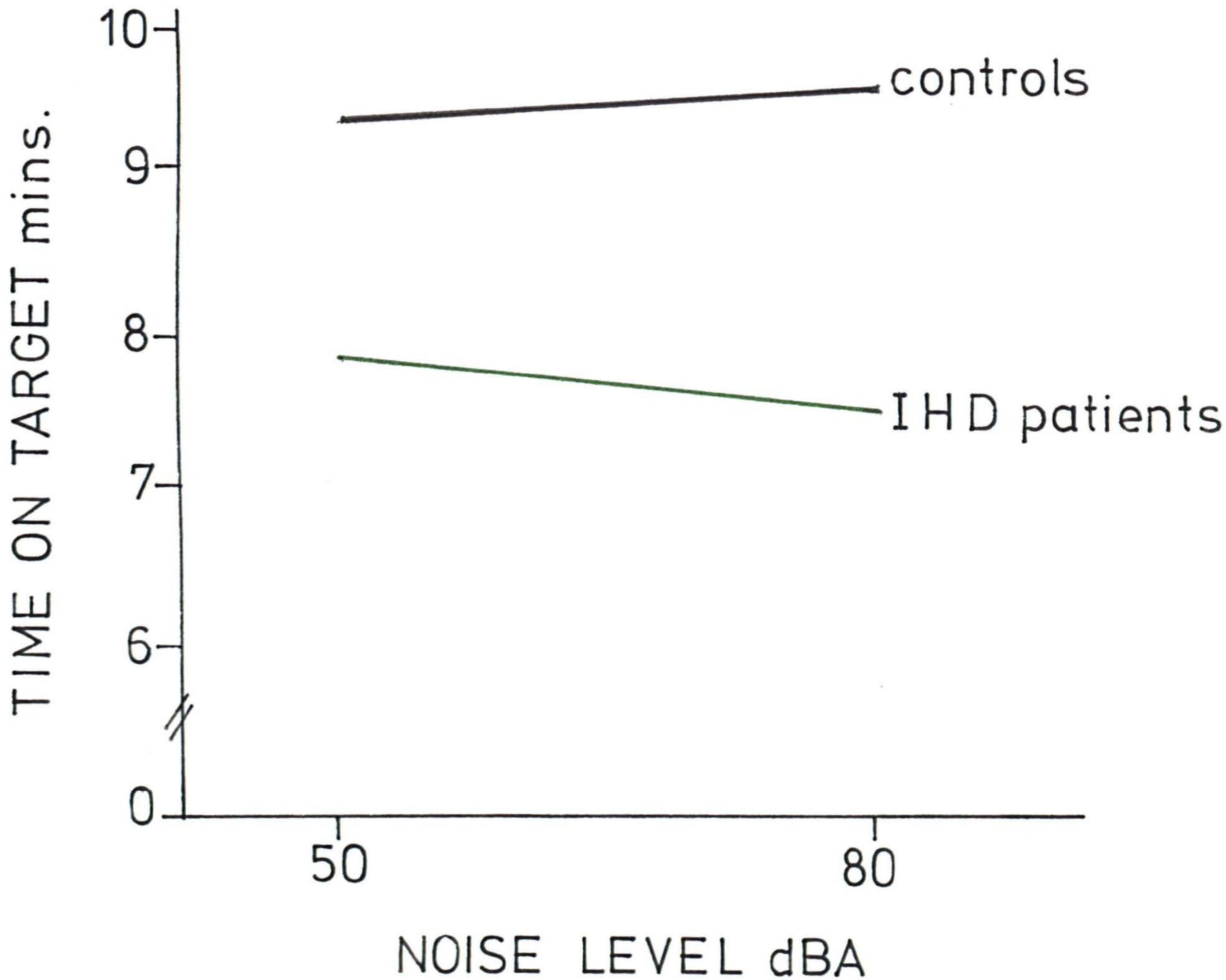
task condition. None of the subjects in the 80dB task condition were using beta blockers or tranquillisers. As there were only 3 subjects taking these drugs in the two task conditions, it was not possible to compare the performance results directly.

There was no effect of noise on IHD patients' time on target scores (F=0.065, DF 1,14, n.s.). The effects of noise on the number of deviations made by these subjects was nearly significant (F=3.926; DF 1,14, P=0.06752); more deviations were made in the noisy condition.

The performance of IHD patients was compared with that of the controls. Time on target scores in the two groups were significantly different. IHD patients obtained considerably lower time on target scores than the controls (F=8.347; DF 1,28; P=0.00738**). Figure 37 shows the difference between the groups. No effects of noise on time

Figure 37: Mean Time on Target Scores by IHD Patients and Controls

IHD patients obtained significantly lower time on target scores than controls (p=0.00738**). There was no significant effect of noise.



TIME ON TARGET mins.
10
9
8
7
6
0
controls
IHD patients
50
80
NOISE LEVEL dBA

on target scores were apparent.

Differences in the number of deviations made by the two groups were less dramatic. However, while the deviations made by controls were little affected by noise, IHD patients made more deviations in the noisy condition, (figure 38). Analysis of variance results are summarised in table 44.

Table 44: Analysis of Variance of Deviations made by IHD and Control Subjects

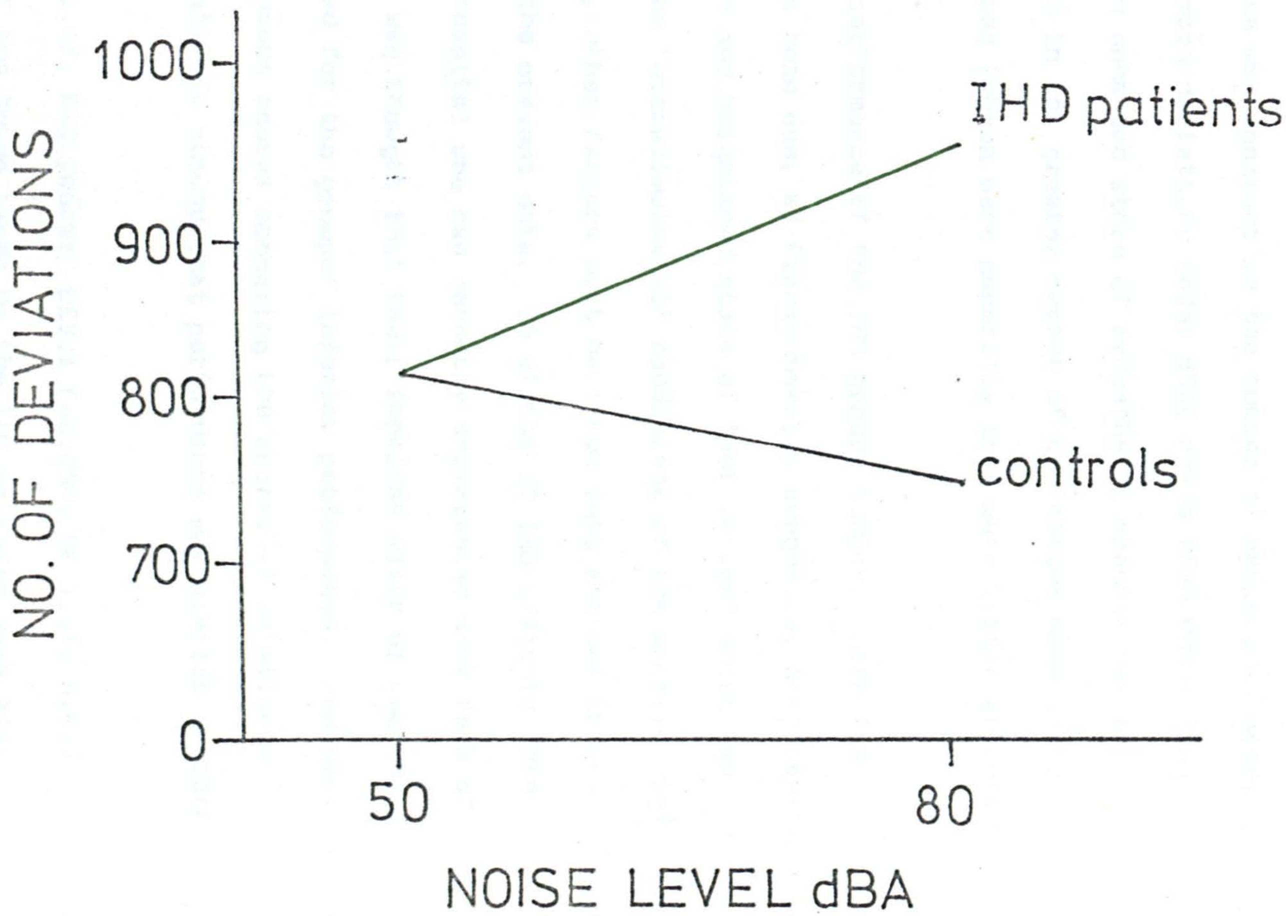
SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A IHD/Controls	80100.0077	1	80100.0077	3.415	28	0.07518
B Noise 50/80	22844.5080	1	22844.5080	0.974	28	n.s.
AB	78507.2425	1	78507.2425	3.347	28	0.07798
Within	$6.5668_{10}+05$	28	23452.7097			
Total	$8.3813_{10}+05$	31				

1.3. Discussion of Blood Glucose and Performance Results

While there was no evidence to suggest that noise increased the sympathetic response of IHD patients, the blood glucose changes of the IHD patients during the task period were different from those of the controls. The data suggested that the experimental session as a whole caused enhanced sympathetic activity in IHD patients which was reflected in overall increases in blood glucose levels rather than the decreases found in the control groups. Differences between the groups were particularly apparent in the task conditions. The stressful nature of the task has already been considered in Chapter 3 and it was likely that the IHD group found the stress inherent in the task more

Figure 38: Mean Number of Deviations Made by IHD Patients and Controls

Differences between the subject groups did not reach significance (p=0.07518). The interaction between subjects and noise did not reach significance (p=0.07798).


NO. OF DEVIATIONS
1000
900
800
700
0
IHD patients
controls
50
80
NOISE LEVEL dBA

demanding than the stress of 80dB noise. The subjective reports of stress are considered in the next session.

There was no effect of noise on time on target scores of either IHD or control subjects. It was suggested in Chapter 3 that the task inherent stress may obscure any effects due to the noise and it is likely that this was again the case with the IHD patients. However, some effect of noise was apparent in the number of deviations made; IHD patients made more deviations under 80dB noise than under 50dB. It appeared that an enhanced state of sympathetic arousal due to noise was reflected in the greater number of deviations made although time on target scores (which were generally low) were little affected by the noise level.

The inferior performance of the IHD groups compared with the controls might have been due, as Frankenhaeuser suggested, to enhanced adrenalin secretion and heightened state of 'activation' which was inappropriate in the 'overstimulating' conditions of the experimental sessions. However, other factors must be taken into account in the interpretation of the present data. 15 of the 32 IHD patients were inpatients at the hospital who had recently experienced some form of acute illness. It was thought that their impaired state of health might have accounted for the groups' inferior performance. However, analysis of performance scores comparing the scores of inpatients with those of outpatients showed that performance was similar in both groups.
(TOT: F=1.484, DF 1,12, P=0.24649: DEV.: F=0.059, DF 1,12, n.s.)

The effects of the drugs taken by the IHD patients were also considered in relation to the results obtained. It would be expected that those patients taking beta blocking drugs or tranquillisers would have experienced less sympathetic activation in response to the experimental conditions and would therefore have shown a smaller rise in blood glucose than the controls. However, the blood glucose results suggested that IHD patients as a group were more activated than the controls despite the inclusion of these 8 subjects. When the blood glucose results were analysed omitting these subjects the interaction between task and subject group was significant at the 5% level. Task inherent stress led to a rise in IHD patients' blood glucose levels under both levels of noise while control subjects showed a fall in blood glucose levels while performing the task.

1.4 Subjective Experience of the Task Period: Results and Discussion

Subjective View of Stress

These data, from the questionnaire described in Section 6 of Chapter 2, were collapsed for analysis into those subjects who reported some degree of stress and those who reported that the 15 minute experimental session was not stressful. A 2x2 contingency table was drawn up for the IHD patients and the results were compared with those of the control group. Significance levels were determined from the tables compiled by Finney and colleagues (1963). The frequency tables for the two groups are presented below.

Table 45: IHD Patients; Subjective View of Stress

	Task		No Task		Total	
	Stress	No Stress	Stress	No Stress	Stress	No Stress
80dB	4	4	2	6	6	10
50dB	4	4	3	5	7	9
Totals	8	8	5	11		

Table 46: Controls; Subjective View of Stress

	Task		No Task		Total	
	Stress	No Stress	Stress	No Stress	Stress	No Stress
80dB	7	1	4	4	11	5
50dB	4	4	1	7	5	11
Totals	11	5	5	11		

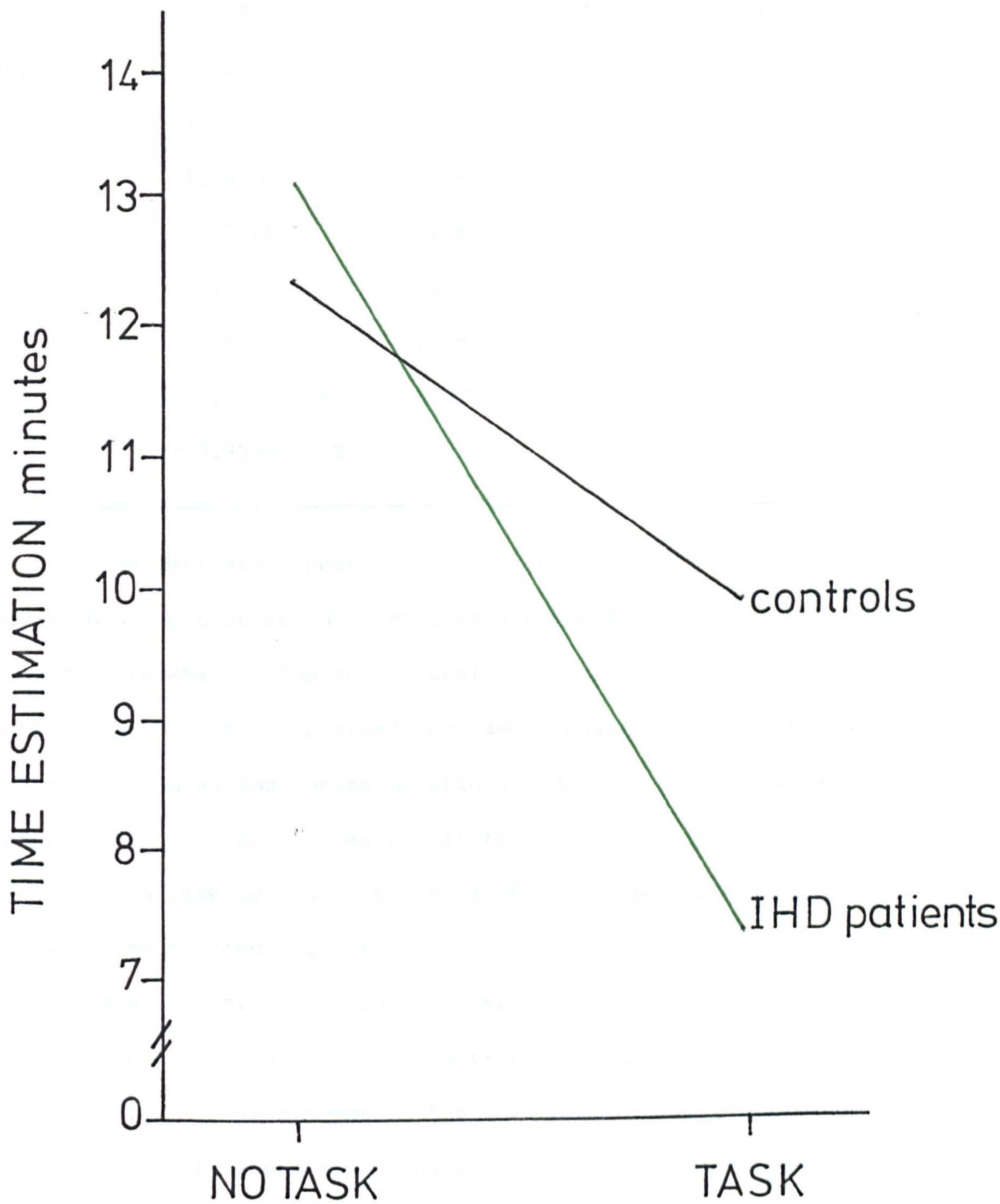
The effects of both noise and task were significant at the 0.05 level on the subjective reports of stress by the control subjects. There were no significant effects of either noise or task on the reports of the IHD patients. No effects of noise or task on blood glucose changes in IHD patients were apparent either and it is therefore not particularly surprising that their reported experience of stress was unaffected by these factors. However, the blood glucose results do suggest that IHD patients showed greater sympathetic arousal in response to the task sessions than the controls. It may therefore be expected that IHD patients would more often report the experimental session to be stressful. However, this was not the case; 13 IHD patients reported some degree of stress while 16 of the controls reported that they felt stressed. It appeared that, if the IHD patients manifested greater sympathetic arousal than the controls, they either did not recognise this activation as a response to stress or they did not report it as such. This question is further considered in this chapter in the discussion of patients' perception and experience of stress in the form of life events.

1.5. Time Estimation: Results and Discussion

Estimates of duration by IHD patients were significantly affected by performance of the task ($F=11.582$, $DF1,28$, $P=0.00203$**). There was no evidence of noise effects. Comparison with the controls showed that task affected both groups in a similar way; performance of the task was associated with shorter estimates of time and this effect was greater in the IHD group, (figure 39). Table 47 summarises the results of the analysis of variance.

Figure 39: Time Estimation by IHD Patients and Control Subjects

Shorter time estimations were given by both groups when performing the task ($p=0.00214^{**}$). The interaction was not significant.



TIME ESTIMATION minutes
14
13
12
11
10
9
8
7
0
controls
IHD patients
NO TASK
TASK

Table 47: Summary of Analysis of Variance of Time Estimations

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A IHD/Controls	12.2500	1	12.2500	0.488	56	n.s.
B Task/No task	260.0156	1	260.0156	10.360	56	0.00214**
C Noise 50/80	23.7656	1	23.7656	0.947	56	n.s.
AB	43.8906	1	43.8906	1.749	56	0.19140
AC	0.7656	1	0.7656	0.031	56	n.s.
BC	0.2500	1	0.2500	0.010	56	n.s.
ABC	7.5625	1	7.5625	0.301	56	n.s.
Within	1405.4375	56	25.0971			
Total	1753.9375	63				

Clearly the time estimation data did not reflect the differences between the groups in blood glucose and performance measures. In the experimental groups studied (diabetic, IHD and control subjects) shorter estimates of time were given when they performed the task compared with the estimates given after sitting at the apparatus without working. It was suggested in Chapter 3 from Ornstein's theory that this finding might be due to the memory of the task period in the form of one 'chunk' of information. Shorter estimates of time might be given than when several 'chunks' of information were stored. When subjects were not concentrating on the task but were able to direct their attention to a variety of stimuli or thoughts, they could have remembered the session in terms of several discrete 'chunks'. Although it was hypothesised that longer time estimates would reflect heightened arousal levels there was no reason to suppose that subjects were less aroused in the task condition. It is far more reasonable to suppose that time estimations are sensitive to factors other than arousal levels, in particular, the demands of the task. Levels of arousal therefore can not be reliably assessed in terms of time estimations.

1.6. Personality Measures: Results and Discussion

Means and standard deviations of E (extraversion) and N (Neuroticism) scores for IHD and control groups are presented in Table 48 along with the statistics from Eysenck's (1959) standardisation groups.

Table 48: Means and Standard Deviations of E and N scores

	IHD		Controls		'Normal English Sample'(Eysenck)		'Psychosomatic Sample'(Eysenck)	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
E	25.59	8.82	27.13	9.30	24.91	9.71	25.38	9.33
N	23.97	10.20	20.97	11.20	19.89	11.02	35.69	10.89

While the E scores of the IHD patients were similar to those of the other groups, the N scores were somewhat higher than the control group's and Eysenck's 'Normal English Sample'. However, the N scores of the IHD patients did not approach the level of those of Eysenck's 'Psychosomatic Sample'. Unfortunately Eysenck did not define the characteristics of this 'psychosomatic sample'. There was little reason to suppose from previous studies of the personality of IHD subjects that this group of IHD patients would differ from the controls in terms of their E and N scores. The characteristics of Type A people (see Chapter 1, Section 5.2) who have been associated with an increased risk of IHD, were not clearly related to the overall measures of E and N.

The only correlation between IHD patients' E and N scores with other dependent variables that was statistically significant was that between E and the measure of body weight, (actual-ideal weight). The less extraverted the subject the heavier was his body weight ($r= -0.40$, $N=32$, $P<0.05$*).

No such relationship was found in the control subjects (r=0.06, N=32, n.s.). The IHD patients were less overweight (Mean A-I wt.=5.6lbs, s.d.=21.6) than the controls (Mean=9.1, s.d.=24.7). This finding was surprising given the much quoted relationship between IHD and excess body weight. However, it was possible that the IHD patients would have been encouraged to lose weight and were more concerned about their weight than the controls. The reason for the negative correlation between E and weight in IHD patients was unclear.

1.7. Summary and Conclusions of Laboratory Study

The hypothesis that IHD patients would demonstrate an exaggerated reaction to noise stress was not supported by the blood glucose changes that occurred. However it was apparent that IHD patients showed a blood glucose response to the experimental task period that was different from that of the controls. It was suggested that the increase in blood glucose shown by IHD patients during the task period may reflect more marked sympathetic activity in these patients.

This physiological response was not, however, associated with an increase in the number of subjects reporting subjectively experienced stress.

Performance of IHD patients was poor in comparison with the control groups. Practical and ethical constraints prevented sufficient control of extraneous variables which may have accounted for the observed differences. However, it did not appear that the apparent increase in glucose mobilisation improved performance in the manner that might be predicted from the results of studies with healthy subjects by Cox and Simpson and their colleagues (1973, 1974). On the contrary, performance was impaired. It was more likely that the apparent increase in sympathetic activity was maladaptive in this situation which may be compared with Frankenhaeuser's 'overstimulating' conditions.

