UNIVERSITY OF KWAZULU-NATAL

The Science of Measuring an Art: Involuntary Psychosomatic Responses of Office Workers to The Office Environment Quality

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DECLARATION

This research has not been accepted previously for any degree and is not being submitted currently for any other degree at any other university.

I declare this dissertation contains my own work, except where specifically acknowledged.

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Signed: _____

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ABSTRACT

The Science Of Measuring An Art:
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by Melanie Kruger

Key words: glucose concentration, indoor environment, insulin response, interior décor, interior design, metabolic rate, office, office environment, office worker, plasma, psychosomatic response, stress.

Twelve participants took part in a clinical trial to investigate whether the office environment quality, specifically the décor and interior design, causes stress in office workers. The stress was measured through psychosomatic responses, to gauge the real subconscious stress, rather than through questionnaires, which measure the conscious response to stress. The participants were office workers from the same administration building, but working in different fields. There were five black, three Indian and four white participants. The gender mix consisted of two female and ten male participants. The age spectrum ranged from 27 years to 55 years of age. Participants were requested to fast from midnight and present themselves early for the tests on two consecutive days. They were divided into two groups. The tests, using two different environment qualities, were presented in a counterbalanced order to the groups, with a control group remaining in the superior environment on both days. A superior environment of four star quality décor and interior design, and an inferior environment of half a star quality were used. From research by Wing et al. (1985), after ingesting a source of glucose, the peak glucose concentration in the plasma is delayed under stress. This was used as the psychosomatic test. Participants drank a solution containing 40 g of polycose, and were then subjected to identical mental stress tests in the different environments. Blood samples were taken at thirty minute intervals for two hours from drinking the polycose, and analysed for changes in glucose concentration. The differences in stress responses were calculated as delays in the time to glucose concentration peak, and analysed. The room factor was highly significant with $F(6;15) = 6.620$ ($p=0.001$ at $\alpha = 0.05$). The day of testing was of much lower significance but still significant at $F(6;15) = 3.402$ ($p=0.025$ at $\alpha = 0.05$). This was due to stress caused by the memory of the pain of repeated jabs with a needle, which would only be observed on the second day. (The time of the peak concentration occurred before the second blood samples were taken, which meant the stress caused by the anticipation of pain remembered was not observed on the first day.) After correcting for the stress effects on the second day due to testing, Tukey's Honestly Significantly Different test yielded two homogeneous subsets (out of a four subsets, which were a combination of the room and day factors). The two subsets were clearly divided by room, and not by day, this time. The subsets (rooms) were both highly significant, ranging from 0.609 to 1.00, for an alpha of 0.05. It was concluded, from causality tests and hypothesis testing, a high quality office environment causes a significantly lower stress response, while a poor quality office environment causes a significantly higher stress response. A model, correlating stress with the office environment, was developed for use by businesses.

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TERMS AND ABBREVIATIONS

(With cross-references and Latin words in italics)

Adrenocortical – pertaining to the adrenal cortex, which is the larger portion of the adrenal gland. It produces hormones essential for homeostasis (the adaptive control process for maintaining the body in steady state). Homeostasis controls heartbeat, blood pressure, body temperature, respiration, electrolytic balance and secretion by the glands (Mosby's Dictionary, 1990).

Artificial light – any form of light not generated by the sun. The sun is generally considered to emit white light, which is the full colour spectrum. Gases, liquids and solids all absorb certain colours of the light spectrum, and emit only a select few colours at different wavelengths. Artificial light therefore emits different colours to natural sunlight due to the absorption of parts of the colour spectrum.

ASHRAE – American Society of Heating, Refrigeration, and Air-conditioning Engineers.

Complex views – views which are not of a single plant or a single building, but rather of many varied plants (complex nature views) or many varied buildings (complex urban views). Contrast complex views with *simple views*.

Cortisol – a steroid hormone acting as an anti-inflammatory agent (Mosby's Dictionary, 1990).

Décor – the result of an implicit deliberate attempt to apply a style or theme to a room in order to adorn it. The Latin *decorare* derives from *decus*, which is an adornment (Collins' English Dictionary, 2003).

Dopamine - the common name for a chemical that acts as a *neurotransmitter*. It is an intermediary in the production of the hormone and *neurotransmitter noradrenaline*. It is

found in the brain. Dopamine is also known as dihydroxyphenylethyalamine (Collins' English Dictionary, 2003).

Endocrine – pertaining to hormones secreted by the glands, as opposed to exocrine, secreted by the salivary gland and sweat glands (UC Pancreatic Disease Centre, 2004).

EVA – Economic Value Added, a financial management tool for increasing value of a company. Corporate decisions on whether to cut costs or invest are assessed in light of the long-term benefits.

Green buildings – buildings which are architecturally designed to be environmentally friendly through the use of natural light, natural ventilation, natural methods of temperature control and the use of solar power where necessary, whilst minimising the use of *artificial lighting* and air-conditioning.

Fasting sugar (or fasting glucose) level – the glucose concentration in the blood after abstaining from food and nutritional or caloric drinks. The fasting period is usually at least a six hour period.

g – glucose concentration in mmol/litre.

Glucose – a simple sugar (or carbohydrate) found in fruits and other foods. It is also produced by the body through the hydrolysis of starches and complex carbohydrates (double sugars). Glucose is absorbed into the blood through the intestines. If the circulating glucose levels increase, the *insulin* response lowers the excess glucose, and the excess glucose is polymerised into glycogen for storage in the liver and muscles. When the glucose is required, it is released back into the blood stream through depolymerisation of the glycogen (Mosby's Dictionary, 1990).

Human issues in horticulture – the studies of the psychological effects of plants and trees on humankind.

IAQ – Indoor Air Quality, the chemical quality of air inside a building or room. Symposiums are held world-wide, between every year and four years, to discuss the quality of indoor air and its impacts on workers. Thousands of research papers have been written and published on various aspects of this broad topic.

Insulin – a hormone which aids in the control of blood *glucose* levels; promotes the transport and entry of glucose into cells of muscles and other tissues; and assists in regulating metabolic processes of carbohydrates, fats and proteins. It lowers blood glucose concentrations as part of a negative feedback control loop. Insulin is secreted in the islands of Langerhans in the pancreas, in response to an increase in blood glucose levels (Mosby's Dictionary, 1990).

LSM – Living Standards Measure

Metabolic – pertaining to metabolism, the sum of all chemical reactions and processes within the body which contribute to growth, energy requirements and waste elimination, and which may affect the chemical processing of a substance in the body (Collins' English Dictionary, 2003).

Morale – the extent of self-esteem or mental confidence, of a person or group (Collins' English Dictionary, 2003). It is an emotional stress.

Natural light – Light generated by the sun, and not by artificial lighting.

Neurotransmitter – a chemical by which communication occurs between either two nerve cells, or a nerve cell and a muscle (Collins' English Dictionary, 2003). Three examples are *dopamine*, *noradrenaline* and *serotonin* (Mosby's Dictionary, 1990).

Noradrenalin – see *noradrenaline*.

Noradrenaline – also known as *noradrenalin* and *norepinephrine*. It is the common name for a chemical which acts in several capacities as a *neurotransmitter*, and as a hormone. It

is secreted by the adrenal medulla and the endings of sympathetic nerves (Collins' English Dictionary, 2003).

Norepinephrine – see *noradrenaline*.

Plasma – the watery fluid portion of the blood in which red and white blood cells and platelets are suspended. The plasma contains no cells. It is essential as a medium for blood circulation, maintaining the pH (acid-base) balance of the body, maintaining osmotic pressure and transporting nutrients. It consists of water, gases, glucose, proteins, fats, electrolytes and bilirubin (Collins' English Dictionary, 2003 and Mosby's Dictionary, 1990).

Polycose – the trademark name for a polysaccharide (a heavy long chain 'sugar' consisting of glucose polymers) with minimal sweetness, derived from corn starch (Mosby's Dictionary, 1990).

ppm – parts per million, used to describe concentrations.

Psychosomatic – physical disorders either caused or aggravated by psychological factors such as stress. It is the interaction between the psyche (the mind) and the body, or the "expression of an emotional conflict through physical symptoms" (Collins' English Dictionary, 2003 and Mosby's Dictionary, 1990).

Room 1 – the room with superior interior design and superior interior décor. A detailed description of Room 1 and its aspects can be found in chapter three. Pictures of Room 1 can be found in chapter three and in the appendix.

Room 2 – the room with inferior interior design and inferior interior décor. A detailed description of Room 2 and its aspects can be found in chapter three. Pictures of Room 2 can be found in chapter three and in the appendix.

SAARF – the South African Advertising and Research Foundation

SAD – seasonal affective disorder. Lethargy, depression and social withdrawal due to increased melatonin production, due to lack of bright light (Mosby's Dictionary, 1990).

Serotonin – the common name for a chemical which acts in several capacities as a *neurotransmitter*, a muscle contractor and a vasoconstrictor. It is found in the blood *plasma*, the brain and intestines, and is partially responsible for lifting depression. It is also known as 5-hydroxytryptamine (5HT) (Collins' English Dictionary, 2003).

Serum – the portion of the blood remaining after coagulation. It is thin and sticky, but unlike plasma, contains no fibrinogen (a plasma protein required in the clotting process) (Mosby's Dictionary, 1990).

Simple views – views consisting of one or a few plants (simple nature views) or else one or a few buildings (simple urban views). Contrast simple views with *complex views*.

Stress – strain due to mental, emotional or physical causes (Collins' English Dictionary, 2003)

t – the time after the start of the test, in minutes.

t' – the time of day on the clock.

$\mathbf{T_{max\_glucose}}$ – the time lag of the peak in plasma glucose concentration, measured in minutes. Smaller $T_{max\_glucose}$ values indicate lower stress, while higher $T_{max\_glucose}$ values indicate higher stress (Wing et al., 1985).

Trunking – rigid housing for flexible cables. The cables could be telephone wires, electric wires, fibre optic cables. The housing (or trunking) is usually made of non-conductive plastic, and is used for both aesthetic purposes to neaten the cables, and for protection. The housing prevents electric shock, and prevents tampering with the wires.

Chapter 1

STATEMENT OF PROBLEMS AND RESEARCH DESIGN

1.1 INTRODUCTION

"Firms need to recognise a reality. Many employees don't just want to work for them; they want to feel as if they belong to the organisation... Employees want to be associated with companies of whom they can be proud, who demonstrate values and long-term goals similar to their own... Experts such as Prahalad and Pfeffer have argued that the effective management of human, not physical, capital may be the ultimate determinant of firm performance." (Knuckey, Leung-Wai & Meskill, 1999)

Stress, low morale and low enthusiasm of workers, as well as unattainable staff retention levels, seem to be the constant battleground for managers, despite the provision of competitive staff benefits. One of the lesser-studied aspects of stress is the physical environment of the office worker, which is the subject of this study.