Although the IHD patients were incapable of meeting the demands of the task as efficiently as the controls, they reported that they experienced the task as stressful less often than the controls. It was not possible to deduce whether this diminished reporting of stress was due to diminished experience of stress or whether it was due to a tendency to deny the experience of stress. The following studies examined the psychological response of MI patients to life events and their perception and use of the concepts employed in describing the stressfulness of such events.

2. Experiment 6: Ratings of Life Events by Myocardial Infarction and Control Patients

This investigation attempted to replicate the study by Lundberg, Theorell and Lind (1975) using a sample of British patients with a history of MI. Theorell and his colleagues had studied 51 male and 5 female survivors of MI and 33 healthy control subjects. The purpose of their study was to differentiate between infarction patients and control subjects on the basis of life change data. Forty-six life change events were presented in a questionnaire that was posted to subjects. The MI patients reported those life changes that they had experienced during the year before their infarction. The reports were given 6 to 24 months after the infarction. The control subjects reported their life changes for a corresponding period of time. The number of events did not differ significantly between the two groups. Six months after they had reported the life changes the subjects were sent one of the two versions of the life change questionnaire. Half of the subjects were asked to estimate how 'upsetting' each of the 46 events would be. The other subjects were asked to rate each event for the amount of 'adjustment' that would be required.

Three types of life change scale were constructed.

1. A total mean scale from ratings of all subjects.

2. Separate mean scales for MI subjects and control subjects.

3. Individual scales using the estimates of each subject.

Total life change scores were calculated for the two variables by adding the scale values for reported events using the three types of scales alternatively. It was found that the MI subjects had higher total life change scores than the controls. The difference between the groups was larger for 'upsetting' ratings than for 'adjustment' and it was in both cases more pronounced when individual scales were used. It was therefore clear that the difference in total life change scores was greater between MI and control subjects when the subjects' own ratings were used rather than the ratings from either a general population or a sample of MI subjects.

The present study investigated differences in ratings between a sample of MI patients and a group of patients sustaining disorders unrelated to MI. It was hoped that the use of such a control group would reduce the risk of response bias leading to greater reporting and higher ratings of life change by MI patients in an attempt to 'explain' their illness.

It was hypothesised (after Lundberg, Theorell and Lind) that MI patients would rate events as more upsetting and requiring more adjustment than the controls. Higher ratings by MI patients may reflect the tendency towards sympathetic overactivity in such patients. However, it should be borne in mind that although the blood glucose results of experiment 2 supported the hypothesis that MI patients would exhibit greater sympathetic overreactivity, measures of subjective experience did not suggest that these subjects found the experimental conditions any more stressful than the controls.

2.1. Method

Subjects The sample of MI patients consisted of 34 male inpatients at the Nottingham City Hospital who had a history of IHD. The patients were either due for return home after recovery from MI, were under observation after a suspected infarction or were admitted with some other medical problem. All patients had survived at least one MI. The ages of these patients ranged from 39 to 73 years. 15 of the 34 MI patients rated the questionnaire for adjustment. The other 19 patients rated it for upsetting.

A sample of 22 control subjects comprised inpatients from the same medical wards as the MI patients. These patients were suffering from a variety of illnesses unrelated to IHD. The disorders were, on the whole, those with recurring acute episodes such as bronchitis or asthma. In this way it was hoped to equate for the chronic nature of IHD with its recurring episodes of MI. A smaller proportion of control patients were recovering from acute viral infections such as meningitis or polyneuritis. The ages of the control patients ranged from 24 to 76 years. 11 controls rated the life events for adjustment, 11 rated them for upsetting.

Questionnaire The questionnaire was previously used by Lundberg, Theorell and Lind and has been described in Chapter 4, Section 1.1.

Procedure The nature of the questionnaire was described to each subject individually on the ward and each subject was asked whether he would be willing to complete one. The experimenter then went through the instructions with the subject to ensure that they were understood. The subject was then left to complete the questionnaire with the experimenter returning occasionally to answer any questions that had arisen. None of the subjects approached refused to participate in the study.

2.2. Results and Discussion The ratings of MI patients were compared with those of the control patients using analysis of variance.

Mean Ratings of Life Events There was no difference between the two subject groups in their mean ratings of all 46 events (F=0.121, DF 1, 52,n.s). Ratings of events were similar whether they were for upsetting or adjustment (F=0.589, DF 1,52, n.s.).

Sum of Ratings of Experienced Events There were no differences in the ratings of the two forms of the questionnaire; upsetting or adjustment. However, there was some evidence to suggest that MI patients gave higher ratings to experienced events than controls (F=2.204, DF 1,52, P=0.14372 n.s.). This trend approached significance for the number of experienced events.

Number of Experienced Events Infarction patients reported that they had experienced more life events over the 12 month period than control patients (F=2.972, DF 1,52, P=0.09065). The difference between the number of events experienced by MI and control patients was greater than the difference between the sum of ratings of those events. This suggested that infarction patients were rating their experienced events as less upsetting and requiring less adjustment than were the controls.

In contrast to Lundberg, Theorell and Lind's findings the present data suggests that MI patients reported more life events but rated them as less disturbing. Lundberg and his colleagues compared their infarction patients with healthy control subjects. The healthy male controls from the study of life change in diabetic patients were therefore used for comparison with the infarction patients and hospitalised controls.

The number and ratings of experienced life events were compared across the three groups. Items 41 to 45 on the questionnaire were excluded. These items concerned smoking, drinking and physical exercise habits. Such life changes were most often reported by the infarction patients and least often by the healthy controls. The patient groups and particularly the infarction patients would have been encouraged by physicians to abstain from smoking and possibly drinking and to limit their exercise as a direct result of their disorder. To include these items would therefore have given an exaggerated impression of the number of life events experienced by these patients.

Analysis of variance showed that the three groups, MI patients, hospital controls and healthy controls differed significantly both in the number of events reported and the ratings assigned to those events, (Tables 49 and 50).

Table 49: Summary of Analysis of Variance: Sum of ratings of experienced events for the three groups

SOURCE	SUM OF SQUARES	DF1	VAR. EST.	F	DF2	P
A MI/Hosp.C/ Conts.	$2.8962_{10}+05$	2	$1.4481_{10}+05$	4.491	80	0.01417*
B Ups/Adj.	3881.9670	1	3881.9670	0.120	80	n.s.
AB	15951.4999	2	7975.7499	0.247	80	n.s.
Within	$2.5793_{10}+06$	80	32241.8400			
Total	$2.8888_{10}+06$	85				

Figure 40 shows that infarction patients reported more life events than the hospital controls. The healthy controls reported fewer life events than the patient groups. This finding was reflected in the sum of ratings of experienced events (Figure 41). Differences between

Figure 40: Number of Experienced Life Events Reported by MI Patients, Hospital Control Patients and Healthy Control Subjects

The difference between the groups was significant ($p=0.01134$*)

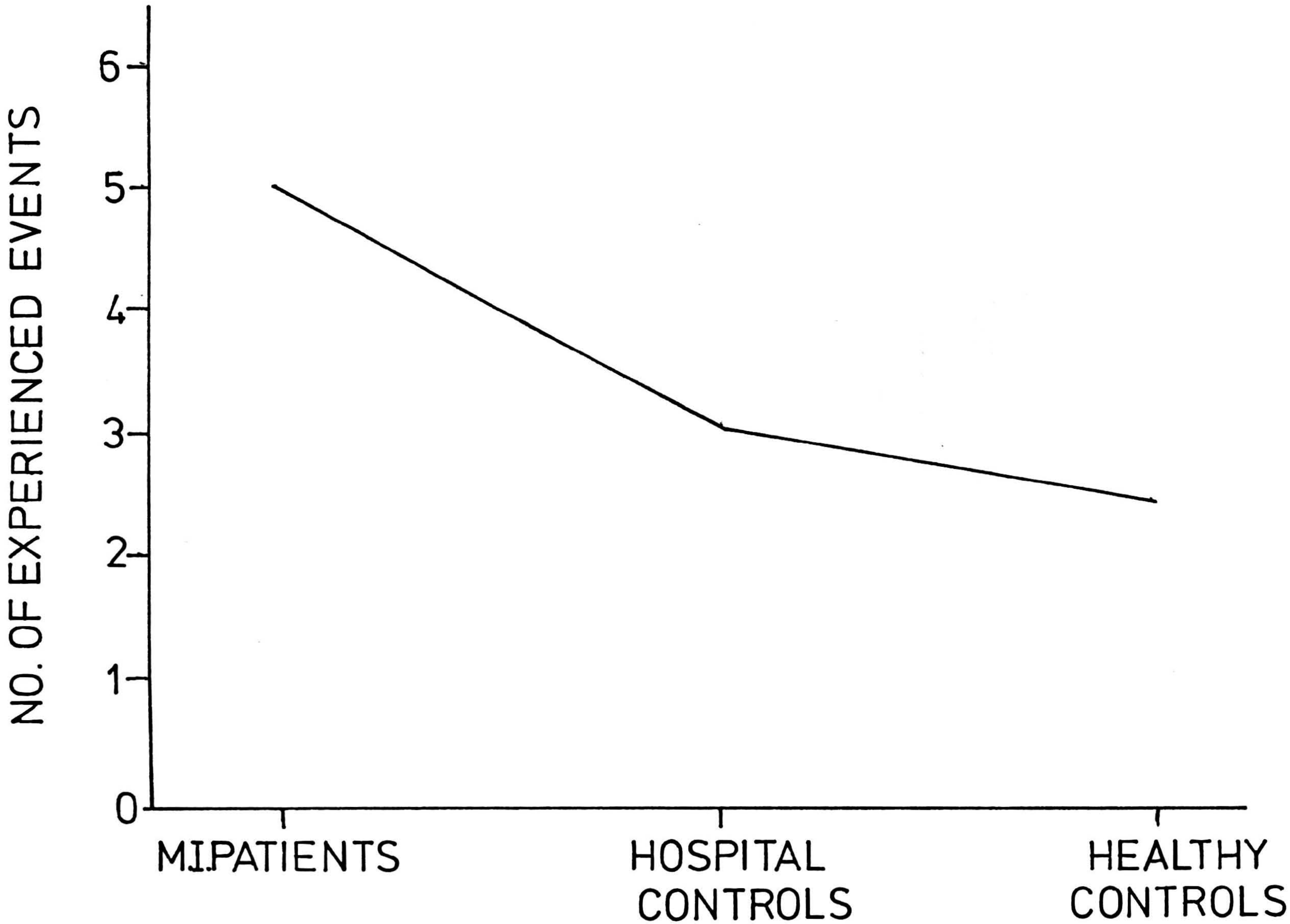

NO. OF EXPERIENCED EVENTS
6
5
4
3
2
1
0
M.I.PATIENTS
HOSPITAL CONTROLS
HEALTHY CONTROLS

Figure 41: Sum of Ratings of Experienced Events Reported and Rated by MI Patients, Hospital Control Patients and Healthy Control Subjects

The difference between the groups was significant ($p=0.01417^*$)

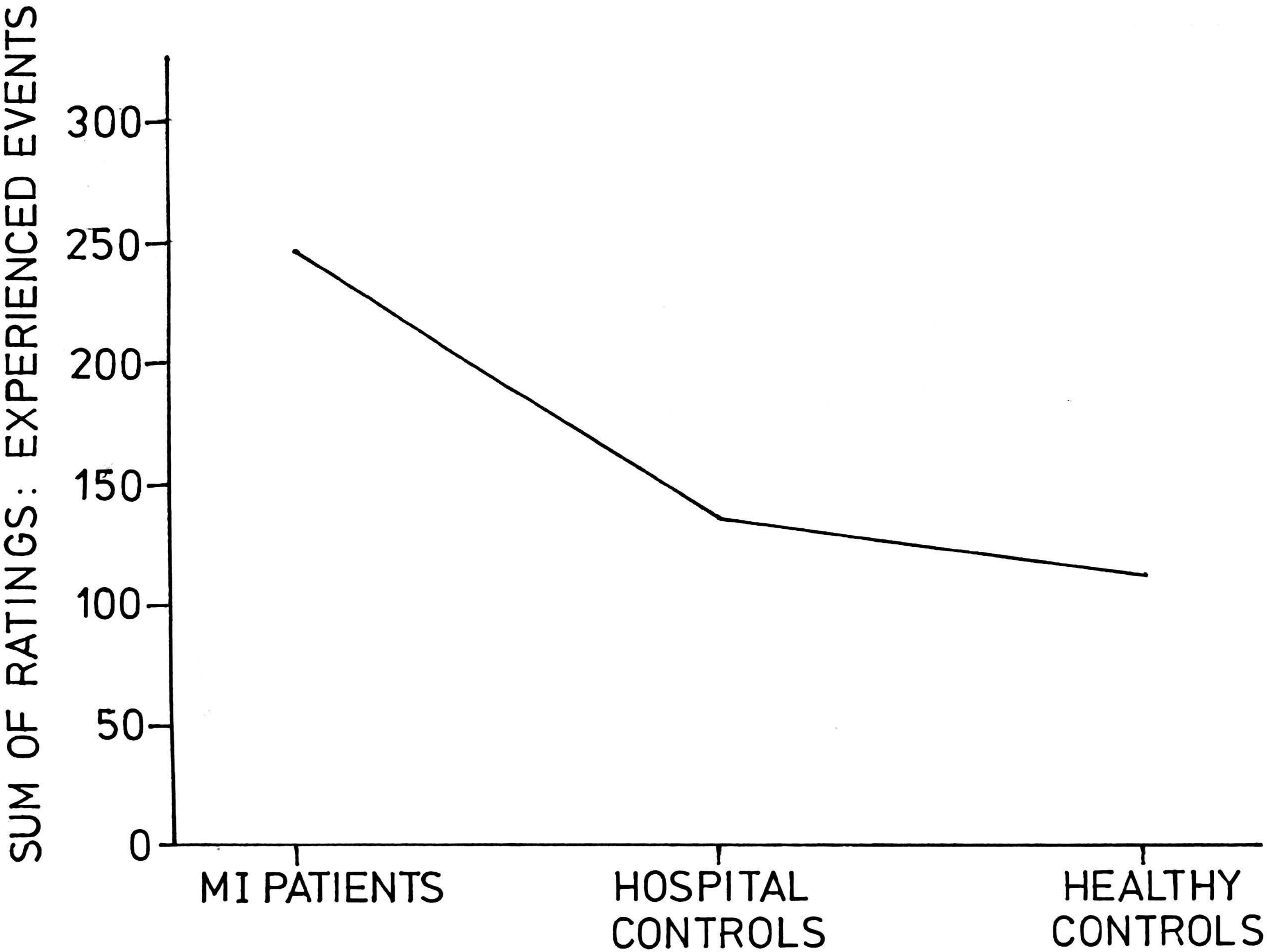

SUM OF RATINGS: EXPERIENCED EVENTS
300
250
200
150
100
50
0
MI PATIENTS
HOSPITAL CONTROLS
HEALTHY CONTROLS

Table 50: Summary of Analysis of Variance: Number of Experienced Life Events Reported by the Three Groups

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A MI/Hosp.C/ Controls	108.8672	2	54.4336	4.740	80	0.01134*
B Ups./Adj.	27.4588	1	27.4588	2.391	80	0.12597
AB	3.7943	2	1.8971	0.165	80	n.s.
Within	918.6992	80	11.4837			
Total	1058.8192	85				

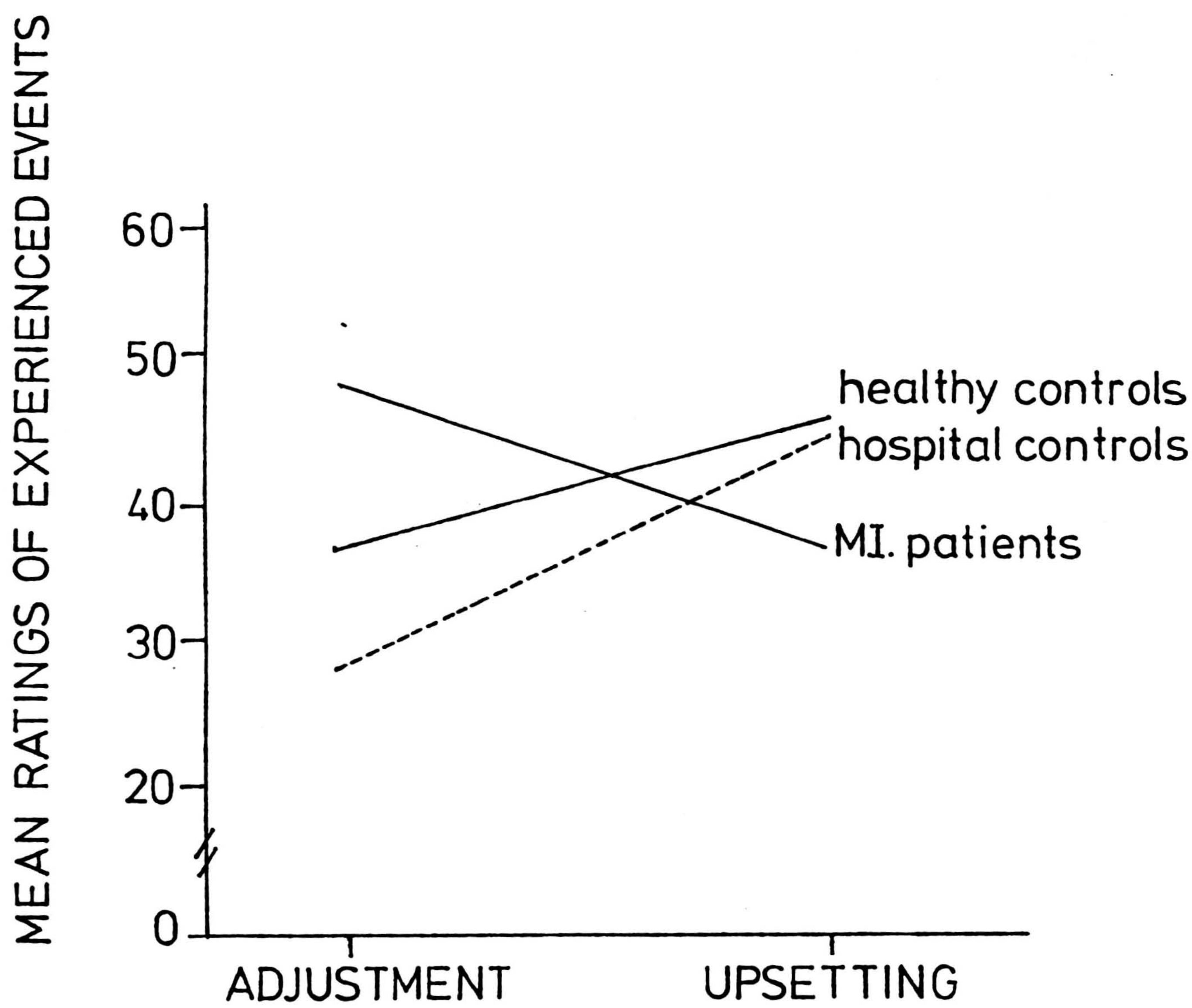
the upsetting and adjustment ratings were not significant.

In order to compare the ratings of experienced events independently of the number of reported events, the mean ratings of experienced events were calculated (sum of ratings of experienced events ÷ number of events reported. Analysis of variance showed that there were no significant differences between the three groups in the level of rating of experienced events, (F=0.301 DF 2,80 n.s.). Figure 42 suggests that there was an interaction between subjects and the form of the questionnaire. The MI patients gave lower ratings to experienced life events on the upsetting questionnaires and higher ratings on the adjustment questionnaires. This trend was reversed in both the control groups. The Analysis of variance showed that the interaction was not statistically significant, (F=1.291, DF 2,80, P=0.28074 n.s.).

There was, therefore, no evidence to support the findings of Lundberg, Theorell and Lind that infarction patients rated experienced events as more upsetting and as requiring more adjustment than controls. On the contrary there was a tendency for the difference between the number of reported events to be greater than the difference between the sum of ratings suggesting that infarction patients were under-

Figure 42: Mean Ratings of Experienced Events by MI Patients, Hospital Control Patients and Healthy Control Subjects

The apparent interaction between the groups was not significant.


MEAN RATINGS OF EXPERIENCED EVENTS
60
50
40
30
20
0
healthy controls
hospital controls
MI. patients
ADJUSTMENT
UPSETTING

estimating the disturbance of such events in comparison with controls.

The following study investigated the perception of the meanings of the terms 'upsetting' and 'adjustment' by infarction patients and hospitalised controls to examine any differences in the use of the concepts by the two groups.

3. Experiment 7: Study of the use of the concepts 'upsetting' and 'adjustment' by MI patients and hospitalised controls using Semantic Differential Scales

The semantic differential scales (Chapter 2, Section 12) were used in the manner described in Experiment 4, Chapter 4.

Subjects 15 male MI patients participated in the study. They were drawn from the same inpatient population described in Experiment 6. The 15 control inpatients were from the same control population that was also described in Experiment 6.

Procedure The procedure was similar to that followed in the previous life events study (Experiment 6). Patients on the wards were given the scales and guided through the instruction sheet before being left to complete the scales. The experimenter was available to answer any queries.

3.1. Results and Discussion The data were treated in the manner described in Experiment 4, Chapter 4. The data from this study were combined with the diabetic and control data for factor analysis which elicited two major factors for each of the 3 concepts 'adjustment', 'upsetting' and 'trouble'.

There were again no obvious differences in the pattern of the scale groupings between the MI and hospital control patients suggesting that there were no qualitative differences in the understanding of the concepts. The same scales loaded relatively highly on each of the concepts for both MI and control patients.

Quantitative differences in factor scores were examined using analysis of variance. The scales loading on each factor have been listed in Table 41, Chapter 4.

Adjustment There was some difference between MI and control patients' ratings of adjustment in Factor 1 scores, (F=3.634 DF 1,28 P=0.06691). While both groups tended to evaluate the term in a positive way, MI patients evaluated the term more highly than controls (figure 43).

Factor 2 also contained some evaluative scales but included activity scales that were not loaded on Factor 1. MI and control patients did not differ significantly in their scores on this second factor (F=0.654 DF 1,28 n.s.). Infarction patients tended to see adjustment as a slower process than controls but other differences on Factor 2 scales were small, (figure 44).