Stress plays a major role in the overall health and well-being of the individual. More importantly, the effects of stress effects are compounded, rather than simply being additive, because stress has psychosomatic impacts. It affects the chemistry of the body through several mechanisms such as the metabolic process, the release of neurotransmitters, the release of hormones, the control of cholesterol, brain wave patterns and many other systems simultaneously. Because these systems are co-dependent, stress has multiplicative effects on the health, energy-levels and emotional well-being of workers. It is therefore important for companies to address any issues relating to stress and

morale (which is emotional stress) at the office, in order to minimise the compounding effects of other stresses. Many of the causes of stress are well-known and well-documented. Despite initiatives to address the causes or the symptoms of stress among workers, stress and staff retention problems persist.

Companies in industrial areas often believe the office environment quality is trivial for its workers, and the quality of the office environment is only important where prospective clients or shareholders need to interact with the company. In the same breath, companies emphasise how valuable employees are. The contradictory visual message which companies send their staff on a daily basis, in the form of the office environment, is often overlooked. Workers spend the majority of their weekly waking hours at the company, confronted daily by the office environment. They associate their experiences with the company during these times. Therefore, during office hours a company needs to market itself to its employees in order to retain staff. Marketing should not only happen through remuneration, which is enjoyed after-hours and is therefore less weakly associated with times at the office.

Décor is a sign of care, interest and enthusiasm. Data collected by SAARF, the South African Advertising and Research Foundation, for each LSM group (Living Standards Measure group) reveal the not insignificant portion of remuneration which a worker spends on homecare, décor and DIY, to be enjoyed after-hours. "Décor" is the product of deliberate efforts expended in employing colours, themes and furnishings. The higher a worker's salary, the more likely he or she is to spend money on the home. In sharp contrast, the office environment often simply 'evolves' in the path of cost-cutting, under the directorship of a clerk. The clerk, who is unlikely to be formally trained in décor or

ergonomics, is assigned to order office supplies and services at the least cost. As a result, there is often little evidence of décor in industrial offices. The aim of this research project is to provide evidence of the effects of stress induced by an office environment devoid of décor, in contrast with the reduced levels of stress experienced in a decorated environment.

To date, very little literature exists directly relating office worker stress to the décor and quality of the office environment. This is the area proposed for research, in this project.

1.2 Statement of Problem

A study is needed to address the gap in literature on whether different office environment qualities result in different psychosomatic (involuntary) stress responses in office workers.

1.2.1 The Problem

Very little conclusively evidence exists in the literature about the relationship between stress and the office environment quality. From a business perspective, there is very little motivation for companies to reduce office worker stress by using décor as a tool.

To date, most other research, conducted in the field of office environment variables and their effect on office workers, perturbs individual office environment quality variables, and then either

- uses a mental stressor to measure differences only in performance (and does not measure the differences in involuntary stress responses), or

- requires participants to record their conscious responses to questions as an indication of stress levels, but does not necessarily indicate the involuntary subconscious stress responses, or else
- measures the stress response using a physical stressor (by measuring the duration for which a participant can hold his hand in an ice bucket), rather than using a mental stressor. The repeatability of the physical stressor measuring the differences in duration is low due to the subjective nature of the test, although the test may be sufficient to gauge very roughly whether average 'shorter' or 'longer' durations are possible under different environment conditions. The use of a physical stressor to gauge mental stress, however, would appear to be an inappropriate instrument.

The problem is the underestimation of the impact of the office environment on the stress of workers, and the lack of conclusive studies in the literature with measurable results to prove the significance of décor. Undoubtedly, décor will not solve all the issues related to office worker stress, but the impact of the visual surroundings should not be underestimated.

1.3 OBJECTIVES

To establish whether differing office qualities cause different psychosomatic responses of office workers.

The following hypotheses will be tested. The null hypothesis is:

H_{01}: Lower levels of stress, as indicated by psychosomatic responses of office workers in clinical trials, are experienced by office workers in better quality office environments, with better décor and better interior design, than by office workers in inferior quality office environments.

The two alternate hypotheses are proposed.

H_{A1}: Higher levels of stress, as indicated by psychosomatic responses of office workers in clinical trials, are experienced by office workers in better quality office environments, with better décor and better interior design, than by office workers in inferior quality office environments.

H_{A2}: No difference in levels of stress, as indicated by psychosomatic responses of office workers in clinical trials, are experienced between office workers in better quality office environments, with better décor and better interior design, and office workers in inferior quality office environments.

The objectives of the study are to address the gap in literature by proving one of the hypotheses. In order to address this topic in depth and to establish causality, interim critical questions will need to be answered.

1.4 Interim Critical Questions

Various types of evidence are required when testing for causality. The following interim questions will need to be addressed to assist in establishing whether causality exists.

1. Covariance between the office environment quality and the psychosomatic response in workers (indicating stress) must be investigated.

- When the office environment quality varies in the clinical trial, do the psychosomatic responses of the office workers vary?
- If the office environment quality does not vary, do the psychosomatic responses remain constant?
- When the office environment quality improves and deteriorates, does the stress response, indicated by the psychosomatic response, decrease and increase?

2. The sequence of events should indicate causality:

- Does the order of the change in the office environment quality correspond to the order of the change in stress responses in the office workers?

3. No other causes for the change in psychosomatic responses should be possible, in order to establish causality of the office environment quality.

- Are there other possible causes for the changes observed?

The research design must support answering these critical interim questions, in order to establish the veracity of one of the hypotheses.

1.5 Research Design

The research design must support the objectives, must support answering the critical questions to establish causality and must provide a means to establish which hypothesis is

true. The following sections provide a step-by-step description of the approach to be adopted in conducting this research project, starting with a review of other work conducted in this field.

1.5.1 How the Literature Survey Will Be Conducted

A literature survey is important to review the variables, to provide greater understanding of the topic and to assess critically the work already accomplished by other researchers in related fields. The literature survey will be conducted using several media resources to cover the various topics. Using these resources, the literature survey will cover the dependent variable 'stress'; the independent variable 'office environment'; and the 'test methods'. These will be divided into several subtopics, which are detailed below. Research undertaken, which may already have attempted to answer similar questions, will also be critically assessed.

Of the media resources to be used, international scholarly journals will be a primary source of information for the literature review. The journals contain published peer-reviewed research papers. Textbooks on the subjects will also be consulted. In this regard, Sabinet, which catalogues the books available at interlending university libraries in South Africa, and Google books will be useful. The Nexus database will be used to check whether similar research is being done or has been done in South Africa. Government and official government research body websites, such as the South African Advertising and Review Foundation, the Human Resource Development Council (HRD), and Statistics SA will also be examined for appropriate data and research. Websites of

universities and educational institutions with information on the topics will be useful, especially where research has been undertaken.

The topics of the literature survey will be divided into subtopics. The first major topic will cover the independent variable, the office environment and its effect on workers. The following subtopics will be reviewed in light of their impacts on productivity, stress and morale (emotional stress):

- views
- lighting;
- acoustics;
- temperature;
- ventilation;
- indoor air quality (gas chemical intake);
- food (liquid and solid chemical intake);
- plants (human issues in horticulture);
- personal control and
- change.

In addition, the following topics related to living standards and accommodation standards will also be reviews.

- LSMs (Living Standards Measures) and
- the Five Star Rating system used in the hotel industry will be discussed.

The second major topic to be divided into smaller topics is the dependent variable, psychosomatic stress. The literature pertaining to the various psychosomatic effects of stress will be discussed. The topic will also cover stress test methods.

The next phase of the research project, once a literature review has been completed, is the design of an appropriate and standardised research instrument for the collection of valid and reliable research data for the project. The next section looks at this next phase of the research project.

1.5.2 How the Research Instrument Will Be Designed and Standardised

A good research instrument should only be designed once a thorough literature review has taken place. The research instrument should consider

- the project objectives and be appropriate to meet the objectives;
- whether the study will be exploratory or formal;
- whether an ex post facto or experimental design will be appropriate;
- the extent, and which will be more appropriate: a smaller focussed clinical trial or a large scale statistically representative study of the population. (Practicalities such as costs and logistics may be of importance);
- the sample size based on the extent;
- the most appropriate method: monitoring, communication or interrogation;
- the time dimension: whether the study will be cross-sectional or longitudinal;
- funds available (the budget);
- where the study will be executed and the logistics;
- how to ensure validity;

- how to ensure the reliability of results; and
- how to ensure the repeatability of results.

These points are discussed in the following paragraphs and sections. The testing and data collection method will be described under section 1.5.4.

The research instrument will be designed to meet the objectives of the project, which are detailed below. Since the study aims to test whether the office environment quality causes any impact on the stress of office workers, the instrument must therefore support a formal study in which causality can be tested.

Causality of the office environment quality on the stress of office workers will be investigated via psychosomatic responses in different office environments. To establish causality the instrument design must enable the interim critical questions, listed previously in 1.4, to be answered. The instrument design will therefore depend strongly on excluding other possible causes of the dependent variable, stress.

Appropriate conditions for data collection will involve minimising the impact of extraneous variables which can affect stress. The choice of an experimental design versus an ex post facto design is therefore critical. In this case, an experimental design is appropriate. Since the dependent variable, stress, can be the result of many possible extraneous variables, an ex post facto design would result in 'noisy' data and therefore post hoc fallacy. An experimental design, however, will allow for greater control of variables to establish causality. Therefore, an experimental design in the form of a clinical trial is most suitable and practical.

In the clinical trial, only the independent variable, office environment quality, will be perturbed whilst monitoring the dependent variable, the psychosomatic stress responses. Monitoring methods are the preferred method of data collection, as opposed to either interrogation or communication methods, because interrogation and communication would elicit only the conscious responses to stress. In this study, the aim is to measure the subconscious responses to stress via the psychosomatic responses. The research instrument will therefore be designed to monitor the dependent variable stress, via psychosomatic responses under controlled experimental conditions. The psychosomatic responses of participants will be monitored by collecting information related to changes in glucose concentration in the plasma over time under different environment conditions. In order to minimise 'noise' related to stress, the time dimension of the clinical trial becomes important.

The time dimension of the clinical trail will be short (cross-sectional). The potential for noise due to the impact of extraneous variables on stress over long periods dictates that clearer (less noisy) results will be obtained with shorter 'snapshots' than if the study was longitudinal. The research instrument will therefore cater for two snapshots under two different office quality conditions, with each test performed within one to two days of each other. A short recovery period will be necessary for participants, although the gap between testing times must be kept small to minimise the risk of extraneous stress-related variables.