It was again apparent that subjects were not using the term adjustment in the same manner in which it was employed in the life events questionnaire. They were considering the process of adjustment rather than the need to adjust to an event: the concept was seen in a more positive way.

Upsetting The MI patients and their controls differed to some extent in their understanding of the concept upsetting on factor 1 (F= 3.735 DF 1,28, P=0.06346); factor 2 scores were significantly different (F=4.605 DF 1,28 P=0.04070*). Infarction patients were more positive in their evaluation of upsetting than their controls (figure 45) who rated the term in a manner similar to the diabetics i.e. they were significantly more positive than the healthy controls.

Healthy Controls	Hospital Controls	Diabetic Patients	MI Patients

Evaluation ⟶

Figure 43: Mean Factor Scores for the Concept 'Adjustment' Rated by MI Patients and Hospital Control Patients

MI patients tended to give higher evaluation scores for adjustment than the controls($p= 0.06691$).
The groups did not differ significantly in their factor 2 scores.

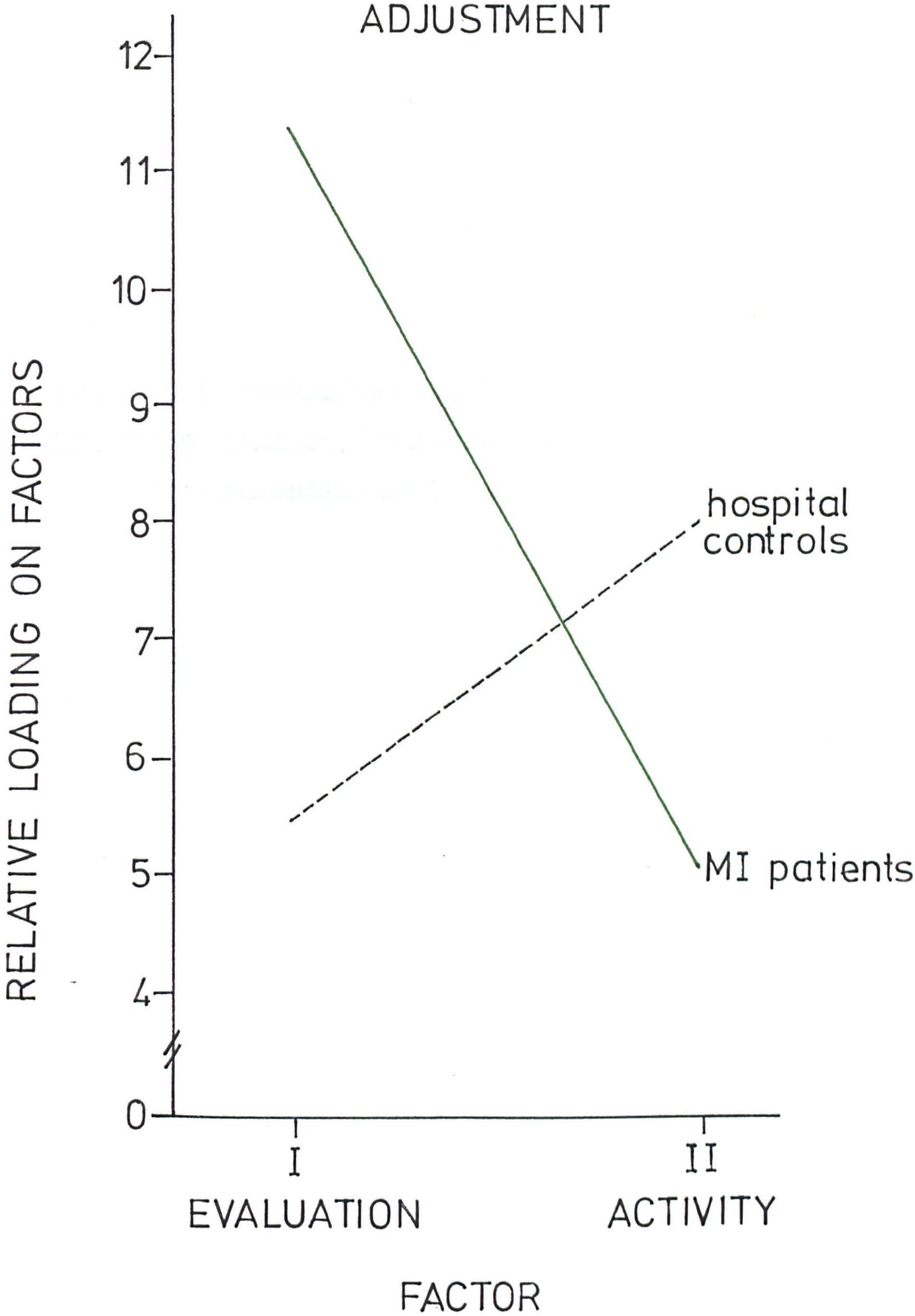
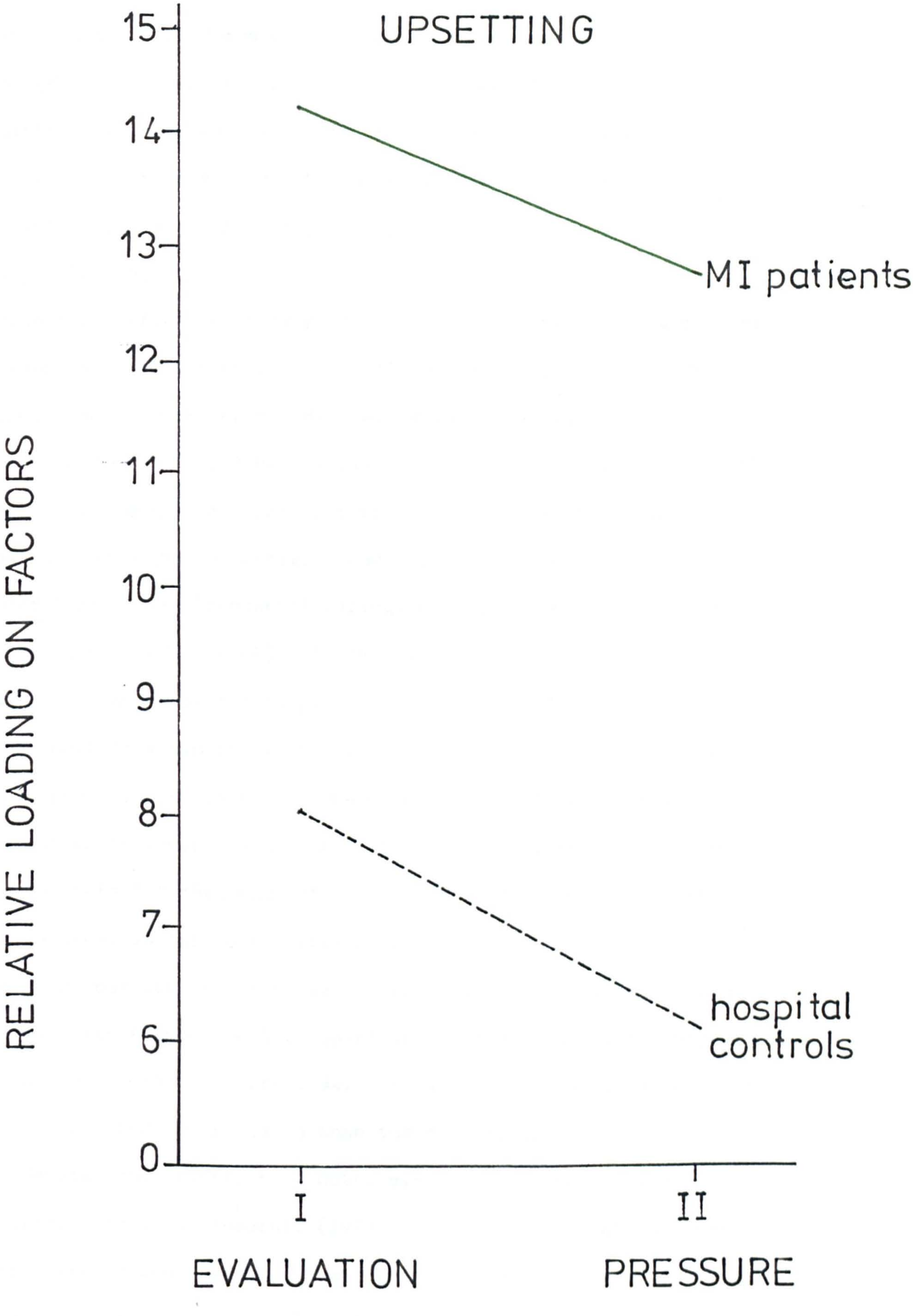

ADJUSTMENT
RELATIVE LOADING ON FACTORS
12
11
10
9
8
7
6
5
4
0
hospital controls
MI patients
I
EVALUATION
II
ACTIVITY
FACTOR

Figure 44: Semantic Profile Showing Mean Scale Ratings of the Concept 'Adjustment' by MI Patients and Hospital Control Patients


ADJUSTMENT
1
2
3
4
5
6
7
good
bad
straight
curved
tight
loose
relief
worry
permanent
temporary
attractive
unattractive
excitable
calm
emotional
unemotional
cheerful
miserable
pleasant
unpleasant
active
passive
angry
peacful
import.
unimportant
positive
negative
interesting
boring
settled
unsettled
puzzling
understand.
hard
soft
strong
weak
fast
slow
timely
untimely
tense
relaxed
controllable
uncontrol.
masculine
feminine
----hospital controls
—— IHD patients

Figure 45: Mean Factor Scores for the Concept 'Upsetting' Rated by MI Patients and Hospital Control Patients

There was some difference between the groups in their scores on factor 1 (p=0.06346). Factor 2 scores were significantly different (p=0.04070*).


UPSETTING
RELATIVE LOADING ON FACTORS
15
14
13
12
11
10
9
8
7
6
0
MI patients
hospital controls
I
II
EVALUATION
PRESSURE
FACTOR

MI patients also rated the concept upsetting as more active and potent (factor 2) than the other groups. Thus although they may be minimising the negative components of the concept they did not deny the 'pressure' or 'force' of the concept: they saw upsetting as strong, fast, active and masculine (figure 46).

Trouble The pattern of response was similar to that for upsetting although the differences between MI and control patients were smaller. The groups did not differ significantly on factor 1, (F=1.009 DF 1,28 P=0.32401) and the difference did not quite reach significance on factor 2 (F=3.089 DF 1,28 P=0.09014). Figure 47 shows a similar pattern to that of the graph for upsetting with MI patients rating higher on evaluation and higher on activity and potency ('pressure'). The results obtained from Jenkins' subjects' ratings of trouble are included on the semantic profile (figure 48). It can be seen that Jenkins' means did not match the means of the hospital controls as well as those of the healthy controls shown in figure 34. The responses of the hospital controls resembled those of the diabetics; in particular they were less negative in their evaluation of the concept trouble. It is of particular interest that the infarction patients used the term upsetting in a less negative but more active/potent way than either group of controls and particularly the healthy controls. It appeared that while the MI patients recognised the impact of an upsetting event, they found such experiences less unattractive, less unsettling and more positive, understandable and controllable than the control groups.

Several researchers have noted similar reactions in their studies of patients with IHD. Theorell (1977, personal communication) observed that MI patients would strive to maintain control over their environment by refusing to acknowledge that events were beyond their control.

Figure 46: Semantic Profile Showing Mean Scale Ratings of the Concept 'Upsetting' by MI Patients and Hospital Control Patients

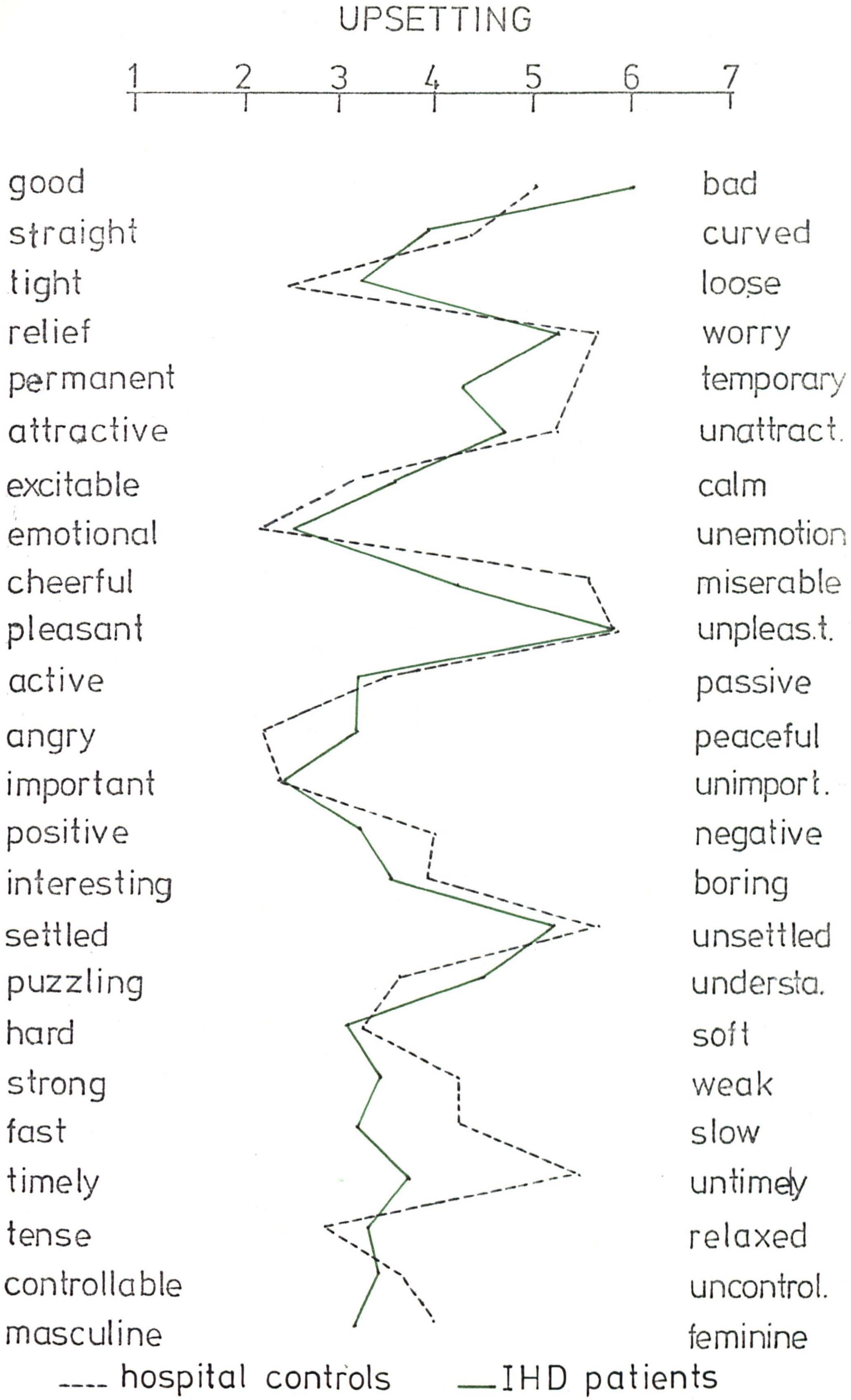
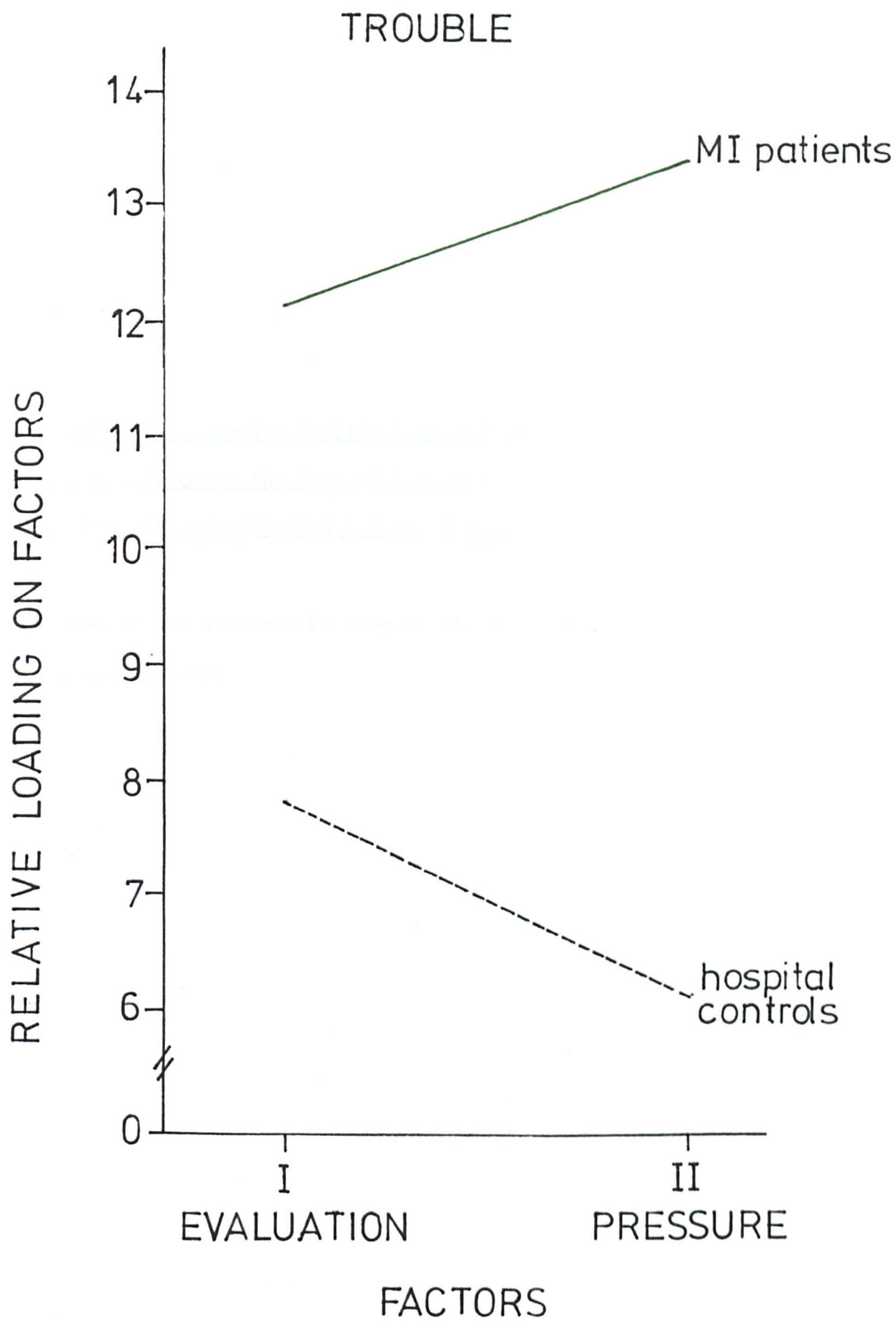

UPSETTING
1 2 3 4 5 6 7
good
straight
tight
relief
permanent
attractive
excitable
emotional
cheerful
pleasant
active
angry
important
positive
interesting
settled
puzzling
hard
strong
fast
timely
tense
controllable
masculine
bad
curved
loose
worry
temporary
unattract.
calm
unemotion
miserable
unpleas.t.
passive
peaceful
unimport.
negative
boring
unsettled
understa.
soft
weak
slow
untimely
relaxed
uncontrol.
feminine
---- hospital controls
— IHD patients

Figure 47: Mean Factor Scores for the Concept 'Trouble' Rated by MI Patients and Hospital Control Patients

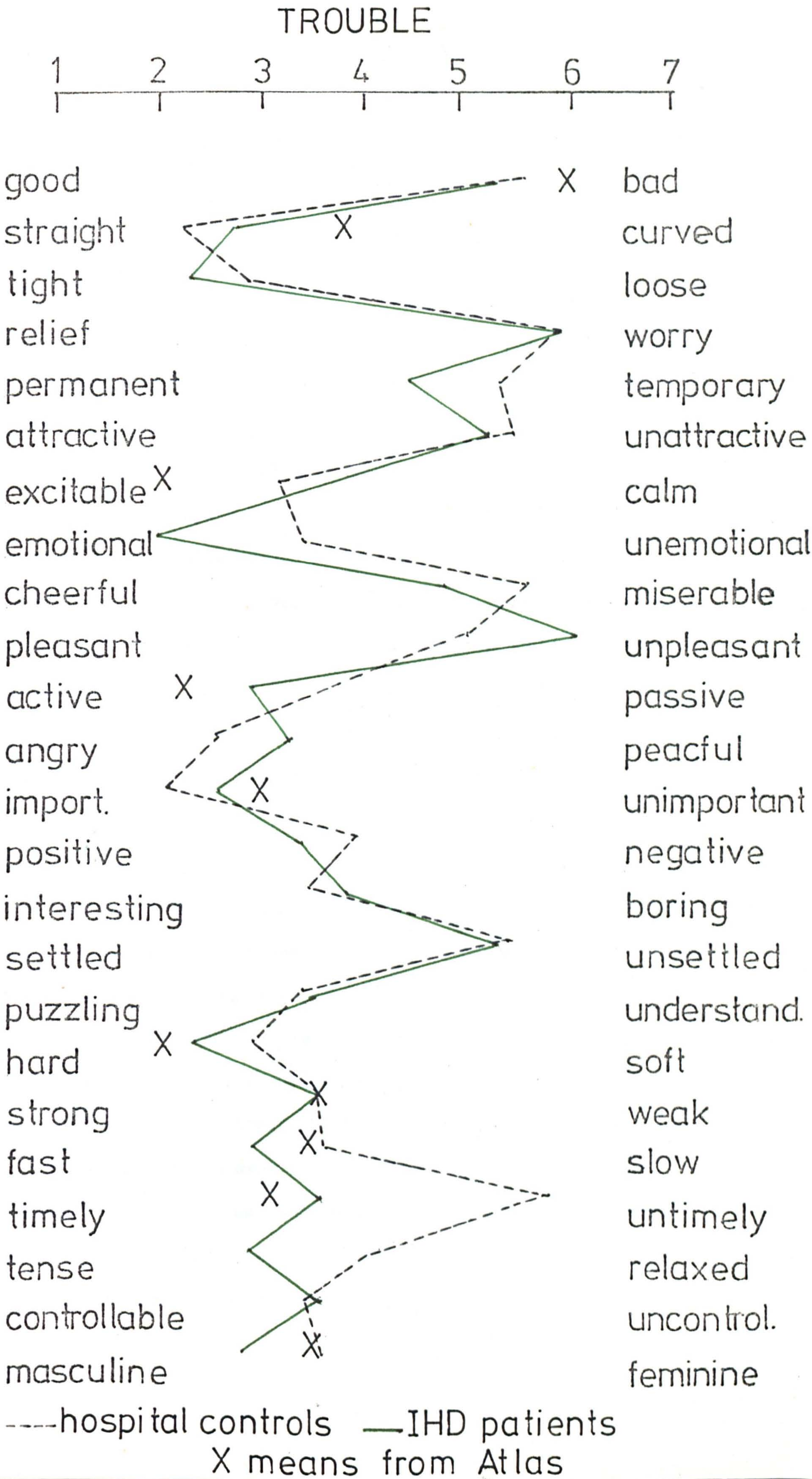
The groups did not differ significantly in their factor 1 scores. Differences in facter 2 scores did not quite reach significance (p=0.09014).