A control group will experience no change in office environment quality conditions, to investigate possible stress introduced through the actual testing method.

The tests will be standardised by using:

- the same two rooms when the participants change environments from day one to day two (which will be described in detail in chapter three);
- a standard 175 ml solution in which 40g of polycose, as a source of glucose, will be dissolved. This must be drunk as quickly as possible to avoid time delay differences.
- a standardised laboratory testing procedure (using a Beckman Glucose Analyser, Sychron CX, to measure glucose concentration in plasma, with a reproducibility of 0.11 mmol/litre within run);
- the identical mental stressor on the first day, for all participants in both Room 1 and Room 2;
- the identical mental stressor on the second day, for all participants in both Room 1 and Room 2. The stressor will be identical in task and difficulty to the stressor on the first day.
- the same the incentive (prize money and breakfast) on both days;
- similar size groups;
- a small time delay between the two sets of tests (preferably one day apart);
- a rating system for the quality of the two office environments.

In summary, the research instrument will be designed as a formal study to investigate causality cross-sectionally, under experimental conditions in a clinical trial. Psychosomatic responses, via blood samples to measure plasma glucose concentrations, will be monitored as the office environment quality is changed. A control group will experience no change in office environment quality. The remaining participants will experience a change in office environment conditions in a counterbalanced order. Noise

in the dependent variable, stress, will be minimised by testing over a short time period. The tests will be standardised across the two days. The tests will be described in detail in chapter three, with pictures, to ensure repeatability. Validity and reliability will be discussed in section 1.5.3

1.5.3 How the Collection of Valid and Reliable Research Data Will Be Ensured

Internal and external validity, and reliability are important features of a good instrument. Various methods of ensuring validity and reliability will be used in the design of the instrument.

Content validity, predictive validity, freedom from bias and construct validity will be used to ensure valid data is collected. Reliability will be achieved through stability and equivalence. Validity and reliability will be discussed in more detail in chapter three.

The number of participants, the sampling method and the structure of the groups of participants are also important features of the research design for ensuring the collection of valid research data, and are discussed below.

Clinical trials, conducted to investigate whether a possible causative relationship exists, mostly involve relatively small numbers of participants, typically upwards of four participants, depending on the cost and nature of the trial. The sample size is often small because of the prohibitive costs. Clinical trials are useful because the studies often focus on depth of understanding at great expense, as opposed to breadth. The trials are conducted under strictly controlled experimental conditions, which aim at eliminating

noise factors. Owing to the large expense of this particular study, and the desire to establish a causative relationship under strictly controlled conditions, a clinical trial will be performed. The sample size will also be restricted by the availability of eligible participants. The aim of the study is to establish possible causality between the office environment quality and the psychosomatic stress response in healthy participants, thereby assisting businesses in understanding one aspect of the complex issue of stress.

For the sample size, the minimum number of participants required for a clinical trial does not appear to be well defined. Typical studies use anywhere upwards of four participants, typically between four and thirty participants, depending on the nature and cost of the study. Most psychosomatic journal articles have studies with less than twenty participants. On the upper scale, the Department of Health and Human Services & National Institutes of Health (2005), regulates grants for HIV studies to a minimum of 20 participants, only because this cost is equal to the core cost of the studies. Cost and practicality appears to be the dominant factor when determining the number of participants. This study will aim for 16 to 20 participants. The method of selecting these participants will ensure a reasonable representation of demographics of the eligible population.

Stratified disproportionate probability sampling will be applied as the sampling method, with participants being required to meet eligibility criteria. Aside from the eligibility criteria for selection, the ethnic group, gender, age and income bracket will be used for stratification. Within each stratum, a simple random sampling approach will be adopted. Some disproportionate sampling will be necessary to get an adequate representation of each group, owing to the fairly small sample size. Once the sample has been selected, the

organisation of these participants into experimental groups and a control group will be the next consideration for valid data collection.

The organisation of these participants must ensure an equal chance of exposure through a random assignment to each group. From the group of participants selected, one part of the group must be used as a control group held under constant office environment conditions, in order to check the office environment quality has not become confounded with other variables. The remainder of the group will be split into two groups who will change rooms between the first and second days.

1.5.4 How the Data Will Be Collected

Designing the collection of data which answers interim critical questions and tests the hypotheses is a crucial part of the structure of the experimental design. The design of data collection must allow for causality to be tested. The three elements required to test causality are: covariance, sequence of events, and no other possible reasons.

1.5.4.1 Covariance, First Requirement of Causality

The first element of the structure must allow for covariance between office environment quality and psychosomatic responses to be tested, by answering three questions. The three questions cover whether the hypothesised difference is observed when conditions are changed, whether there is no observed change when the variables are not changed, and whether the change in response observed is in the correct

direction for which the variables are perturbed. The three questions are expanded below, with regard to data collection.

1. Does varying the environment quality cause the hypothesized difference in psychosomatic stress response?

   In order to collect appropriate data in this regard, some of the participants must be subjected to different office environment qualities on different days. Two groups of office workers will experience different office environment quality conditions on the first day. Group 1 will experience superior office environment conditions in room 1, while group 2 will experience poorer office environment conditions in room 2. On the second day, each of the two groups will change offices. Group 1 will experience inferior office conditions in Room 2, while group 2 will experience superior office conditions in room 1.