TROUBLE
14
13
12
11
10
9
8
7
6
0
RELATIVE LOADING ON FACTORS
MI patients
hospital controls
I
EVALUATION
II
PRESSURE
FACTORS

Figure 48: Semantic Profile Showing Mean Scale Ratings of the Concept 'Trouble' by MI Patients and Hospital Control Patients

The mean values obtained by Jenkins are included for comparison (x)


TROUBLE
1
2
3
4
5
6
7
good
bad
straight
curved
tight
loose
relief
worry
permanent
temporary
attractive
unattractive
excitable
calm
emotional
unemotional
cheerful
miserable
pleasant
unpleasant
active
passive
angry
peacful
import.
unimportant
positive
negative
interesting
boring
settled
unsettled
puzzling
understand.
hard
soft
strong
weak
fast
slow
timely
untimely
tense
relaxed
controllable
uncontrol.
masculine
feminine
----hospital controls
—IHD patients
X means from Atlas

Tibblin, Lindström and Ander (1972) noted that

> 'The denial of fear is commonly found in coronary care units. In many cases it means an unusual ability to deny being frightened rather than to accept the fear at face value. Fear or reasonable concern is so appropriate for myocardial infarction patients that its total absence is peculiar.'

The present results suggest, however, that MI patients were not denying the impact of upsetting events, they were merely construing the upset in a more positive way. It is possible that MI patients welcome the stimulation that upset or trouble brings and perhaps actively seek such stimulation. Certainly the life change data showed that MI patients reported that they had experienced more life events. Their ratings of these experienced events as upsetting tended to be lower than controls' and in this sense they appeared to be minimising the consequences of such events. However, this is not to say that they did not experience physiological responses to stressful events. Indeed MI patients rated trouble as highly emotional (figure 48) - considerably more so than the controls. However their cognitive evaluation of this reaction tended to be more positive.

The findings of the laboratory experiment (Experiment 5) showed that while the IHD patients demonstrated blood glucose responses suggesting greater sympathetic arousal in response to the task period they reported that the experience was less stressful than did the controls. It appeared that the subjective assessment of stressful experience by MI patients did not reflect their physiological response.

The results of these experiments suggest that the ratings of stressful experiences by MI patients underestimate the physiological impact that such experiences have. Since the physiological effects of such experiences may be more dramatic in MI patients than in their controls the subjective estimates of control subjects may also be underestimates of the impact of such experiences on MI patients. Lundberg, Theorell and Lind (1975) found that MI patients rated experienced events as more upsetting and requiring more adjustment than controls. The findings of the present study suggest that these differences may actually be even greater than they appeared since MI patients tend to minimise the negative aspects of disturbing events.

4. Summary and Conclusions

It was found that MI patients reported that they had experienced more life change events in the previous year than either the hospital controls or the healthy controls. MI patients did not rate these events as more upsetting or requiring more adjustment than the controls as Lundberg, Theorell and Lind had previously found in their Swedish study. On the contrary, there was a tendency for the present MI sample to rate the events as less upsetting than did the controls.

The results of the semantic differential study showed that MI patients understood the concepts 'upsetting' and 'trouble' in more active/potent terms than the controls. However, they were also more positive in their evaluation of these concepts. While MI patients were not denying the 'force' or 'pressure' of upset or trouble they were denying the negative aspects of the terms. The MI patients' physiological emotional response to an upsetting event may therefore be greater than their subjective estimates of stress would suggest. The results of Experiment 5 showed that there was little subjective reporting of stress although the objective measures suggested a considerable physiological response. The MI patients' subjective estimates of stress may therefore provide a false impression of the extent of the physiological reaction.

CHAPTER 6

HEALTHY SUBJECTS; STUDIES OF FACTORS AFFECTING THE RELATIONSHIP BETWEEN GLUCOSE, NOISE AND PSYCHOMOTOR PERFORMANCE

This chapter is concerned with questions arising from various studies which investigated blood glucose changes during skilled performance under noise stress.

The laboratory studies on diabetic, IHD and control subjects reported in chapter 3 and 5 of this thesis arose from the work of Simpson, Cox and Rothschild (1974). In this study of the response of healthy subjects to noise stress, they found that performance was impaired by 80dB noise but that this impairment was attenuated by preloading with 18gms glucose. The preloaded subjects showed a fall in the high blood glucose levels induced by glucose preloading when subjects were working under 80dB noise. Preloading in the quiet condition impaired performance without a significant fall in blood glucose.

The control subjects studied in the hospital experiments described earlier in this thesis produced different results some of which could not be adequately accounted for without further experimentation. The no glucose group showed blood glucose changes comparable with those of the equivalent group in Simpson, Cox and Rothschild's work (see figures 21 and 22). However, no performance impairment was found to result when subjects were working under noise. It was suggested that differences in the task situation itself increased the difficulty of the task in the hospital studies. There was evidence to suggest that the task was found to be more stressful than the noise. The task inherent stress might have obscured noise effects on performance.

The 30gm glucose preloaded hospital controls did not show the significant differences in performance under the two levels of noise that were found with Simpson, Cox and Rothschild's 18gm preloaded subjects. Again this result might be accounted for by the difference in task inherent stress. However, the blood glucose changes observed were completely different. The glucose preloaded hospital controls showed greater decreases in blood glucose levels at 50dB than at 80dB. There was some indication that improved performance was associated with greater falls in blood glucose in the hospital study although the conditions under which these responses occurred were different from those in the Simpson, Cox and Rothschild study.

Lundberg and Frankenhaeuser have since reported (1976) results which suggest that when performance is maintained under noise stress by an increase in effort, higher subjective and physiological costs are involved than when performance is impaired. In the Simpson, Cox and Rothschild study, the fall in blood glucose associated with a lack of impairment in performance with 80dB noise may be seen to represent a 'higher physiological cost'.

The performance impairment due to noise was too small in the hospital studies to show any obvious association with blood glucose measures. However, the 30gm glucose preloaded controls tended to perform better in the quiet condition (which they reported to be more stressful than the noisy condition) and this slightly improved performance was associated with enhanced blood glucose decreases.

Poulton (1976; 1977) suggested that the impairment of performance at 80dB noise, found in Simpson, Cox and Rothschild's no glucose groups, might be due to the lack of auditory feedback from the programming equipment. Although this explanation would still leave the interactive effects of noise and glucose preloading on performance unexplained, this hypothesis has been given some consideration. Mackay, Cox and Freeman (1977; unpublished) tested the hypothesis directly by superimposing auditory feedback on the high and low noise levels and compared these conditions with equivalent 'no feedback' conditions. There was little support for Poulton's hypothesis in the data obtained.

The increase in stress from the task itself might account for the lack of significant noise effects on performance in the hospital studies. However the different blood glucose responses and performance measures of the 30gm glucose preloaded groups remained unaccounted for. Reduced significance of effects could have been accounted for by the increased variability of results associated with the more heterogeneous hospital population, however, the blood glucose results obtained from the glucose preloaded groups were significantly affected by noise and task but the <u>pattern</u> of results differed from that of the Simpson, Cox and Rothschild study. The time of day when testing took place differed between the university and hospital studies and it was possible that differences in arousal levels associated with time of day were affecting the level of performance. However by far the most dramatic differences between the two studies were the differences in blood glucose changes of the preloaded groups. It was therefore probable that the larger amount of glucose used in preloading the hospital subjects was the factor contributing most to the different pattern of results obtained.

An experiment was designed and carried out in conjunction with Mackay to test the hypothesis that increasingly loud noise levels can be titrated against increased amounts of glucose preloading. It was thought that 30gm glucose preloaded subjects might perform more efficiently under higher levels of noise. The experiment by Simpson, Cox and

Rothschild (1974) was therefore extended to examine the effects of 95dB noise levels and 30gm glucose preloading on performance at the pursuit rotor task. Cox and Mackay had already examined the effects of noise levels increased to 95dB on no glucose and 18gm preloadeu subjects. 95dB impaired performance of both groups compared with performance under 50 or 80dB noise. 18gm glucose appeared to attenuate performance impairment with 80dB noise but not with 95dB noise. The following experiment, run jointly by Mackay and Bradley (Bradley, Cox and Mackay; 1977), investigated the effects of 95dB noise and 30gm glucose preloading on performance measures with a comparable group of healthy student subjects.

1. Experiment 8: Titration Experiment; Investigation of the Effects of White Noise and 30gm Glucose Preloading on Performance

95dB noise had been shown to impair performance of no glucose and 18gm glucose preloaded subjects. It was hypothesised that performance would not be impaired by 95dB noise after 30gm glucose preloading. It was also hypothesised that 30gm glucose preloading would impair performance at 80dB and 50dB noise compared with that of the 18gm glucose and the no glucose groups respectively.

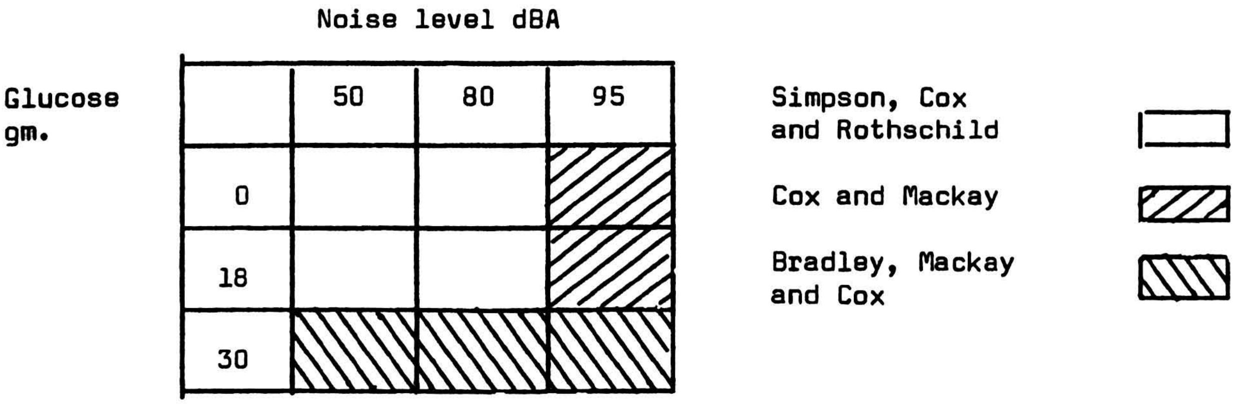
1.1. Method

Design

Three groups of 30gm glucose preloaded subjects performed the pursuit rotor task under one of the three noise levels 50dB, 80dB and 95dB.

The experimental procedure and task situation were identical to those used by Simpson, Cox and Rothschild in the original study and by Cox and Mackay in their extension of the experiment. The subjects were drawn from a similar population. It was felt that comparisons could reasonably be made between the nine groups described in table 51. A replication of the entire study was precluded by the amount of time that would have been involved and by the number of subjects that would have been required.

Table 51: Summary of design of titration experiment



All subjects performed the stellate pursuit rotor task (Section 8, Chapter 2). Time on target and deviation scores were measured. Only the time on target scores were compared since the number of deviations made from the light was not measured by Simpson, Cox and Rothschild.

Subjects 24 male students aged between 18 and 30 years from a College of Further Education participated in this study. All were healthy by their own report. Subjects were recruited by one of the two experimenters (CB or CJM). They were told that the session would involve three thumb prick blood samples and that they would be asked to work at a tracking task. The session would not last for more than an hour. Subjects were given an appointment to attend the laboratory. They were asked to fast for a minimum of three hours before this appointment. All appointments were in the morning between 10.00 and 12.45 hours. Subjects were randomly assigned to either the male (CJM) or the female (CB) experimenter who took all three blood samples.

(On two occasions it was necessary for practical reasons to involve both experimenters in blood sampling from the same subject).

Procedure The usual experimental procedure was followed. The first blood sample was taken (Section 1, Chapter 2), the subject was then given the glucose drink and told that it was one of a possible four harmless dietary substances - saccharin, glucose, water or caffeine. (This was the information given in the previous studies by Simpson, Cox and Rothschild (1974) and Cox and Mackay (submitted to J. Human Stress). The second blood sample was taken after a 30 minute waiting period. Subjects performed the task for 15 minutes and the final blood sample was then taken.

The MPI (Section 5, Chapter 2) was completed by subjects during the 30 minute wait. A SACL (Section 6.2., Chapter 2) was completed before and after the task period. The SEQ (Section 6.1., Chapter 2),concerned with the subjects' experience of the task period, was also completed after the task.

1.2. Results and Discussion

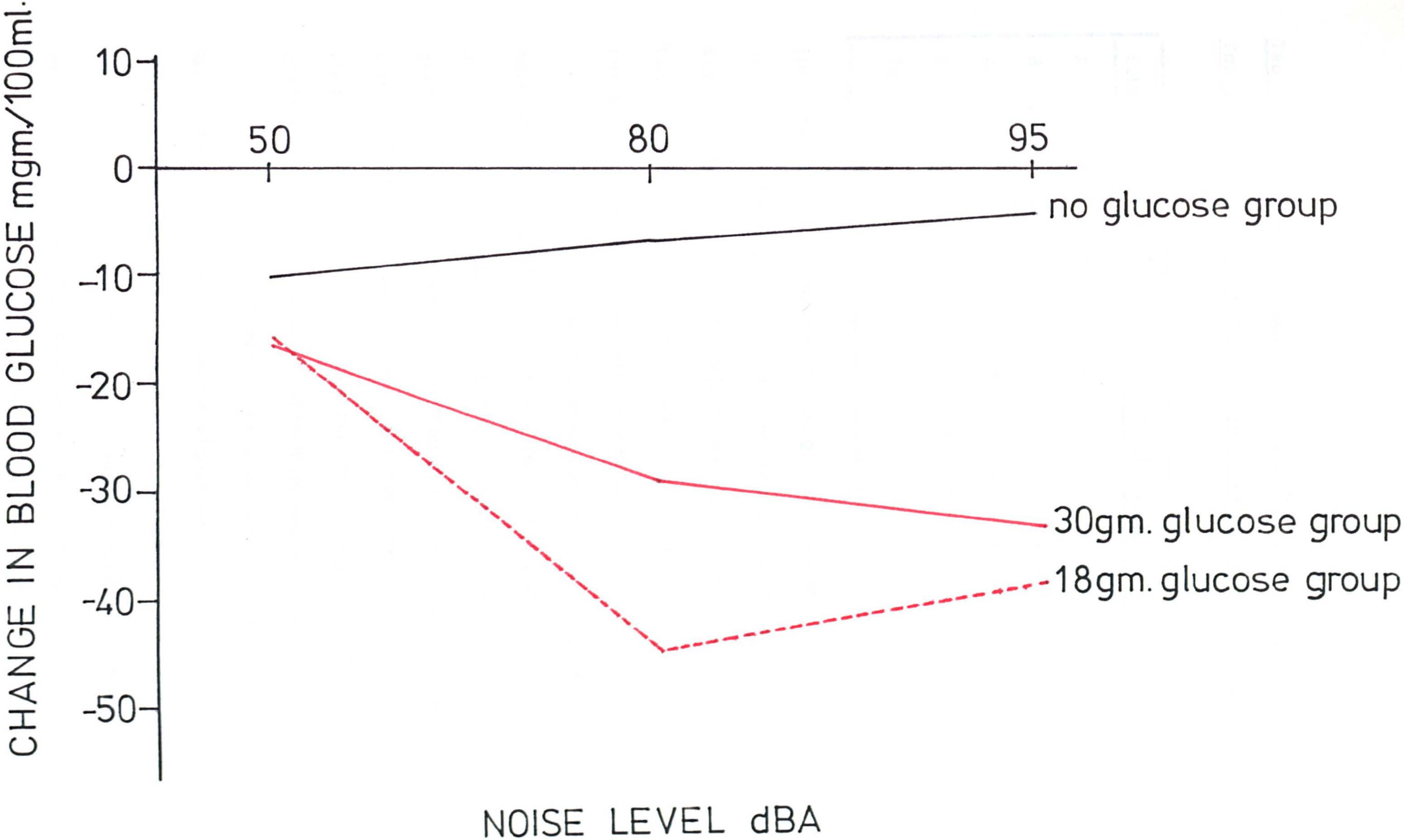
Blood glucose and performance

Analysis of variance showed that changes in blood glucose levels during the task period were not significantly affected by increasing noise levels, (F=1.032; df 2,21, p=0.37353 n.s.). Figure 49 shows these changes in blood glucose levels along with the changes previously found with 18gm glucose preloading and no glucose. Time on target scores appeared to improve with increasing noise levels although the improvement was not statistically significant, (F=0.471; df 2,21, n.s.).

Time on target scores for the 30gm preloaded groups were compared with the data for 18gm preloaded and no glucose groups. Analysis of variance results are summarised in table 52.

Figure 49: Changes in Blood Glucose Levels During the Task Period

The data from the present study of 30gm glucose preloaded subjects are presented along with the previous data from no glucose groups and 18gm glucose preloaded groups (Simpson, Cox and Rothschild, 1974; Cox and Mackay, submitted to J. Human Stress). Changes in the blood glucose levels of the 30gm glucose groups were not significantly affected by increasing noise levels.



CHANGE IN BLOOD GLUCOSE mgm./100ml.
10
0
-10
-20
-30
-40
-50
50
80
95
no glucose group
30gm. glucose group
18gm. glucose group
NOISE LEVEL dBA

Table 52: Summary of Analysis of Variance of Time on Target Scores for 0, 18 and 30 gm Glucose Preloaded Subjects Under 50, 80 and 95dB Noise

SOURCE	SUM OF SQUARES	DFI	VAR.EST.	F	DF2	P
A Noise	3.8544	2	1.9272	0.498	63	n.s.
B Glucose	13.6163	2	6.8081	1.760	63	0.18034
AB	66.2687	4	16.5672	4.284	63	0.00396**
Within	243.6508	63	3.8675			
Total	327.3901	71				

The interaction between noise and glucose preloading was highly significant. The significance of the interaction found in the data from the original 6 groups of subjects was higher (F=8.75 df 2,42 p=0.0007***) but the data from the 30gm preloaded subjects conformed to the predicted pattern of results. The results supported the hypothesis that increased glucose preloading may be titrated against increased noise levels to maintain performance efficiency. The time on target scores are presented graphically in figure 50. At 50dB, 30gm glucose preloading was associated with a greater decrement in performance than 18gm glucose. This relatively low level of performance was maintained with increasing noise levels to 95dB. The 18gm preloaded subjects showed significantly ($p<.05$*) impaired performance at 95dB compared with 80dB noise. The results can be described (figure 51) by a step function or a reversed ogive (Bradley, Cox and Mackay,1977). Without glucose a significant impairment of performance occurred between 50dB and 80dB noise. This was not made worse by increasing noise levels to 95dB. Glucose preloading served to compress and displace this step/ogive to the right in proportion to dose.