2. When the environment quality remains unchanged, does the psychosomatic response remain unchanged?

   In order to collect suitable data to answer this question, some participants must not be subjected to changes in office environment quality. These participants will form part of the control group who experience constant office environment conditions. Two participants will experience superior office environment conditions in room 1 on both of the two days of testing. This will establish whether unchanged office environment quality results in

corresponding unchanged psychosomatic responses.

3. When the office environment quality improves and deteriorates, does the psychosomatic response correspondingly improve and deteriorate?

   In order to collect appropriate data to answer this question, the testing must be done in a counterbalanced order, as described in the first question. Half of the participants, who will be subjected to changes in office environment conditions, will first be subjected to the superior office environment conditions and then move to the inferior office environment on the second day. The other half of the participants, who will be subjected to changes in office environment conditions, will start with the inferior office environment on the first day and move to the superior office environment on the second day. This will also establish whether change or learning experiences have any impact on the psychosomatic responses.

These three questions must be answered to establish covariance, which is the first element of three elements required to establish causality.

1.5.4.2 Sequence of Events, Second Requirement of Causality

After covariance, the second evidence for causality required in the data collection is whether the office environment quality changes before the change in psychosomatic response occurs. The nature of the tests already dictate a time order (the office

environment will be set up, participants will enter the room and be tested), in which case the data collection in regard to time order needs no special dictates.

1.5.4.3 No Other Reasons, Third Requirement of Causality

The third evidence of causality is if there are no other possible reasons for changes in psychosomatic responses. The data will be collected under conditions where food cannot influence the response and where extraneous stress variables are minimised by performing the tests on two consecutive days.

1.5.4.4 Data Collection Method

The actual data collection method will be based largely on the study by Wing et al. (1985), with differences to suit this study. The difference involves mental stressors which engage both the left and right brain of each participant, and the use of office environments of differing qualities, to test the effect of the office environment quality on stress. The method is described here in detail.

Overview: The peak in the glucose response in the plasma phase is delayed under stress. At the recruiting and screening phase, diabetics and people with hyperglycaemia and hypoglycaemia will be excluded. Five blood samples will be collected from each participant over a two-hour period to gather data about the changes in glucose concentration in the plasma phase. The time at which the plasma concentration peaks will be checked.

First blood sample: Participants will be requested to fast from midnight on the night before the tests until the start of the tests, to establish a baseline glucose level with the first blood sample. Participants will be requested to arrive at 07h00 and to relax in the assigned room for thirty minutes. The first blood sample will be taken after the thirty minutes of relaxation, noting the time at which the sample is taken.

Glucose source: Participants will then be given a high calorie load (40 g of polycose, which is a glucose polymer, dissolved in 175 ml of diet lemonade soda) and be asked to drink it as quickly as possible. The time at which the polycose is drunk will be recorded.

Mental stressor: Immediately thereafter, participants will be subjected to 30 minutes of a standardised mental stressor to induce a stress response. The additional stress, potentially caused by the office environment quality, will provide the additional variable source of stress. The standardised mental stressors will consist of seven three-minute tests with a one-minute break in between each test. The identical tests will be performed in Room 1 and Room 2 on the first day. The tests will be very similar on both of the two days. The identical tests will be performed in Room 1 and Room 2 on the second day. The tests will comprise arithmetic tests, conundrums and visualisation problems. The tests will be aimed at engaging both the left and the right brain of each participant. Participants will compete for money, to raise the stress levels. Each room will be divided into two groups. Within each group of four people, participants will compete for ZAR 5 per mini test. The highest mark in each sub group of four people will win ZAR 5.

Subsequent blood samples: Thirty minutes after drinking the polycose, in which time the standardised mental stressor will have been executed and completed, the second blood sample will be drawn, noting the time of the sample. Thereafter, participants will be requested to relax and read a book or a magazine. Further blood samples will be taken at half-hourly intervals, noting the time of each sample, resulting in a total of five blood samples on each of the two days, over a two hour period. The room number, time and participant number will be recorded for each sample, as part of the data collection. The blood samples will be drawn by qualified nurses from the pathology laboratory, with a qualified doctor on site to assist the nurses when required.

Blood sample testing: The blood samples will be centrifuged to separate the plasma from the blood cells. The plasma will be analysed for glucose concentration using a Beckman Glucose Analyser, Synchron CX. The glucose concentration results, times of samples, participant numbers and room numbers will form the raw data.

Blood result data collection: The results will be printed by the laboratory and supplied to the researcher.

Second day: The tests will be repeated, but this time, two to three participants will remain in Room 1 as a control group, while the remainder of the groups change rooms.

Once the data or the blood glucose levels in plasma has been collected (along with the times of sampling, the room condition and the day of testing), the data can be analysed.

1.5.5 How the Data Will Be Analysed

Statistical analysis will proceed once the laboratory results have been collected. In order to analyse the data, the dependent and independent variables must first be identified clearly.

Regression analysis will be used to obtain a relationship between the plasma glucose concentration (dependent variable) and time (independent variable) for each participant in each room. The zero value of the derivatives of these relationships will yield the time at which the curves peak in each instance.