It has been suggested (Bradley, Cox and Mackay; 1977) that the

Figure 50: Time on Target Scores

The scores of the 30gm glucose preloaded group from the present study are presented along with previous data for no glucose groups and 18gm glucose preloaded groups. (Simpson, Cox and Rothschild; 1974, Cox and Mackay, submitted to J. Human Stress). The overall interaction between noise and glucose was highly significant (p=0.00396**)

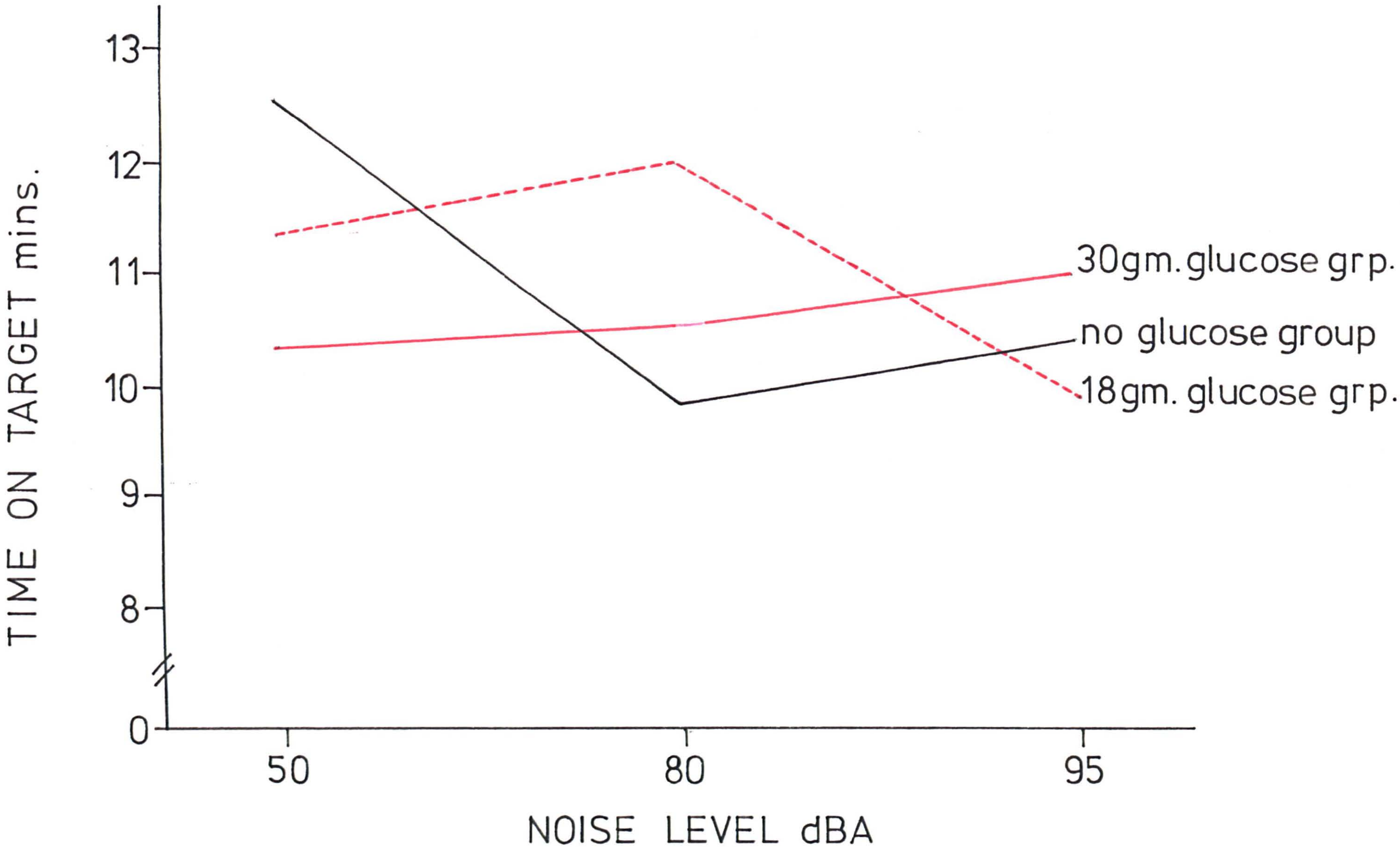
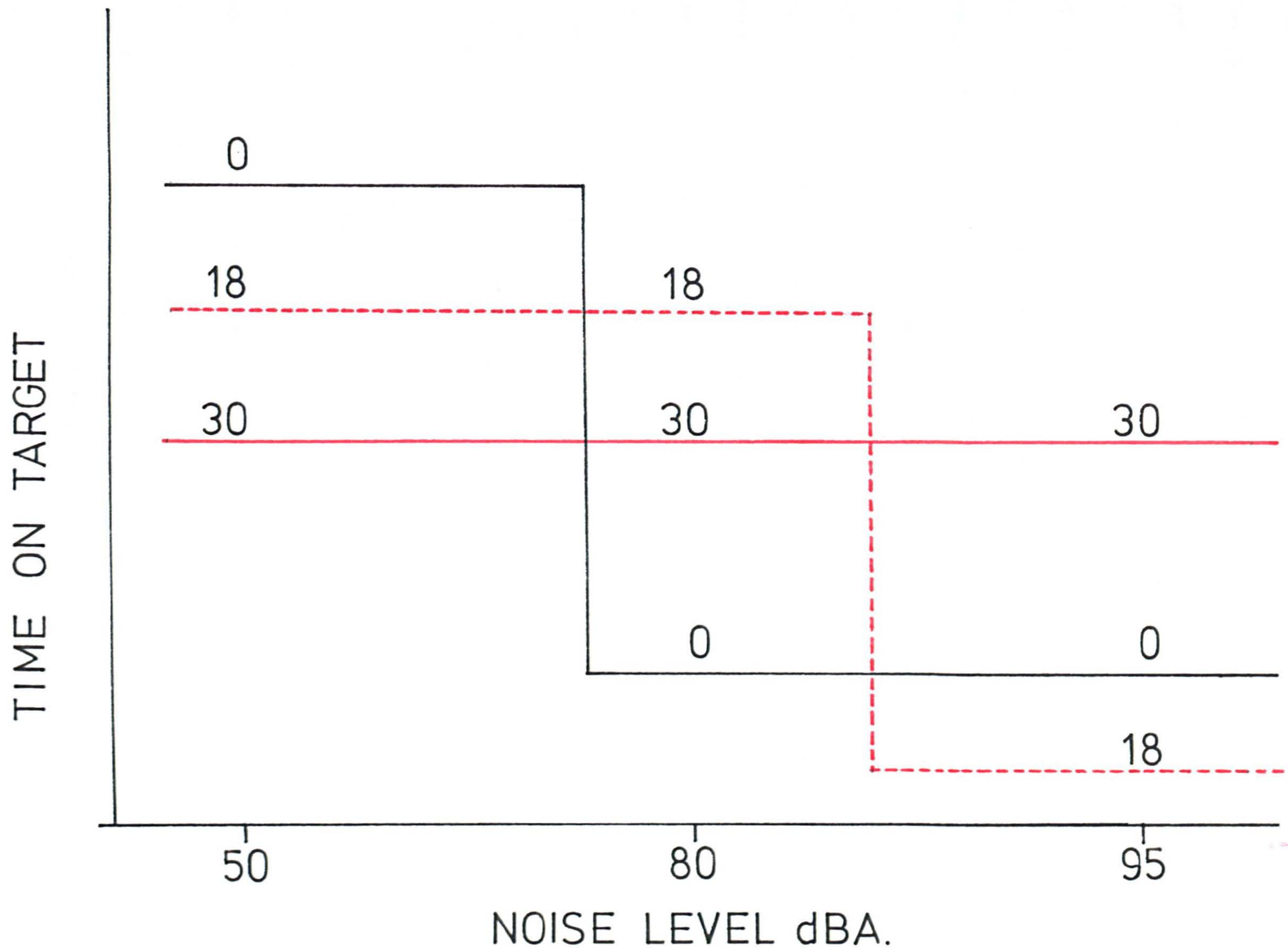

TIME ON TARGET mins.
13
12
11
10
9
8
0
50
80
95
NOISE LEVEL dBA
30gm. glucose grp.
no glucose group
18gm. glucose grp.

Figure 51: Diagrammatic Representation of Performance Efficiency in Relation to Noise Level

The amount of glucose used to preload the subjects in the different groups is indicated (0, 18, 30gms).



TIME ON TARGET
0
18
18
30
30
30
0
0
18
50
80
95
NOISE LEVEL dBA.

step/ogive may represent the person's level of 'internal noise' in a single channel model of human information processing. The person's information processing system may attempt to maintain an optimum signal to noise ratio. If the external noise is high, then the system may act to decrease the level of internal noise through increased vagal-insulin activity. Vagal-insulin activity may serve to inhibit cardiac and respiratory activity and the internal noise associated with it. It also serves to decrease existing blood glucose levels. The evidence suggests that without glucose preloading this system is unable to compensate adequately for external noise. However if the vagal-insulin mechanism is primed with extra glucose, then it is able to compensate and a blood glucose response (decrease) to noise occurs. The effects of such a mechanism, described in figure 52 would be as follows:

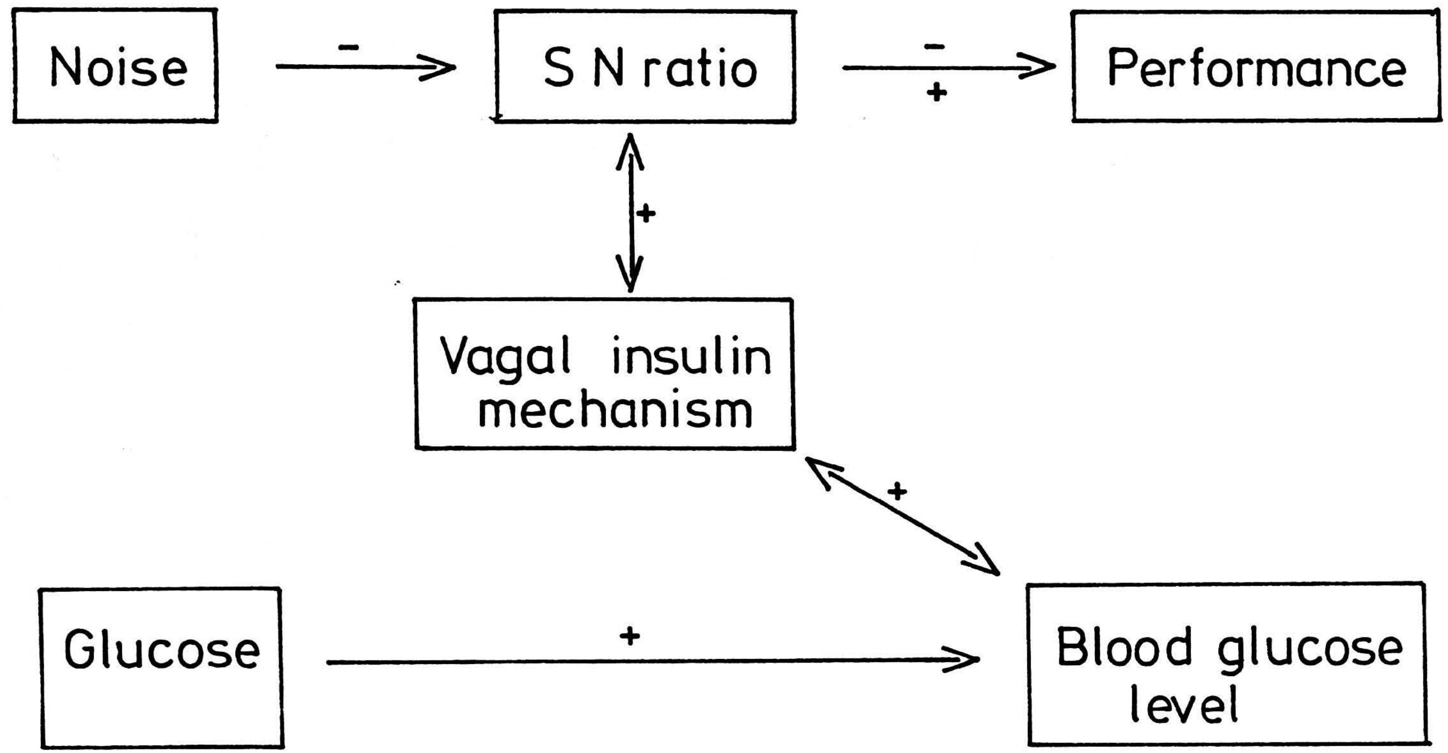
Noise ⟶ S/N↓ ⟶ Performance↓

Glucose + Noise ⟶ V-I Activity ↑ ⟶ S/N ↑ ⟶ Performance↑

Blood glucose and performance data corresponded well to such a model. Further support was needed, however, from other physiological measures such as heart rate. It would be predicted from this model that heart rate would decrease with noise when subjects were preloaded with glucose. Some data are available from an unpublished study by Cox and Malins which showed that heart rate decreases in subjects working at the pursuit rotor task under noise. A series of further studies investigating the effects of stress and glucose preloading on heart rate and other physiological measures is being planned by Cox and Mackay.

The work by Broadbent (e.g. 1972) on the effects of noise on performance and arousal levels suggests that subjective measures of arousal would reflect the experimental manipulations made in the present

Figure 52: Postulated Mechanism Determining the Effects of Noise and Glucose Preloading on Performance Efficiency and Blood Glucose Levels


Noise
–
S N ratio
–
+
Performance
+
Vagal insulin mechanism
+
Glucose
+
Blood glucose level

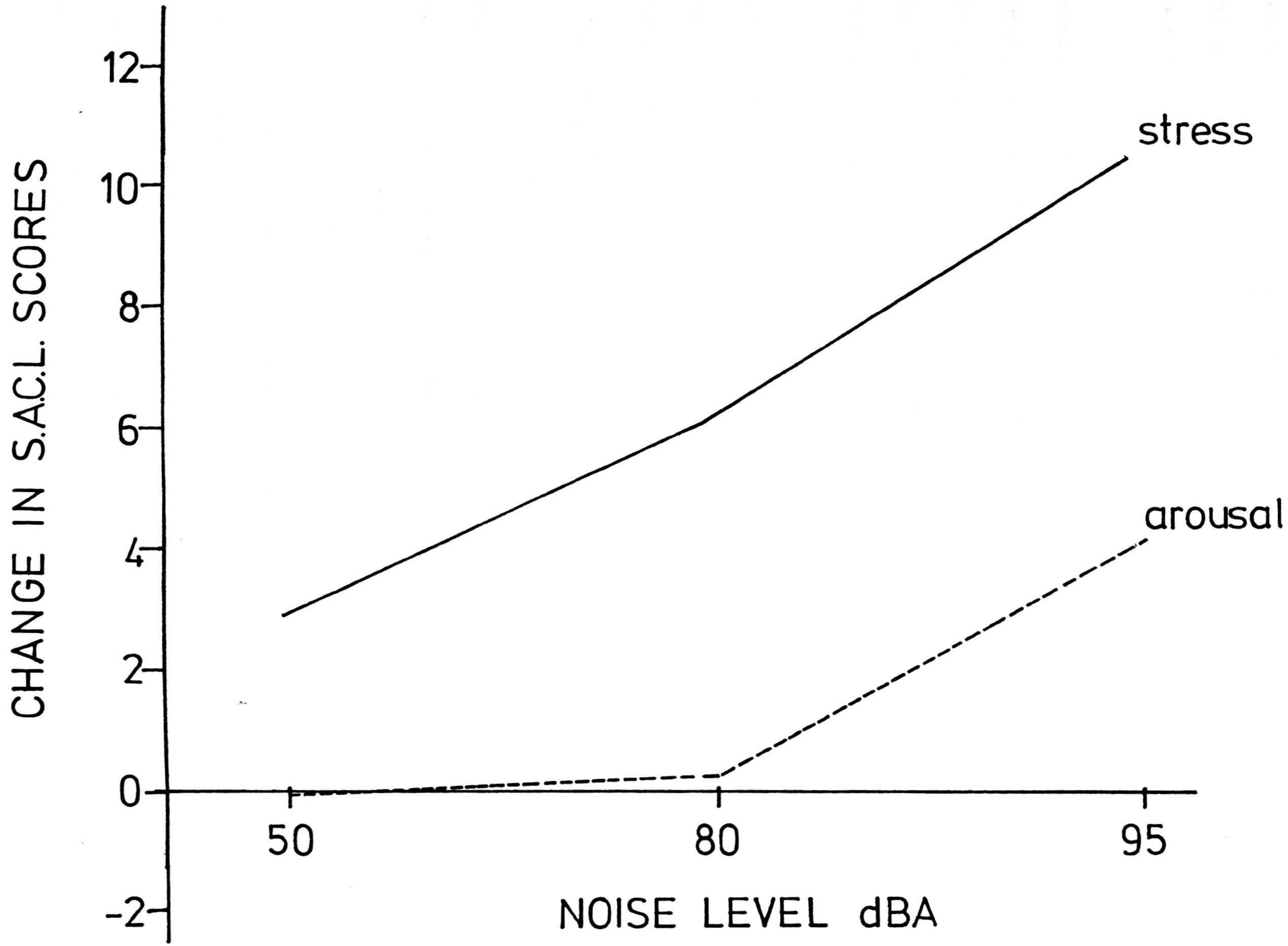
studies. Increases in arousal should be associated with increased noise. Possibly decreases in arousal may be associated with glucose preloading. The subjective experiences of the 30gm preloaded subjects are considered in the following section.

1.3. Subjective Experience of the Task Period: Results and Discussion

Changes in stress and arousal scores measured by the Stress Arousal Checklist (SACL) are presented graphically in figure 53. Reports of stress increased significantly with increasing noise levels ($F= 5.92421$ df 2,20, $p<.01$**). It can be seen that 80dB noise had little effect on arousal levels compared with 50dB noise but 95dB was associated with a considerable increase in arousal scores. The overall effect of noise on changes in arousal was not statistically significant ($F=2.31731$ df 2,20, n.s.). Since all subjects were preloaded with glucose it was not possible to examine the effects of glucose preloading on arousal levels. Such data were not available from the previous studies by Simpson, Cox and Rothschild. The second experiment referred to in this chapter (Experiment 9) examined glucose and no glucose groups and used the SACL measure. The effects of glucose preloading on arousal levels will be discussed later in this chapter. It could, however, be seen from the present results that the greater increase in reported stress and arousal during the task period with increasingly loud noise was not associated with greater impairment of performance. On the contrary, performance improved slightly with louder noise in these 30gm preloaded subjects and there was a small positive correlation between time on target scores and the increase in reported stress during the task period ($r=0.28$ $N=24$ n.s.). However, time on target scores correlated negatively with pre task stress scores ($r= -0.42$, $N=24$, $p< .05$*) suggesting that initial feelings of stress that were not due to the task period itself

Figure 53: Changes in Stress and Arousal Scores During the Task Period with 50, 80 or 95dB Noise

Stress scores increased significantly with increasing noise ($p < 0.01$**). The effect of noise on change in arousal scores was not statistically significant.


CHANGE IN S.A.C.L. SCORES
12
10
8
6
4
2
0
-2
stress
arousal
50
80
95
NOISE LEVEL dBA

partly determined performance. The correlation between time on target scores and increase in arousal over the task period was highly significant ($r= 0.53$ $N=24$ $p< .01$**). There was no correlation, however, between the number of deviations made and arousal levels. In these healthy subjects, deviations did not appear to be affected by arousal levels.

Time estimations were positively associated with increases in arousal although the correlations were not significant ($r=0.14$ $N=24$ n.s.). Subjective view of stress scores measured by the direct question on the Subjective Experience Questionnaire (SEQ) were sensibly related to the SACL stress measures: the restricted range of the SEQ question made correlations with SACL scores inappropriate.

The relationship between the subjective measures of experience and between these measures and performance scores and blood glucose change are discussed more fully later in this chapter with reference to the results of Experiment 9.

1.4. Summary and Conclusions

There was some support for the hypotheses. Performance was not impaired with 30gm glucose preloading under 95dB noise. A slight improvement in performance scores occurred with increasing noise that was not statistically significant. Blood glucose levels decreased more with increasing noise but again this result did not reach significance.

When the present results were compared with the results from previous studies, there was a highly significant interaction between the effects of noise and glucose on performance. At 50dB noise time on target scores were highest for the no glucose group, at 80dB for the 18gm preloaded group and at 95dB for the 30gm preloaded group. The results were described in terms of a step/ogive function which was compressed and displaced by glucose preloading in proportion to the dose. It was suggested that glucose preloading might prime the vagal-insulin system leading to decreases in blood glucose levels: inhibition of cardiac and respiratory activity might also occur. Performance might also be improved as a result of a reduction in the level of internal noise and by an increase in the signal to noise ratio.

The subjective experience of stress and arousal increased with increasing noise levels. Increases in arousal levels were significantly correlated with performance scores. It was suggested that glucose preloading might decrease pre-task arousal levels which were increased by noise. Performance efficiency was maintained when a balance between these two factors, noise and glucose preloading, was achieved.

The model proposed from these data would suggest that the effects of glucose preloading were largely physiological in origin. This assumption was tested in the following experiment by Bradley and Mackay (Bradley, Cox and Mackay, 1977).

2. Experiment 9: Investigation of the Physiological and Psychological Effects of Glucose Preloading

This experiment was designed to examine the effects of the drink and the information given concerning the drink on the interaction between glucose, noise and performance. It had been assumed that the effects of glucose preloading were mainly physiological but the possibility that psychological factors were involved was not eliminated.

The possibility that the results were susceptible to experimenter effects was also investigated in this study. Various explanations have been suggested to account for differences between the results of the hospital controls and those of the university subjects: one possibility was that the differences might have been due to the different experimenters involved.

2.1. Method

Design

18gm glucose in 100ml water was matched for taste with a saccharin/water solution (see Chapter 2, sections 10, 10.1, 10.2 and 10.3) so that subjects could be sensibly told that they were drinking glucose or that they were drinking saccharin when they were drinking either. In past experiments, subjects were more usually informed that they were drinking 'one of the following' from a list of harmless dietary substances. This condition (type of information) was included for comparison with 'saccharin' and 'glucose'. Since 100ml water had been used as a control for the glucose drink in past experiments, the effect of water was also examined in this experiment. Subjects who were given water could not be informed that they were drinking glucose or saccharin without endangering the credibility of the experiment. All subjects performed the pursuit rotor task with 80dB noise, this being one of the conditions in which the effects of glucose preloading were obvious. The experimental design is summarised in table 53.

Table 53: Design for Study of Physiological/Psychological Effects of Glucose Preloading

		← DRINK →		
		Water	Glucose	Saccharin
INFORMATION	?	8	8	8
	G		8	8
	S		8	8

All groups performed the pursuit rotor task with 80dB Noise

<u>Subjects</u> 56 healthy male students, aged between 18 and 25 years, from a College of Further Education participated in the experiment. Subjects were recruited in the manner described in the previous study (Experiment 8) for morning appointments between 10.00 and 12.45 hours. Subjects were randomly assigned to either the male (CJM) or female (CB) experimenter. One experimenter, on all but four occasions, took all three blood samples. The data from those subjects, when, for practical reasons, the second experimenter took one of the samples, were not included in the analysis of the experimenter effects.

<u>Procedure</u> The standard experimental procedure was followed in the manner described for Experiment 8 with the following exceptions. Each subject was given one of three drinks:

1. 100ml water
2. 43mg saccharin in 100ml water (Chapter 2, section 10.3).
3. 18gm glucose in 100ml water.

Subjects were given one of three types of information concerning the drink:

? - 'This is a harmless dietary substance. It could be glucose, water, saccharin or caffeine' (The order in which the four possibilities were mentioned was varied from subject to subject).

G - 'This is a solution of glucose in water'.

S - 'This is a solution of saccharin in water. As you probably know, saccharin is a substance that tastes sweet like sugar but is not a sugar. It's physiologically inactive'.

Subjects who were given water were all given '?' information. Subjects given glucose or saccharin were given one of the three types of information (see table 53).

The MPI, SACL and SEQ questionnaires were completed as before in experiment 8. In addition a short questionnaire was given at the end of the experimental session to determine the subjects' expectations concerning the effects of the drink on their ability to perform the task (see Appendix).

2.2. Results

Blood glucose and performance results

Changes in blood glucose levels during the task period were significantly affected by the drink but were not affected by the information concerning the drink. Figure 54 shows greater decreases in blood glucose levels during the task in the glucose groups compared with the saccharin groups. The type of information given did not affect this pattern of results. Table 54 summarises the results of the analysis of variance.

Table 54: Analysis of Variance of the Effects of Drink and Information on Changes in Blood Glucose Levels

SOURCE	SUM OF SQUARES	DF1	VAR. EST.	F	DF2	P
A Drink (G/S)	11163.6097	1	11163.6097	57.905	42	0.00000***
B Information (G/S/?)	343.8845	2	171.9423	0.892	42	n.s.
AB	755.1774	2	377.5887	1.959	42	n.s.
Within	8097.2492	42	192.7916			
Total	20359.9211	47				

Time on target scores were higher in the glucose preloaded groups than in the saccharin groups. There was no evidence to suggest that the information about the drink influenced performance scores. Analysis of variance (Table 55) showed that the effect of the drink on performance did not reach significance.

Figure 54: Changes in Blood Glucose Levels During the Task Period in Subjects Preloaded with Saccharin or Glucose

The different drinks had significantly different effects on blood glucose levels ($p = 0.00000$***).

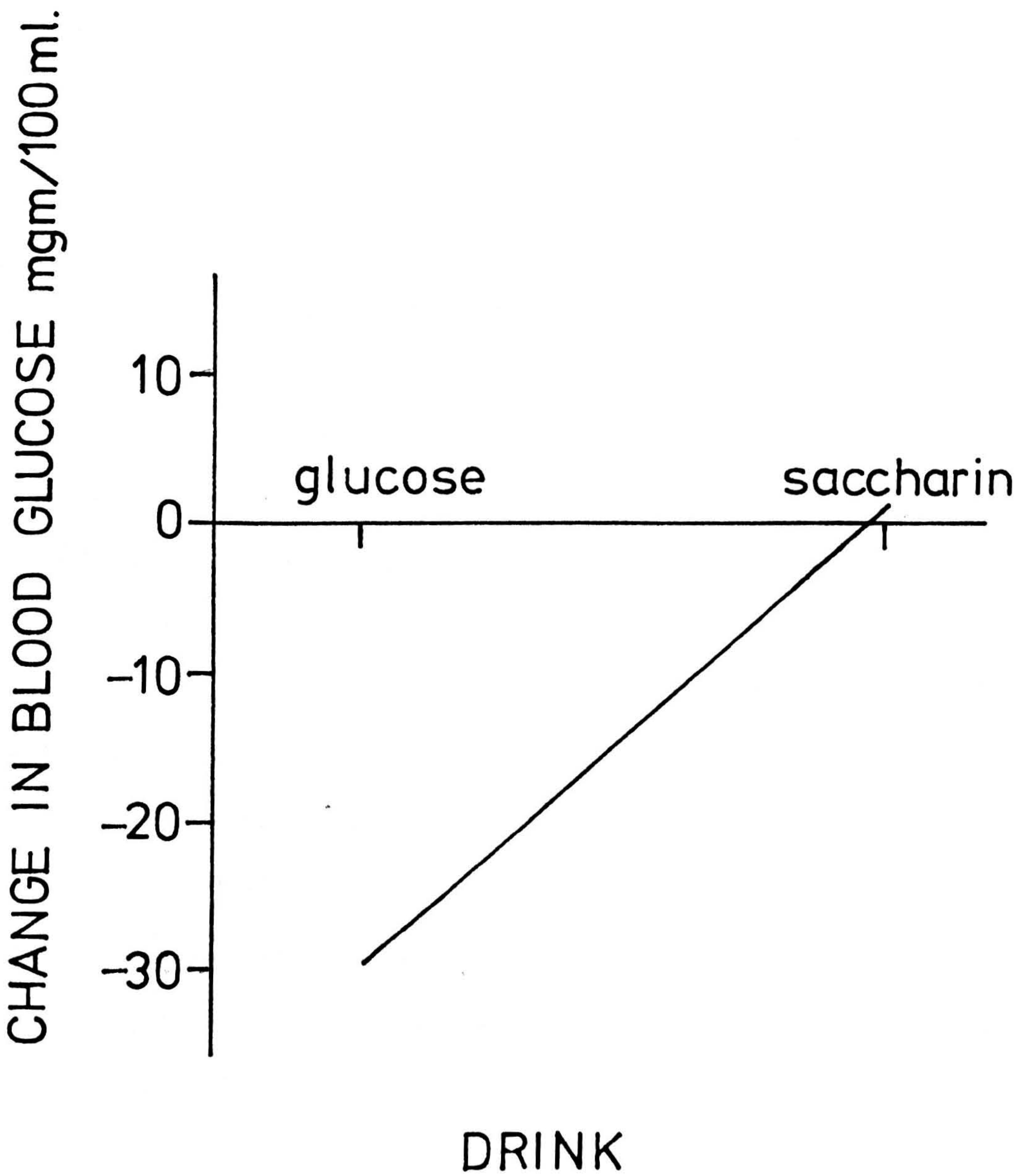

CHANGE IN BLOOD GLUCOSE mgm/100ml.
10
0
-10
-20
-30
glucose
saccharin
DRINK

Table 55: Analysis of Variance of the Effects of Drink and Information on Time on Target Scores

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A Drink (G/S)	11.2520	1	11.2520	2.624	42	0.11273
B Information (G/S/?)	1.0643	2	0.5321	0.124	42	n.s.
AB	2.8799	2	1.4399	0.336	42	n.s.
Within	180.0858	42	4.2878			
Total	195.2820	47				

There was some indication that more deviations were made by the saccharin groups but this result was not significant (F=0.401 df 1,42 n.s.).

There were no differences between the blood glucose changes or performance scores of the saccharin groups and the water group given the same (?) information (BS3-2; F=0.018 df 1,14 n.s.: TOT; F=0.079 df 1,14 n.s. Dev.; F=1.671, df 1,14 n.s.). The sweetness of the saccharin solution may have lead to subjects supposing that they were drinking glucose but clearly such an impression did not affect the subjects' performance or blood glucose responses.

Experimenter Effect on Blood Glucose and Performance Results

The results presented above were further analysed for any effects of experimenter. CJM obtained significantly higher levels of blood glucose than CB when initial blood glucose readings were compared (F=10.433 df1,43 P=0.002**). Such a difference was also found in the reliability study discussed in Chapter 2, Section 1.1. It appeared that the difference was due to the amount of blood collected by each experimenter. The change in blood glucose levels was not, however, significantly affected by the experimenters (F=1.608 df1,41 n.s.).

Both the degree and pattern of blood glucose change was the same for each experimenter.

Performance appeared to be highly susceptible to experimenter effect. CJM obtained significantly higher time on target scores from his subjects than CB did from hers (see Figure 55).

When the variability due to the experimenters was taken into account, analysis of variance showed the effects of drink on time on target scores to be significant, (Table 56).

Table 56: Summary of Analysis of Variance of the Effects of Experimenter and Drink on Time on Target Scores

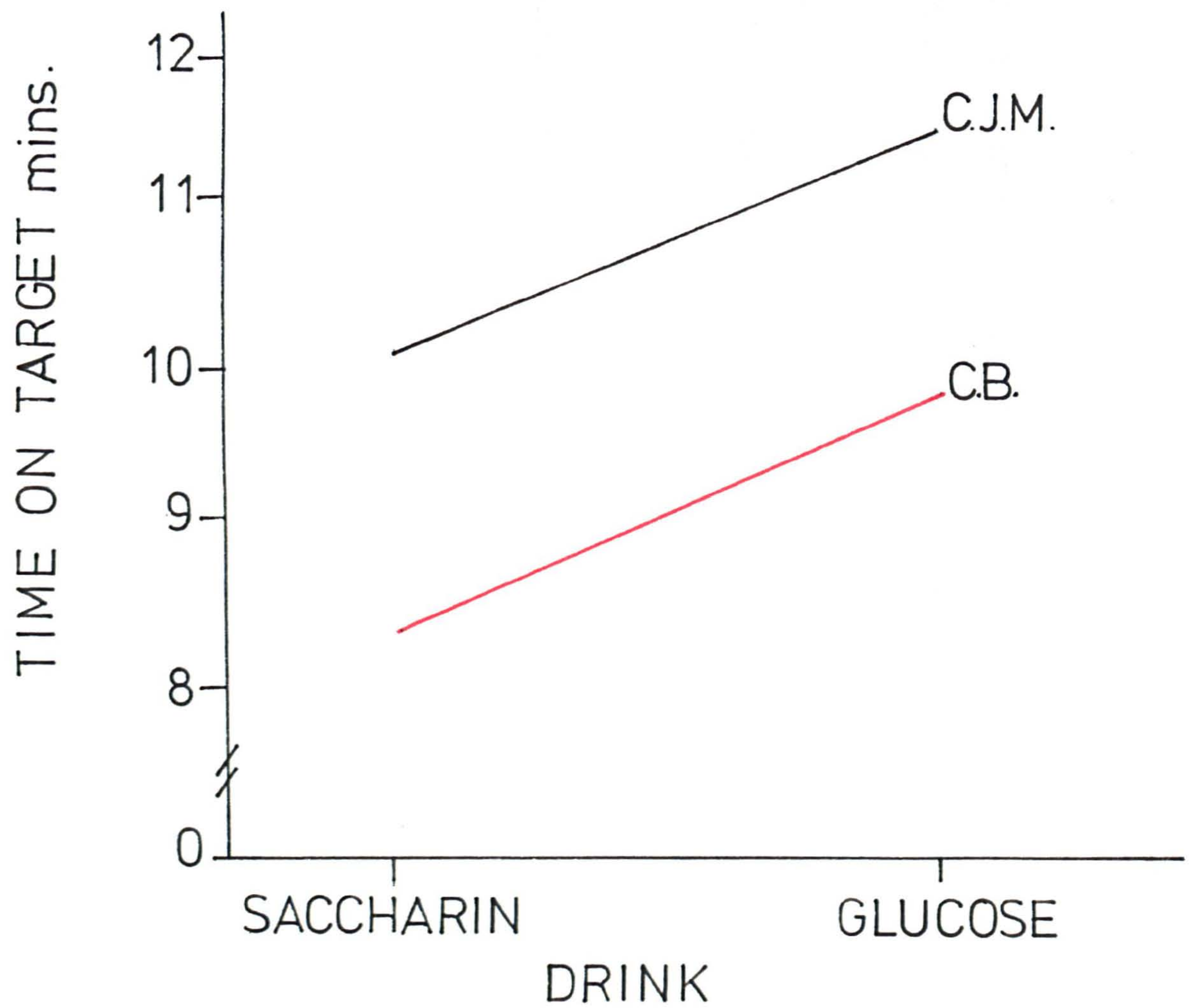
SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A Drink	15.7909	1	15.7909	4.169	41	0.04763*
B Experimenter	21.5747	1	21.5747	5.696	41	0.02170*
AB	0.7886	1	0.7886	0.208	41	n.s.
Within	155.2886	41	3.7875			
Total	193.4428	44				

The number of deviations made was similarly affected by the experimenter with CJM obtaining fewer deviations (i.e. better performance) than CB (Figure 56). Again the effect of drink became more apparent although the probability level did not reach statistical significance (Table 57).

It was clear that the male experimenter (CJM) obtained better performance scores from his subjects than did the female experimenter (CB). However, this difference was a difference in the degree of response and not in the pattern of the response. There was no interaction between the effect of experimenter and the effect of drink on either measure of performance.

Figure 55: The Effect of Drink (Glucose or Saccharin) and Experimenter (CJM or CB) on Time on Target Scores.

CJM obtained significantly higher time on target scores from subjects than CB (p=0.02170*). Time on target scores were significantly higher for glucose preloaded subjects than for saccharin preloaded subjects (p=0.04763*).


TIME ON TARGET mins.
12
11
10
9
8
0
C.J.M.
C.B.
SACCHARIN
GLUCOSE
DRINK

<u>Figure 56: The Effect of Drink (Glucose or Saccharin) and Experimenter (CJM or CB) on the Number of Deviations Made</u>

CJM obtained signficantly fewer deviations (i.e. better performance) than CB (p=0.00002***).

Glucose preloaded subjects made fewer deviations than subjects drinking saccharin but the difference was not statistically significant (p=0.16423).

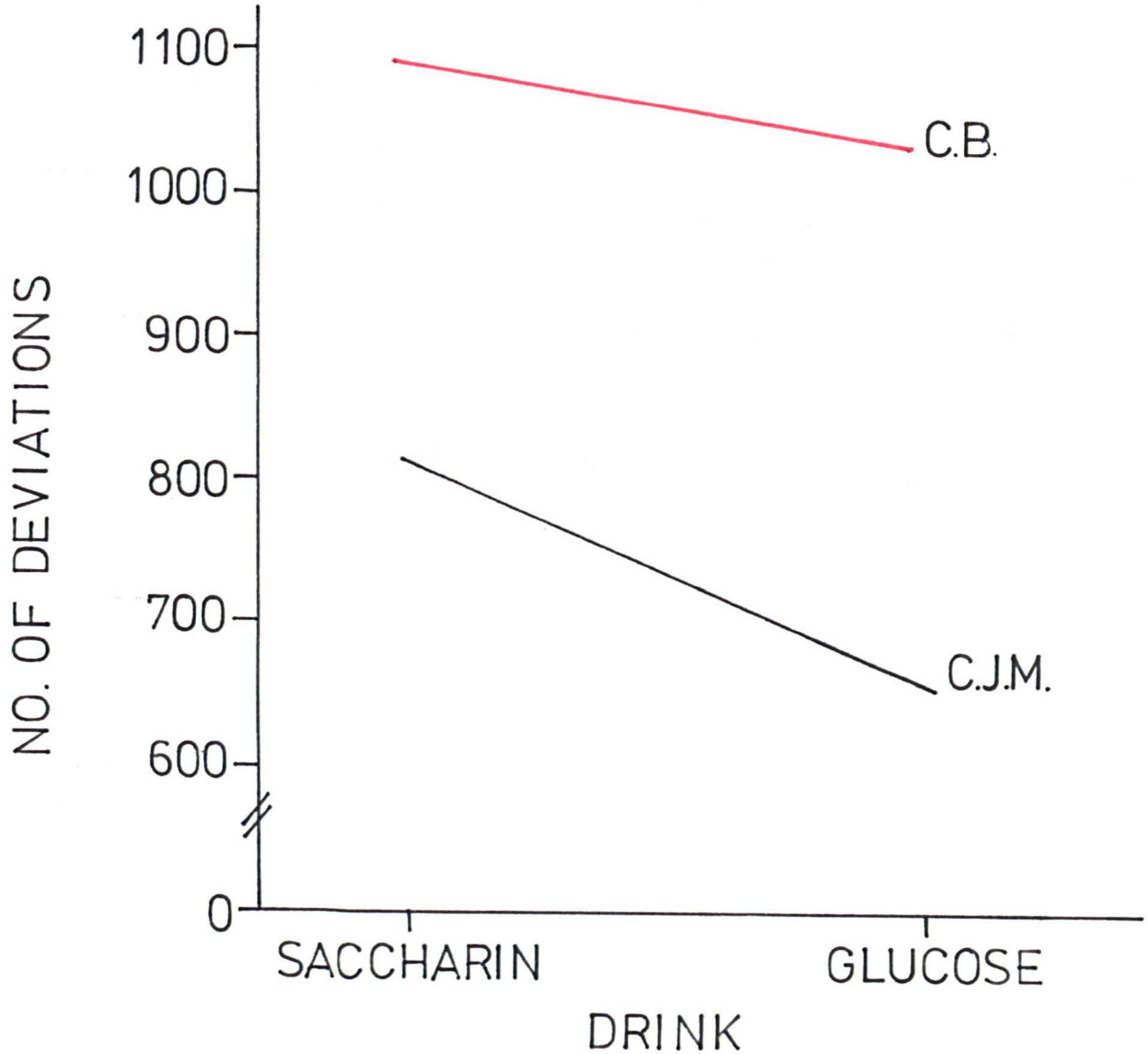

NO. OF DEVIATIONS
1100
1000
900
800
700
600
0
C.B.
C.J.M.
SACCHARIN
GLUCOSE
DRINK

Table 57: Summary of Analysis of Variance of the Effects of Experimenter and Drink on Deviation Scores

SOURCE	SUM OF SQUARES	DF1	VAR. EST.	F	DF2	P
A Drink	$1.0372_{10}+05$	1	$1.0372_{10}+05$	2.006	41	0.16423
B Expt.er	$1.1953_{10}+06$	1	$1.1953_{10}+06$	23.117	41	0.00002***
AB	16136.6040	1	16136.6040	0.312	41	n.s.
Within	$2.1200_{10}+06$	41	51706.7076			
Total	$3.4351_{10}+06$	44				

It was clear that the male experimenter (CJM) obtained better performance scores from his subjects than did the female experimenter (CB). However, this difference was a difference in the degree of response and not in the pattern of the response. There was no interaction between the effect of experimenter and the effect of drink on either measure of performance.

2.3. Discussion of Blood Glucose and Performance Results

The results supported the hypothesis that the effects of glucose preloading on blood glucose and performance were physiological rather than psychological. The information concerning the drink had no effect on these measures.

The effects of the experimenter on performance efficiency were considerable. Rosenthal has extensively contributed and reviewed the evidence concerning the extent and nature of 'experimenter effects' from a social psychological standpoint (Rosenthal, 1966; Rosenthal and Rosnow, 1969). Some data from psychophysiological studies have also suggested the importance of these effects. Such studies have been reviewed by Christie and Todd (1975). The differences between experimenters in absolute blood glucose measures were clearly differences of the 'recording error' variety referred to by Christie and Todd (1975). The differences in performance scores obtained by the experimenters were probably due to complex subject-experimenter interactions which may be determined by certain experimenter attributes. The most obvious difference between the experimenters was their sex. A number of studies have examined the effects of experimenter sex differences on subjects' performance. There is some evidence to suggest that male experimenters obtain better motor performance from their subjects than females. Stevenson and Odom (1963) studied children performing a lever pulling task and found that male experimenters obtained more responses even though they merely instructed subjects and then left them to the task. Stevenson, Keen and Knights (1963) also found that male experimenters were associated with better performance from subjects dropping marbles into a hole. Stevenson and colleagues interpreted the results in terms of increased anxiety associated with male experimenters. It was suggested that young children would have relatively much less contact with males and that this might have made them anxious or excited over the interaction with the male experimenter. For simple tasks this might have served to increase performance. The difference in performance levels obtained by the experimenters' subjects decreased with time, suggesting that excitement wore off with adaptation.

In the present study with male student subjects it was thought unlikely that the male experimenter would have aroused more anxiety or excitement for the reasons suggested by Stevenson i.e. that the subjects had more contact with females. However, although initially the first 20 or so subjects were recruited by both experimenters, when the experiment was underway the female experimenter (CB) more often recruited the subjects. Hence it may be that subjects who encountered the female experimenter in the laboratory were less anxious, as a result of the prior contact with that person, than were subjects encountering the male experimenter for the first time. Prior contact may increase or decrease performance depending on the task involved. Rosenthal (1966) considered this factor as follows:

> 'The effects of prior contact also seem to depend on the task set for the subject. When the task is a simple, repetitive motor task such as dropping marbles into holes, complete strangers seem to be more effective reinforcers than experimenters known to the subjects. . .
> This is just what we would expect on the basis of Hullian learning theory. When the response is a simple one, easily available to the subject, an increase in anxiety, such as we expect to occur in the presence of strangers increases the performance level. When the response is a difficult one, not easily available to the subject, as in an intelligence test, an increase in anxiety makes these less available responses less likely to occur because the more available responses, more often wrong, become more likely due to the so-called multiplicative effect of drive.'

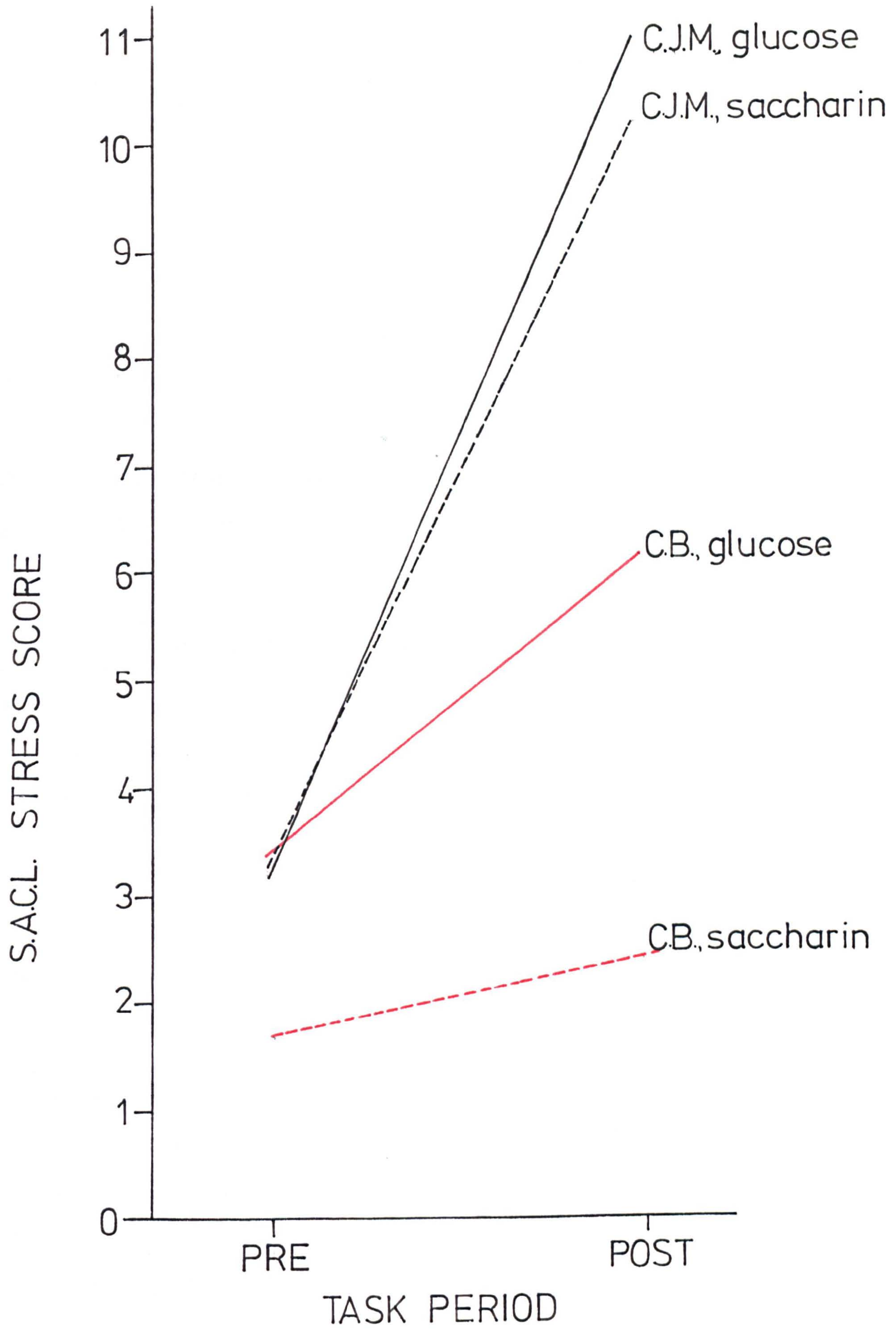
Thus it would be necessary to categorise the pursuit rotor task as a relatively simple motor task to account for the anxiety induced improvement in performance. It would be expected from such an explanation of the performance differences that subjects would score higher on the SACL measures with the male experimenter (CJM) with whom most subjects had had no prior contact. The data from the subjective experience questionnaires are considered in the following section.