The peak of the plasma glucose concentration is delayed under stress (Wing et al., 1985). Calculation of the time of the peak, referred to as $T_{max\_glucose}$ in this study, is therefore important. It is the dependent variable which will be hypothesised to be influenced by the quality of the office environment (in other words, the room, which is the independent variable). The $T_{max\_glucose}$ values of all participants, except for the control group, will be used to analyse which room was more stressful. Higher $T_{max\_glucose}$ values indicate higher levels of stress (Wing et al., 1985). The $T_{max\_glucose}$ values for the control group, who will stay in the same room on both days of testing, will be used to check if the testing itself caused any stress. The day of testing will therefore also be recorded as an independent variable to check whether there were any effects on $T_{max\_glucose}$ due to the day of testing.

$T_{max\_glucose}$ will be analysed statistically with tests for significance. Graphical representation of $T_{max\_glucose}$ comparisons will also be provided.

Post hoc tests using Bonferroni, a modified Bonferroni (Sidak) and Tukey's Honestly Significantly Different tests will be conducted to check for homogeneous subsets within the data, and to check whether the difference in the environment quality (the room) can be associated with significant differences in $T_{max\_glucose}$.

The tests for significance and the post hoc tests will therefore assist in establishing whether causality exists, by enabling the questions from 1.5.4 to be answered. Veracity of the null hypothesis or one of the alternate hypotheses can then be established once causality has either been established or ruled out.

This is a brief outline of the data analyses which will be performed once the data have been collected. More detail about the approach for the data analysis will be provided in chapter four. A brief overview of all the chapters in the dissertation follows.

1.6 Overview Of Dissertation Chapters

The first chapter provided the research question and the proposed research design to investigate the impact of the office environment quality on the stress of office workers, in a clinical trial. The remainder of the document will examine the literature, and describe the actual research carried out with its results and conclusions. Below is a more detailed description of the chapters, starting with the literature review in chapter two.

Chapter two will contain a critical overview of the literature associated with the topic. The sources will include journals with peer-reviewed articles by other researchers, books, research papers, and government and educational websites. The topic is comprised of several diverse subtopics. The threads of these topics will be drawn together and examined in this research project. The two overarching topics include, broadly, the psychosomatic impacts of stress and the various specific details related to the office environment quality, as it pertains to the stress, morale and productivity office workers. A concept matrix will be developed and placed in the appendix, which will tabulate the topics and the resources to be used. Once a critical examination of the literature has been presented in chapter two, the research experiment will be conducted, and described in chapter three.

Chapter three will contain a description of how the testing phase of the research was conducted. Any practical problems encountered and deviations from ideality will be described and discussed. Improvements to the sampling procedure, testing procedure and data collection methods will be recommended for future researchers who wish to use this research project as a springboard for their own investigations. Any shortcomings of the research design or deviations from design will be described, in order to provide a full basis for understanding the discussion of the results, which will be presented in chapter four.

Chapter four will contain a discussion of the data analysis, including the statistical analysis. Any of the shortcomings of the design on the analysis will also be discussed. The conclusions and recommendations from these results will be presented in chapter five.

Chapter five will contain a discussion using the statistical data to test the hypotheses. Prior to testing the hypotheses, causality must be established, but prior to establishing causality, the interim questions, which cover the three elements of causality must be answered.

Chapter six will contain the limitations of the project, future improvements recommended (should the tests be repeated) and areas for future research.

Chapter seven will encapsulate the conclusions and recommendations of the research project, and will contain a model of the stress and office environment relationship. The aim will be to indicate what was achieved in the project, and to make recommendations to industries regarding the office environment qualities provided to office workers. The primary aim in this chapter will therefore be to provide new insight for companies to increase margins through reduction of office worker stress, and thereby to provide the potential for increasing office worker retention and productivity through new means.

1.7 CONCLUSION

The project is an undertaking to investigate the effects of décor and interior design on the stress of office workers. Scientific measurements of the impact of décor on office workers have, to date, been limited. Measuring how much people like or dislike something of artistic value, and measuring the stress response invoked at a subconscious level is not often attempted, perhaps because methods for quantifying these responses have not yet been considered. The conscious responses of stress, via questionnaires, have been gauged, but measuring the subconscious responses to art, with minimal subjectivity in the measurements, does not appear to have been attempted. It is the science of measuring an

art. The décor quality will also be quantified using the five star rating system. Through the research, it is hoped to provide industries with another tool for increasing productivity and staff retention through stress reduction. It is also hoped to provide other researchers with new methods of measuring subconscious (real and unacknowledged) responses to intangibles.

Chapter 2

LITERATURE SURVEY

2.1 INTRODUCTION

In many of the major manufacturing environments in South Africa, companies do not decorate or design the office environment in such a way as to reduce stress, maximise worker productivity, actively encourage staff retention and satisfaction, or encourage creativity. Lack of resources spent on the office environment could have far-reaching negative consequences for the value of companies. Lack of understanding of the stress of the office environment quality on workers could also be detrimental. The discussion, which follows, is a review of the current literature pertaining to the topic.

2.2 HOW THE LITERATURE SURVEY WAS CONDUCTED

The literature survey was conducted by critically assessing and comparing various journal articles, textbooks and research papers pertaining to the office environment and to stress. The internet and available textbooks were searched for these articles, along with the Nexus database of current research in the field in South Africa. Currently, no research has been done in this field same field in South Africa. No other research articles were found which attempt to measure and compare the psychosomatic stress responses to décor and interior design.