2.4. Subjective Experience: Results

When the SACL stress scores were analysed by analysis of variance, without taking experimenters into account, there was a significant increase in stress during the task period (F=33.37764 df 1,42 p=<0.001**) but no effect of drink or information (Figure 57). When the results were analysed for possible experimenter effects, these were found to be significant. With CJM, subjects reported significantly

Figure 57: The Effect of Experimenter (CJM or CB) and Drink (G or S) on Stress Scores

CJM's subjects' stress scores increased significantly more over the task period than those of CB's subjects ($p=0.001$***).


C.J.M., glucose
C.J.M., saccharin
C.B., glucose
C.B., saccharin
S.A.C.L. STRESS SCORE
0
1
2
3
4
5
6
7
8
9
10
11
PRE
POST
TASK PERIOD

more stress. This was particularly apparent with the post scores and the interaction between experimenter and pre/post scores was significant. CJM was associated with greater increases in stress during the task period rather than with greater initial stress scores. (There were no significant differences between experimenters on pre stress scores (F=0.597 df 1,36 n.s.)). There were no significant effects of drink on stress scores and no interactions between experimenter and drink affecting stress scores (Figure 57). Analysis of variance results are summarised in table 58.

Table 58: Summary of Analysis of Variance of the Effects of Drink (G and S), Experimenter and pre/post Task Measures on Stress Scores

SOURCE	SUM OF SQUARES	DF1	VAR. EST.	F	DF2	P
A Drink	47.00534	1	47.00534	2.77386	41	n.s.
B Expt.er	270.65570	1	270.65570	15.97182	41	<0.001***
D Pre/Post	459.26224	1	459.26224	43.78750	41	<0.001***
AB	27.15137	1	27.15137	1.60224	41	n.s.
AD	12.24110	1	12.24110	1.16711	41	n.s.
BD	177.30314	1	177.30314	16.90464	41	<0.001***
ABD	2.75495	1	2.75495	0.26267	41	n.s.
Subjects	694.77895	41	694.77895	9.62672	4	10 n.s.
Subjects x D	430.02571	41	430.02571	2.16680	4	10 n.s.

Comparable analysis of variance examining information, experimenter and pre/post effects showed no significant effects of information on stress scores and no interactions of other variables with information.

SACL arousal scores were analysed in the same manner. Arousal scores increased significantly over the task period (F=7.64427 df 1,42 p<0.001***). Analysis of experimenter differences again showed that

CJM was associated with higher scores (Figure 58). However, in the case of arousal levels, this effect was most apparent with pre task arousal scores (F=12.317 df 1,39 p=0.00115**). The interactions between experimenter and drink and between experimenter and pre/post task scores were not significant although there was a significant interaction between drink and pre/post task scores. Arousal levels increased with saccharin but did not increase with glucose during the task period (Figure 59). The results are summarised in table 59.

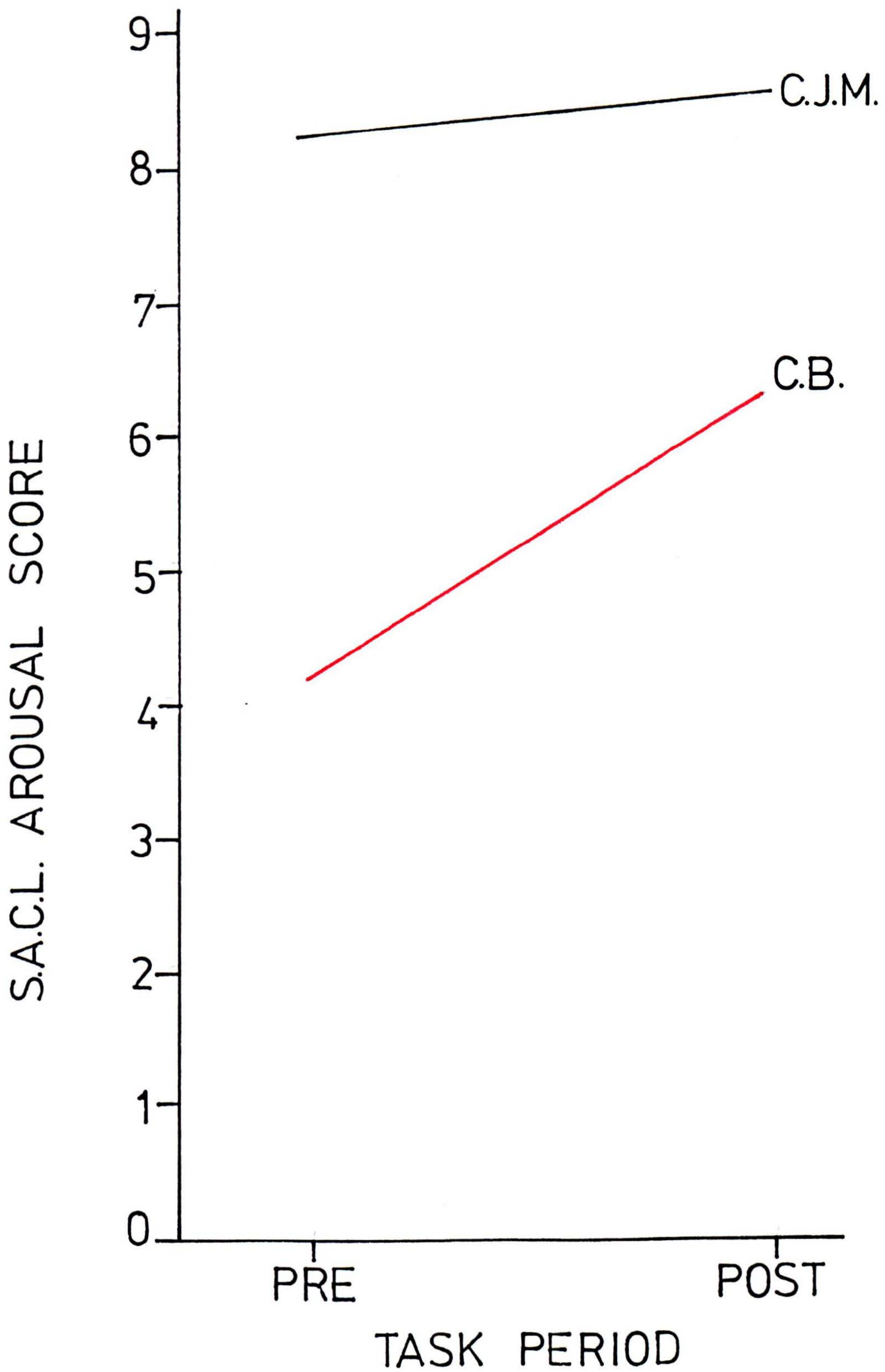
Table 59: Summary of Analysis of Variance of the Effects of Drink (G/S), Experimenter (CJM/CB) and Pre/post Task Measures on Arousal Scores

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A Drink	5.85466	1	5.85466	0.28625	41	n.s.
B Expt.er	180.98752	1	180.98752	8.84884	41	<0.01**
D Pre/Post	35.09401	1	35.09401	4.61243	41	<0.05*
AB	0.00930	1	0.00930	0.00045	41	n.s.
AD	36.08366	1	36.08366	4.74250	41	<0.05*
BD	17.48805	1	17.48805	2.29847	41	n.s.
ABD	14.93931	1	14.93931	1.96348	41	n.s.
Subjects	838.58333	41	20.45325	1.75949	4	10 n.s.
Subj. x D	311.95130	41	7.60857	2.97761	4	10 n.s.

A similar analysis was carried out to examine the effects of experimenter, information and pre/post task effects on arousal scores (see Table 60).

Figure 58: The Effects of Experimenter (CJM or CB) on Arousal Scores

CJM was associated with significantly higher arousal scores than CB (p=0.01**).


9
8
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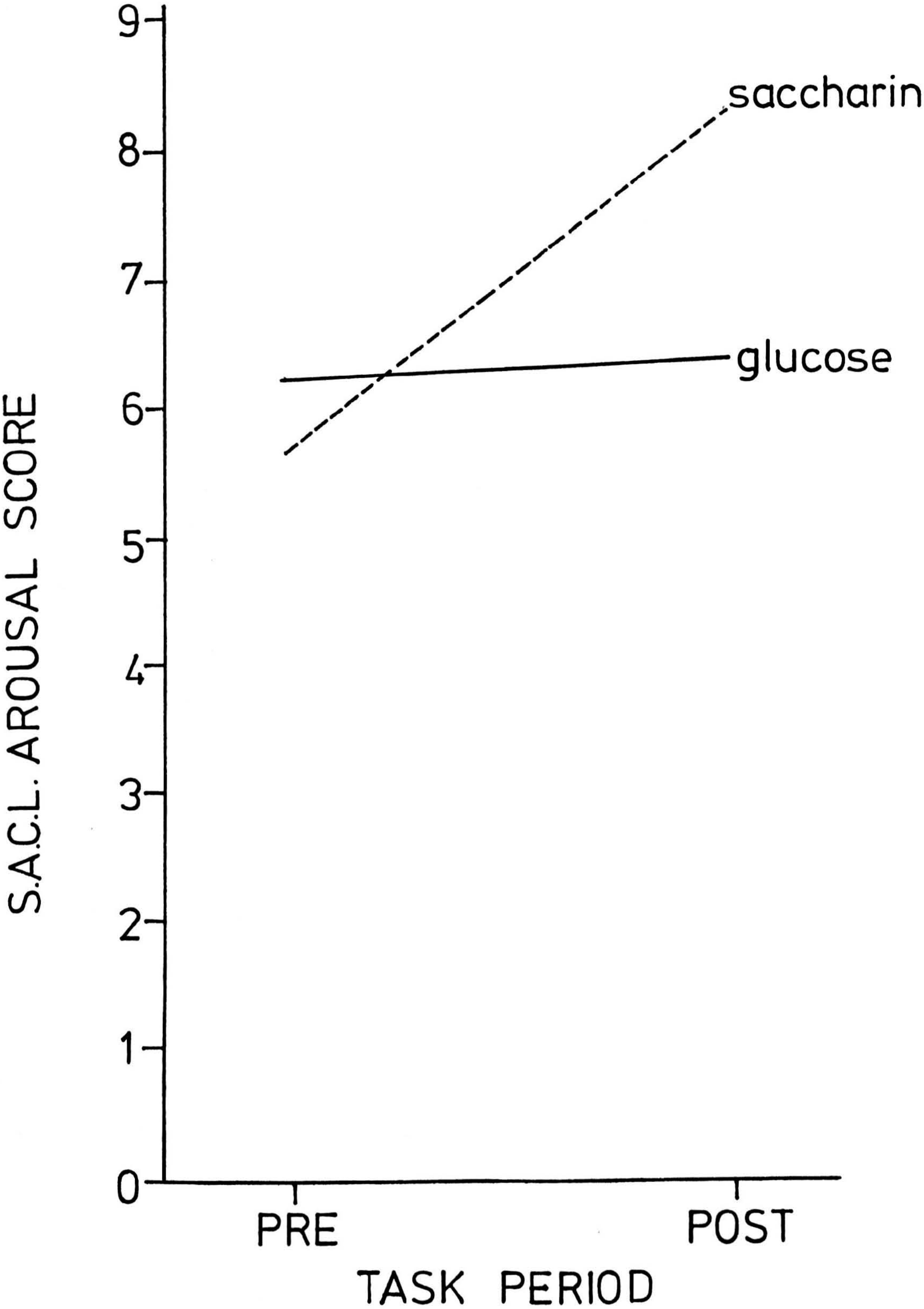
C.J.M.
C.B.
S.A.C.L. AROUSAL SCORE
PRE
POST
TASK PERIOD

Figure 59: Effect of Drink on Arousal Scores

Arousal scores increased during the task period with saccharin but did not increase with glucose (p=0.05*).



9
8
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1
0
S.A.C.L. AROUSAL SCORE
saccharin
glucose
PRE
POST
TASK PERIOD

Table 60: Summary of Analysis of Variance of the Effects of Information (G/S/?), Experimenter (CJM/CB) and Pre/Post Task Measures on Arousal Scores

SOURCE	SUM OF SQUARES	DF1	VAR.EST.	F	DF2	P
A Inform.	26.58260	2	13.29130	0.64231	39	n.s.
B Expt.er	193.14510	1	193.14510	9.33391	39	<0.01**
D Pre/Post	51.11590	1	51.11590	6.59636	39	<0.025*
AB	9.44707	2	4.72353	0.22827	39	n.s.
AD	3.09632	2	1.54816	0.19979	39	n.s.
BD	9.69507	1	9.69507	1.25112	39	n.s.
ABD	52.90695	2	26.45348	3.41374	39	<0.05*
Subjects	807.02083	39	20.69284	3.71341	6	7 n.s.
Subj. x D	302.21528	39	7.74911	3.54176	6	7 n.s.

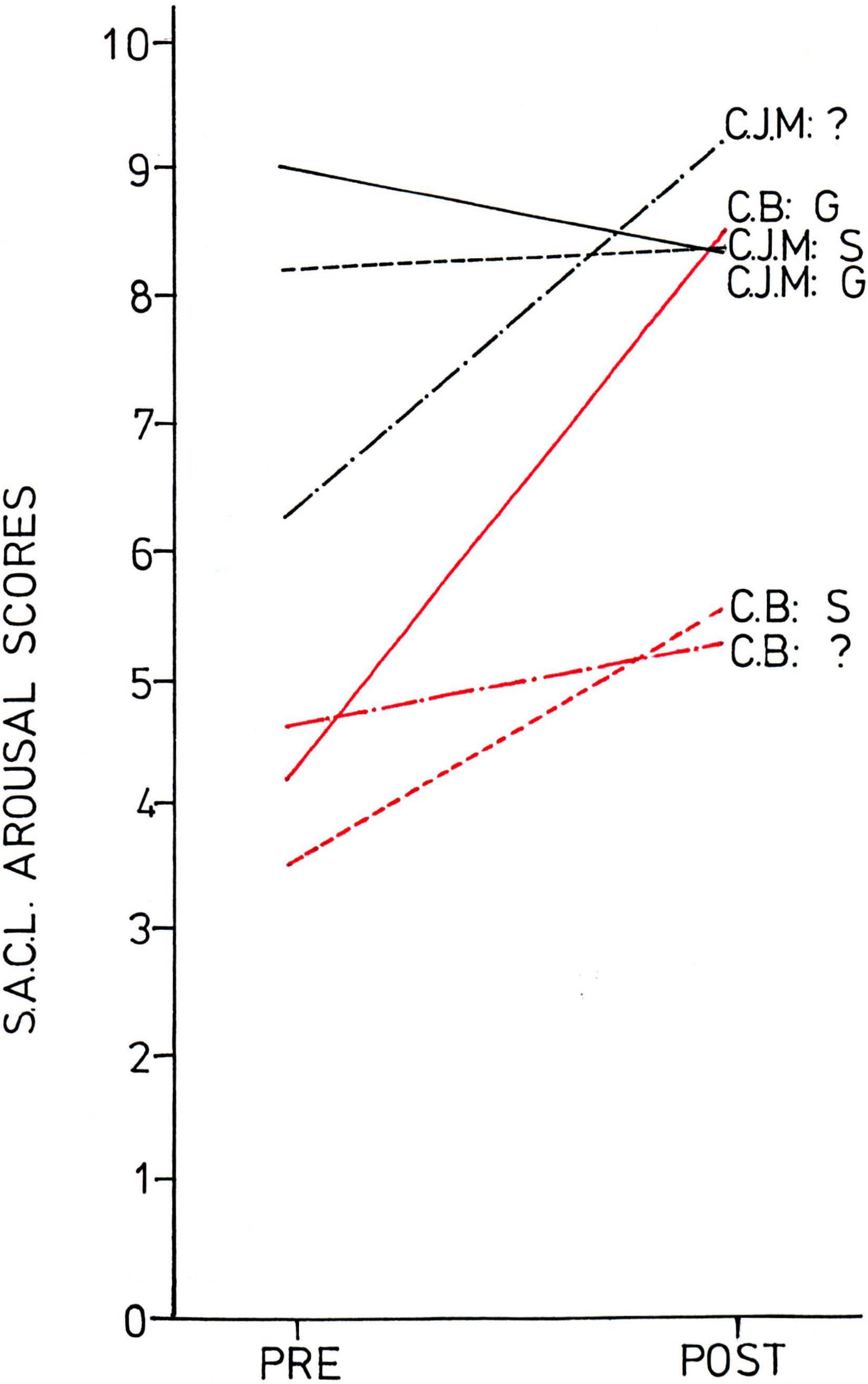
Here not only was the experimenter effect significant but there was also a significant interaction between the experimenter, information and pre/post task arousal scores. It can be seen from the results presented graphically in figure 60 that CB's subjects showed the greatest increase in arousal when told they were drinking glucose and least when not specifically told what the drink contained (?). CJM's subjects, on the other hand, showed the greatest increase when given no specific information (?) and little change when told the drink was glucose or told saccharin.

2.5. Subjective Experience: Discussion

The effect of experimenter on reported stress was mainly a difference of degree and not of pattern. However, the interactions affecting arousal scores were rather more complex. It appeared that the measure of arousal was more sensitive to the effects of information

Figure 60: The Effects of Experimenter and Information on Arousal Scores

CJM's subjects had significantly higher arousal scores than CB's (p=0.01**). Arousal scores increased significantly over the task period (p=0.025*). The three factors (information, experimenter and pre/post measures) interacted significantly (p=0.05*) to produce a complex pattern of results.


S.A.C.L. AROUSAL SCORES
10
9
8
7
6
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1
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C.J.M: ?
C.B: G
C.J.M: S
C.J.M: G
C.B: S
C.B: ?
PRE
POST
TASK PERIOD

than the measure of stress or performance and blood glucose measures. The measure of arousal was the only measure investigated to be affected by experimenter and information not only in terms of the degree of response but also in the pattern of the response shown.

It was suggested in the discussion of experimenter effects on performance that the better performance scores obtained by CJM might be due to greater anxiety or excitement in CJM's subjects. SACL responses confirm that CJM's subjects were indeed more aroused prior to the task period than CB's subjects. This higher level of arousal may have accounted for CJM's subjects better performance at the task. Although it was possible that subjects were more aroused with CJM because many of them had no previous contact with him, having been recruited by CB, other factors might have played a role here. For example these male subjects might behave more competitively towards a male experimenter. Greater motivation to perform well for the male experimenter might account for the higher pre-task levels of arousal and greater increases in stress during the task period. However, it was not possible to do more than speculate on the reasons for the differences in mood associated with the two experimenters.

The extent and degree of experimenter effects had not been anticipated. On the whole, only the absolute scores of stress and arousal were influenced by the experimenters although the increase in stress over the task period was greater for CJM and arousal scores were affected by the experimenters who interacted with type of information and pre/post measures to produce different patterns of results. It is possible that if subjects were more aroused with CJM, their degree of arousal was disproportionately increased by the non-specific type of information (?) which might be more anxiety inducing than the straightforward information that the drink was 'glucose' or 'saccharin'. However, the pattern of change in arousal over the task period also differed between experimenters for the subjects told that they were drinking glucose. Arousal levels increased for the female and decreased for the male experimenter. No obvious explanation for these interactions could be given.

Since the subjective report of arousal and, to a lesser degree, stress was affected by the experimenter in interaction with other variables caution was clearly necessary in the interpretation of such measures.

2.6. Other Measures of Subjective Experience: Results and Discussion

Subjective view of stress scores elicited from the Subjective Experience Questionnaire (SEQ) related sensibly with SACL scores. Time estimations were positively associated with SACL arousal scores although the correlation with post task arousal did not reach significance (r=0.21, N=56, n.s.). However, there did appear to be some support for the original hypothesis that longer time estimations would be given in states of heightened arousal.

The questionnaire concerned with the expectations held by subjects about the drink and their perceptions of the drinks' effect was only used after the first eleven subjects had been run. Data were only available for 45 subjects. Observation of these data showed that 10/12 subjects told 'glucose' expected the drink to affect their performance and 8 of these thought that their performance would improve with glucose. However, whereas 3/4 subjects, who were actually given glucose felt that their performance did improve, none of the 6 subjects who were told they were drinking glucose but actually drank saccharin, thought that their performance did improve with the drink. These data suggested that subjects were a) making sensible predictions from the information given and b) assessing the effects of the drink independently of the information. Subjects appeared to be extremely perceptive with regard to the effects of glucose and saccharin.

3. Summary and Conclusions

The results of this experiment supported the assumption that the effects of glucose preloading on performance and blood glucose change were physiological in origin. The results were also consistent with the model proposed earlier in the discussion of the titration experiment. It was suggested that performance efficiency under noisy conditions was maintained by increasing the signal to noise ratio. This may be achieved by reducing internal noise through vagal-insulin activity which may be stimulated by glucose preloading. The reduction in internal noise was associated with improved performance by glucose preloaded subjects working under noisy conditions. The performance of subjects drinking saccharin or water was impaired by 80dB noise.

The step function description of the data where glucose preloading suppresses and shifts the steps to the right accounted for the effects of noise and glucose preloading on performance more adequately than Broadbent's simple inverted U relationship between arousal and performance where noise increased arousal levels. Further research may demonstrate that glucose preloading decreases arousal while noise increases arousal and maximum performance is attained when the two factors are in equilibrium. However, the data from the present work concerning arousal levels are limited and, furthermore, are complicated by experimenter effects on arousal levels. The data available at this stage will not conform to such a simple pattern.

The analysis of experimenter differences in Experiment 9 produced considerable evidence to suggest that different experimenters affected the results differently. CJM obtained better performance than CB. Subjects also reported higher levels of pre-task arousal with CJM as their experimenter than with CB. However performance was most efficient when arousal levels did not increase further during the task period. Thus CJM obtained good performance scores from subjects whose pre-task arousal levels were high but did not increase during the task; indeed they decreased slightly. CB's subjects were less aroused pre-task but became more aroused during the task and performance was less efficient than CJM's subjects. Arousal levels tended to increase more with saccharin than with glucose and performance was impaired in comparison with that of glucose preloaded subjects working with 80dB noise. There was some indication therefore, to suggest that without glucose preloading, arousal levels increased when working at the task in noisy conditions: with glucose preloading the 80dB noise did not result in increased arousal levels. However, this pattern of results was more apparent in data obtained by CJM than in that obtained by CB. While the effect of experimenter on performance levels and reported stress was mainly a difference of degree and not of pattern, the interactions affecting the arousal scores were rather more complicated. The measure of arousal was the one measure investigated to be affected by experimenter and information not only in terms of the degree of response but also in the pattern of the response shown.

The study reported here examined the effects of different experimenters on the independent variables but was not designed to investigate possible experimenter-subject interactions. Such interactions may be particularly relevant in psychophysiological studies of sex differences. Cox, Mackay and Slade (1978), looked at sex differences in the effects of noise on blood glucose levels and performance and found that, overall, females were less physiologically responsive to noise stress than males. The experiment was not designed to examine the effects of the experimenters' sex and it is possible that such effects may have contributed towards the results. However, the results reported by Cox, Mackay and Slade were consistent with other reports in the literature (Johansson, 1972). An experiment by Alcroft at Salford University (unpublished communication, 1974) supported the conclusion that the effects observed in this area of research are sensitive to experimenter/subject effects. She examined the effects of glucose preloading on psychomotor performance with 80dB noise. Two different groups of subjects were used. With male university students she replicated the present findings. However, with male subjects drawn from non-university groups, she found little or no effect of glucose preloading.

Similarly the performance levels of the hospital control groups in the experiment carried out by the writer (CB) and reported in Chapter 3 were lower than those of subjects from the university population found in experiments carried out by CJM and jointly by CB and CJM. Both diabetic and control groups were less sensitive to noise in terms of their performance of the task. The results of Experiment 9 observing experimenter effect would suggest that quantitative differences in performance may have been due to the experimenter with CB obtaining lower levels of performance.

It is clearly necessary when replicating or extending psychophysiological experiments to take account of the characteristics of the experimenters as well as those of the subjects and the interactions between them. Further systematic investigations of experimenter-subject interactions may point more specifically to the factors that are contributing to the observed effects. The experience of stress as an individual perceptual phenomenon is likely to be particularly susceptible to the expectations of experimenter and subject and the interaction between the two.

CHAPTER 7: OVERVIEW

1 Physiological Changes and Performance Efficiency Under Noise Stress

The investigations of the effects of noise, glucose preloading and task performance produced data which showed that glucose preloading could be titrated against increasingly loud noise to maintain performance efficiency. For example, 30gm glucose preloading led to more efficient performance in 95dB noise than did 18gm glucose. It was suggested that this result might have been due a) to greater impact on the vagal-insulin mechanism with 30gm glucose leading to enhanced parasympathetic activity and reduced levels of internal "noise" balancing the effects of the external noise or b) more directly to the additional supply of glucose. The first explanation was the more satisfactory for it also accounted for the reduced performance efficiency with 30gm glucose in 80dB noise compared with 18gm. At 80dB noise, 30gm glucose might have stimulated excessive parasympathetic activity and the resulting reduction of internal "noise" might have exceeded the increase produced by the 80dB white noise. If 80dB noise may be said to increase 'arousal' it might be suggested that 30gm glucose produced a decrease in 'arousal' but overcompensated and resulted in an overall reduction in 'arousal' levels.

It was unlikely that performance was improved purely as a result of glucose availability. Low glucose insulin requiring diabetics had large reserves of glucose (compared with non-diabetics) and insulin available, and yet their performance was no more efficient than that of the high glucose diabetics who could be presumed to have had little available insulin and hence poor access to their glucose reserves.

80dB noise stimulated endogenous increases in the blood glucose levels of IHD patients (untreated with beta blocking drugs or tranquillisers) but the performance of these patients was significantly poorer than that of the control subjects. This suggested that an increase in blood glucose levels was not in itself the factor which was directly related to performance efficiency under stress. Physiological arousal in the form of increased blood glucose levels was associated with impaired performance in IHD patients. It could be hypothesised that with glucose preloading, the increase in blood glucose levels would not be apparent in IHD patients since vagal-insulin activity would lead to greater clearance of the blood glucose and performance might be improved in noisy conditions by a reduction of internal "noise" levels.

Vagal-insulin activity appeared to occur to some extent in the no-glucose control subjects who tended to show some decrease in blood glucose during the task period. This decrease was enhanced by glucose priming. Such an unprimed decrease in blood glucose was not apparent in IHD patients: possibly the sympathetic activity exceeded parasympathetic activity.

In university or college students, decreases in blood glucose were associated with attenuation of performance impairment with noise. Performance was less efficient in control subjects from the hospital population even when working under 50dB noise. 80dB noise did not lead to a significant impairment of performance. It was possible that the lower level of performance of the hospital controls was due in part to the experimenter effects demonstrated in Experiment 9. However, differences in the task situation leading to greater difficulty with the task for hospital subjects might have accounted for the results. Unlike noise stress, task stress did not appear to be relieved by glucose preloading. The increase in task stress for hospital subjects was probably due in part to muscle fatigue; it would not be expected that such fatigue would be relieved by a reduction in the level of internal "noise".

Under the more difficult task conditions at the hospital, performance of diabetic subjects was not significantly different from that of the control subjects. Even the high glucose diabetics with their exaggerated blood glucose responses did not appear to experience excessive problems with the task. However, only the short term effects of stressful conditions were examined in the laboratory. Chronic problems of diabetic management might be reflected in long term measures of work efficiency if the excessive physiological responses to stressful conditions could not be adequately controlled.

2. Subjective Experiences of Stress

The relationship between SACL measures of stress and arousal and the physiological changes was most obvious in the student population of subjects: the noisy conditions were associated with increases in reported stress and arousal. SEQ measures of stress were less clearly related to the physiological measures from the hospital populations. The hospital control subjects reported both task and noise to be stressful. These results might be explained by increased task difficulty. However, diabetic subjects reported only the task as stressful and IHD subjects reported little experience of stress under any of the experimental conditions. This lack of reported stress by IHD subjects was particularly striking since IHD subjects demonstrated physiological and behavioural evidence of stress.

The concept of alexithymia was discussed in relation to the results of the life change studies. This concept could also be considered in relation to the results of the laboratory studies of IHD subjects and to a lesser extent to those of the diabetic subjects where physiological reactions were associated with seemingly inappropriate reports of subjective experience.

The diminished reporting of stress experienced by diabetic subjects was particularly apparent in the data from the life events study described in Chapter 4 and was surprising in view of the association found between life events and disturbance of the diabetic condition.

It was not logically possible to conclude from such a retrospective study that life events were a causal factor in physiological disturbance of diabetes. It was feasible that problems of diabetic control led to an increase in certain life events that were, at least in part, dependent on the behaviour of the individuals themselves e.g. 'Trouble with Boss' or 'Marital separation'. However, such a relationship would leave unexplained the reasons for the physiological disturbance. Furthermore the laboratory studies demonstrated that experimentally induced stress resulted in physiological disturbance. It therefore appeared to be highly probable that for the most part, life events preceded disturbance of diabetic control. Closer monitoring of the life events of individual diabetics with more frequent measures of physiological control would be required in order to confirm the present findings which indicated that stressful life events impaired diabetic control.

3. Differences in Stress Response

The physiological disruption associated with life events was shown to occur in both male and female diabetics. Sex differences in stress responses of healthy subjects have been reported by the Swedish researchers and observed by the Stress Research Group at Nottingham University; females were found to report greater subjective experience of stress while males were physiologically hyperreactive. Such sex differences were not apparent in the diabetic subjects' reports of stress experiences. The female diabetics did not report more stress than the males while female control subjects reported that life events were significantly more stressful than male controls or diabetics of either sex.

The concept of alexithymia was considered in relation to these findings. It was suggested that males in general are more alexithymic to the extent that they tend less often to express their feelings verbally. This alexithymic tendency was particularly apparent with the IHD patients; there might be a direct relationship in these cases between their inability to perceive and verbalise emotional states, an exaggerated physiological reaction to stress, and heart disease. Nemiah and Sifneos suggested that 'psychosomatic' patients might benefit physically from therapy encouraging verbal expression. If a direct relationship between alexithymic response and physical disorders exists, the effectiveness of such therapy would depend on the ability of patients to relearn habitual patterns of response and this in turn might depend on the reasons for the original response pattern. Developmental studies would be important here to determine the factors which encouraged verbal expression on the one hand and alexithymic repression of emotions on the other. Epidemiological evidence suggested that women were less prone to myocardial infarction than men despite the presence of atherosclerosis. The experimental findings suggested that women were physiologically less hyperreactive to stress than men. The verbal coping mechanism more common among women might serve to protect them from excessive physiological reactions which appear to have pathological significance. The pattern of enhanced physiological reactions to stress and decreased verbal expression of emotions among poorly controlled diabetics was interesting in relation to the increased incidence of IHD among the diabetic population.

4. Further Research

The writer is at present planning a series of clinical studies of individual diabetic patients to investigate some practical applications of suggestions made in this thesis. It was proposed in Chapters 3 and 4 that a more flexible, individual approach to diabetic treatment might lead to more satisfactory management of the condition in those diabetics demonstrating poor control but who are capable of accepting some personal responsibility for their treatment. While physicians concerned with diabetic patients may adapt patients' treatment regimes to cope with periods of strenuous physical activity by recommending increased carbohydrate intake, the present research indicated that certain forms of psychological stress should also be considered prospectively. Examination of individual life styles might reveal possibilities for adapting insulin treatment and diet to allow for those unavoidable stresses seen to disturb diabetic control.

The adaptation of physical treatment could be accompanied by an analysis of the patient's habitual coping mechanisms. It would be of value to examine the effects of encouraging the use of verbal expression as a possible method of reducing the impact of certain types of stress.

Research into comparable forms of therapy of IHD patients could also include investigations of more adaptive strategies for coping with stressful conditions; the possibility of using these strategies as preventive measures could also be examined.

Research is required to investigate further the relationship between subjective and physiological responses to stress and the feasibility of affecting physiological responses by modifying the individuals perception and expression of stressful experiences. Studies of individual differences in response to stress are needed to clarify the association between response styles and physical illness.

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APPENDIX

I Subjective Experience Questionnaire

II Instructions for Mood Ajective Checklist (Stress and Arousal Checklist)

III Mood Adjective Checklist (Stress Arousal Checklist)

IV Index of Life Changes (Life Change Inventory used in Pilot Study)

V Life Events Inventory used in the Experimental Studies. (Adjustment Version)

VI Semantic Differential Rating Scales - Instructions

VII Semantic Differential Rating Scales (Adjustment Version)

VIII Questionnaire to Determine Subject's Expectations Concerning the Effects of the Drink on their Ability to Perform the Task.

NAME ....

QUESTIONS ON EXPERIMENTAL SESSION

(during the time you were sitting at the machine)

For each of the following three questions please tick the word which is the best description of how you felt.

1. VERY PLEASANT ☐
   PLEASANT ☐
   UNPLEASANT ☐
   VERY UNPLEASANT ☐

2. VERY TENSE ☐
   TENSE ☐
   RELAXED ☐
   VERY RELAXED ☐

3. VERY BORED ☐
   BORED ☐
   INTERESTED ☐
   VERY INTERESTED ☐

4. How stressful did you find the session? (please tick)

   VERY ☐
   SLIGHTLY ☐
   NOT AT ALL ☐

5. Could you estimate for how many minutes you were sitting at the machine?

   ....

Instructions for Mood Adjective Check-List

Each of the words on the next sheet describes feeling or moods. Please use the list to describe your feelings at this moment.

If the word definitely describes how you feel at the moment you read it, circle the double plus (++) to the right of the word. For example, if the word is RELAXED, and you are definitely feeling relaxed at the moment, circle the double plus as follows: RELAXED (++) + ? -

If the word only slightly applies to your feelings at this moment, circle the single plus as follows: RELAXED ++ (+) ? -

If the word is not clear to you, or you cannot decide whether or not it applies to your feelings at the moment, circle the question mark as follows: RELAXED ++ + (?) -

If you clearly decide the word does not apply to your feelings at the moment circle the minus as follows: RELAXED ++ + ? (-)

First reactions are usually the most reliable, therefore do not spend a long time considering each word. Work as rapidly as possible. Work down the first column then go on to the second.

Please turn the page and begin working.

Mood Adjective Checklist

(++)	+	?	-	definitely feel
++	(+)	?	-	feel slightly
++	+	(?)	-	cannot decide
++	+	?	(-)	definitely do not feel

TENSE	++	+	?	-	PEACEFUL	++	+	?	-
RELAXED	++	+	?	-	ACTIVATED	++	+	?	-
VIGOROUS	++	+	?	-	TIRED	++	+	?	-
STIRRED-UP	++	+	?	-	IDLE	++	+	?	-
RESTFUL	++	+	?	-	UP TIGHT	++	+	?	-
ACTIVE	++	+	?	-	ALERT	++	+	?	-
APPREHENSIVE	++	+	?	-	LIVELY	++	+	?	-
EXPECTANT	++	+	?	-	STIMULATED	++	+	?	-
WORRIED	++	+	?	-	AROUSED	++	+	?	-
ENERGETIC	++	+	?	-	AT REST	++	+	?	-
DROWSY	++	+	?	-	SOMNOLENT	++	+	?	-
INSENSITIVE	++	+	?	-	CHEERFUL	++	+	?	-
BOTHERED	++	+	?	-	PASSIVE	++	+	?	-
UNEASY	++	+	?	-	CONTENTED	++	+	?	-
INTENSE	++	+	?	-	JITTERY	++	+	?	-
DEJECTED	++	+	?	-	SLUGGISH	++	+	?	-
LEISURELY	++	+	?	-	STILL	++	+	?	-
QUIET	++	+	?	-	PLEASANT	++	+	?	-
NERVOUS	++	+	?	-	SLEEPY	++	+	?	-
PLACID	++	+	?	-	COMFORTABLE	++	+	?	-
QUIESCENT	++	+	?	-	CALM	++	+	?	-
DISTRESSED	++	+	?	-	EXCITED	++	+	?	-
FEARFUL	++	+	?	-					

THANK YOU FOR YOUR HELP

CB/EMS/Nov 75

INDEX OF LIFE CHANGES

		VALUES.
1.	Unemployment (of head of household)...	
2.	Trouble with people at work	
3.	New job in same line of work	
4.	New job in new line of work	
5.	Change in hours or conditions in present job ...	
6.	Promotion or change of responsibilities at work...	
7.	Retirement	
8.	Moving house..	
9.	Purchasing own house (taking out mortgage).. ...	
10.	New neighbours	
11.	Quarrel with neighbours...	
12.	Income increased substantially (25%)..	
13.	Income decreased substantially (25%)..	
14.	Getting into debt beyond means of repayment. ...	
15.	Going on holiday	
16.	Conviction for minor violation (e.g. speeding or drunkenness) ...	
17.	Jail sentence.	
18.	Violent argument or involvement in fight	
19.	Immediate family member starts drinking heavily...	
20.	Immediate family member sent to prison	
21.	Death of spouse	
22.	Death of immediate family member	
23.	Death of close friend	
24.	Immediate family member attempts suicide	
25.	Immediate family member seriously ill.	
26.	Gain of new family member (adoption, birth, old person moving in, etc.). ...	
27.	Personal problems related to alcohol or drugs ...	
28.	Serious restriction of social life	
29.	Period of homelessness (hostel or sleeping rough).	
30.	Serious physical illness or injury requiring hospital treatment	
31.	Prolonged ill health requiring treatment by own doctor..	
32.	Sudden and serious impairment of vision or hearing ...	
33.	Pregnancy (wanted) of self or partner.	
34.	Unwanted pregnancy " " " "	
35.	Miscarriage " " " "	

	VALUES
36. Abortion (self or partner's)	
37. Sex difficulties of self or partner	
38. Problems related to relationship with wife, husband, girlfriend, boyfriend	
39. Reconciliation of differences with sexual partner (eg marital reconciliation) ...	
40. Marriage	
41. Wife begins or stops work	
42. Increase in number of family arguments (eg with spouse, parents, children)	
43. Trouble with other relatives (eg in-laws, cousins) ...	
44. Children in care of others	
45. Trouble or behaviour problems in own children	
46. Son or daughter leaves home	
47. Break up of family (eg due to divorce, marital separation etc)	
48.. Break up with steady boy or girlfriend	

Item	Tick	Adjustment: Least Adjustment 0	Moderate Adjustment 50	Most Adjustment 100
1. Changing to different line of work				
2) Retirement from work				
3) Stop taking extra jobs ...				
4) Start taking extra jobs ..				
5) Taking a course or studying at home for work purposes				
6) Major change in working time....................				
7) Increased responsibility at work.................				
8) Decreased responsibility at work.................				
9) Trouble with Boss				
10) Trouble with colleagues ..				
11) Being unemployed for more than one month...........				
12) Other major changes in working conditions....... (change of work place, colleagues, etc.)				
13) Increased income..........				
14) Decreased income..........				
15) Less expenses............				
16) More expenses.............				
17) Marriage				
18) Marital separation........				
19) Divorce..................				
20) Trouble with wife/husband.				
21) Trouble with family.......				
22) Trouble with other relatives...................				

Item	Tick	Adjustment Least Adjustment 0	 Moderate Adjustment 50	 Most Adjustment 100
23) To be separated from wife/ husband more than one month due to work, travelling, etc				
24) Wife/husband starting work...				
25) Wife/husband ending work....				
26) Birth or adoption of child..				
27) Change in sexual habits.....				
28) Wife/husband seriously ill.				
29) Death of spouse............				
30) Son/daughter seriously ill..				
31) Death of son/daughter.......				
32) Close relative seriously ill				
33) Death of close relative.....				
34) Close friend seriously ill..				
35) Death of close friend......				
36) Change of residence.........				
37) Addition of new member to household, e.g. relative....				
38) Family member leaving home..				
39) Other changes in living conditions.................				
40) Major change in social habits				
41) Change in physical exercise habits......................				
42) Start smoking...............				

Item	Tick	Adjustment: Least Adjustment 0	Moderate Adjustment 50	Most Adjustment 100
43) Stop smoking............				
44) Start drinking..........				
45) Stop drinking............				
46) Major change in personal habits..................				
Anything which has happened to you not mentioned above				
47)				
48)				

Please go through the list and tick those events you have experienced over the past year.

Thank you very much for your co-operation.

INSTRUCTIONS

The purpose of this study is to discover the meaning of certain words by asking you to rate the words on a set of descriptive scales.

The following pages consist of seven sheets each with a set of scales and each with a different word at the top of the page to be rated on every scale. We would like you to rate the words on the basis of what they mean to you. Place a cross on each of the scales at whichever point you feel that the word should be rated. Work as fast as you can; don't take too long to make any rating and rate according to your first impressions of the words. Don't hesitate to use the extreme ends of the scales where-ever these seem appropriate.

Here is an example of how the word FRIGHTENING could be rated:

FRIGHTENING

	1	2	3	4	5	6	7	
fast		X						slow
relaxed							X	tense
controllable						X		uncontrollable
relief							X	worry

.... and so on for the rest of the scales.

For many of the scales there will be no obvious 'correct' answer - so rate it as you see it. We want your first impressions of the words.

When you have finished please check that you have put one cross on all 24 scales on each page.

THANK YOU FOR YOUR CO-OPERATION

ADJUSTMENT (to an event)

	1	2	3	4	5	6	7	
angry	____	____	____	____	____	____	____	peaceful
unattractive	____	____	____	____	____	____	____	attractive
timely	____	____	____	____	____	____	____	untimely
negative	____	____	____	____	____	____	____	positive
cheerful	____	____	____	____	____	____	____	miserable
tight	____	____	____	____	____	____	____	loose
unsettled	____	____	____	____	____	____	____	settled
calm	____	____	____	____	____	____	____	excitable
emotional	____	____	____	____	____	____	____	unemotional
good	____	____	____	____	____	____	____	bad
controllable	____	____	____	____	____	____	____	uncontrollable
straight	____	____	____	____	____	____	____	curved
strong	____	____	____	____	____	____	____	weak
hard	____	____	____	____	____	____	____	soft
pleasant	____	____	____	____	____	____	____	unpleasant
passive	____	____	____	____	____	____	____	active
feminine	____	____	____	____	____	____	____	masculine
boring	____	____	____	____	____	____	____	interesting
slow	____	____	____	____	____	____	____	fast
puzzling	____	____	____	____	____	____	____	understandable
temporary	____	____	____	____	____	____	____	permanent
relief	____	____	____	____	____	____	____	worry
relaxed	____	____	____	____	____	____	____	tense
important	____	____	____	____	____	____	____	unimportant

NAME:...

Questions concerning the drink

1. Did you expect that the drink would have any effect on your performance at the task?

Please tick: YES ☐ NO ☐

2. If YES to Question 1, did you expect it to increase or decrease your performance? Please circle appropriate word.

3. Do you think it did have an affect?

Please tick: YES ☐ NO ☐

4. If YES to Question 3 do you feel that it increased or decreased your performance at the task? Please circle appropriate word.