2.3 Overview of Literature Relating To the Theoretical Framework of the Dissertation

'Décor' has long had the stigma of being unmanly and frivolous. The intention of the research project is to dispel the notion of frivolity and to highlight the latent benefits of décor and design in the workplace as a tool for stress reduction among workers.

The latest data available (from Horowitz & Bowmaker-Falconer, 2000), showing management trends by gender in South Africa across the different sectors, indicate the high prevalence of male managers in all sectors of business, apart from education, health (and welfare) and the public sector. In the manufacturing sector in South Africa, male manager prevalence is especially high. An excerpt from the table in the appendix (page 156) shows gender prevalence amongst employed managers and in recruitment into management in the manufacturing sector in the year 2000 in South Africa.

Table 2.1 Employed Managers and Recruitment of Managers in the Manufacturing Sector of South Africa, 2000

Sectors	Employed Managers		Recruitment into Management	
	Male%	Female %	Male %	Female %
Chemical and allied industries	76.8	23.2	74.5	25.5
Clothing, textiles, leather and footwear	73.0	27.0		
Construction	91.4	8.6	100.0	0.0
Energy	88.2	11.8		
Food	83.1	16.9	76.7	23.4
Forestry, furniture, pulp and paper, board and wood products	90.0	10.0	82.9	17.2
Metal, plastics, motor retail, auto manufacture, tyres	88.6	11.4	54.4	45.5
Mining and minerals	93.3	6.7	87.2	12.7

Source: adapted from Horowitz, F.M. & Bowmaker-Falconer, A. (2003) *HRD review 2003 - human resource development review: managers*. South Africa, HSRC.

The percentage of employed managers who are male managers ranged from 73.0% to 93.3%. Recruitment figures indicate the trend was likely to remain stable, with recruitment of male managers in these sectors ranging from 54.4% to 100.0%

Given most managers in the manufacturing sector are male, and there is an unmanly stigma attached to décor, it is therefore not surprising the décor and design of the office environment, in the manufacturing sector of South Africa, have in many cases received little focus as levers for reducing stress, increasing efficiency and effectiveness, or increasing worker satisfaction. It is also not surprising the budgets for office decorating are consequentially low, as will be illustrated below. Many male managers would be less apt, relative to their spouses, to perceive the real costs and importance of providing well-decorated, comfortable environments. The following two examples are quoted from a South African company who has offices typical of the South African manufacturing environment.

One South African company, whose offices are typical of the manufacturing environment through lack of décor and ergonomically designed furniture, and who wished to remain anonymous, budgeted ZAR 40 000 in 2006 for office furniture, for some 400 office staff. The average chair price ranged from ZAR 2000 for a partially ergonomically-designed and partially adjustable chair (retail outlet prices from Makro and Game, 2006, pers. comms.) to ZAR 7410 for a fully ergonomically-designed and multi-adjustable chair, from the HÅG range of ergonomic chairs H05 (The Back Shop International, 2003). If no other office renovations and maintenance were done, 20 to 70 years of service would be required before each office worker was able to receive such a chair. In realistic terms, this means it would be impossible for every worker on site to have a fully ergonomically designed chair

with the current budget, especially since it is only valid if no other office maintenance and renovations were undertaken.

As a second example, the approved contractor on site at the same manufacturing company charged ZAR 5000 for two new desks (D Gengan, July 2006, pers. comm.). If the office employees each needed a new desk and a bottom-of-the-range semi-ergonomic chair, then with an annual budget of ZAR 40 000, each of these employees would wait an average of 45 to 90 years, provided no other office décor was undertaken. The company had budgeted less for painting than for refurbishments (which was is the category available for furniture).

This company is not unique. There is general a low level of importance attached to décor and employee wellness in the South African manufacturing sector. The following sections deal with the literature related to the office environment quality and stress. The reader is referred to the concept matrix in the appendix for an overview of references and topics.

2.4 Survey of Literature Relating To Office Quality and Accommodation

2.4.1 Introduction

The office indoor environment may initially seem like a simple topic, but, by the sum of its parts, is in fact very broad. The topic has been split into various facets to give an overview of its breadth. Many of the articles reviewed were research documents funded by different government departments for countries such as the United States of America, Finland, Canada, South Africa, New Zealand. Research articles reviewed also include

papers by architects involved in "green buildings" for projects such as the redesign of the World Trade Centre. Poor staff retention, low levels of concentration and productivity (measured by effectiveness and efficiency), as well as reduced personal safety, are among some of the growing trends as a result of cost-cutting related to the office environment. Many first world countries recognise improvement in worker productivity as a major untapped resource in most businesses and organizations. Numerous resources by governments and organisations have been expended on investigating and quantifying the potential benefits, and it seems as if the energy poured in this direction will reap substantial pay-offs. Countries are realizing "cost-cutting" drives within companies could be antiquated and short-sighted. Most cost-cutting drives do not consider the 'benefit' side of the cost/benefit equation. What follows is an overview of some of the relevant literature in each subtopic.

2.4.2 Views

Windows are complex. They provide natural lighting and views which improve productivity, but also provide opportunities for thermal discomfort and glare, which negatively affect productivity.

Views have several beneficial effects on productivity. Views, when larger windows and nature views are visible, they increase efficiency, determined by speed within mental tests, by 6% to 12%. Views also increase another aspect of productivity, namely effectiveness. An increase effectiveness and memory recall, determined by accuracy on mental tests, of 10% to 25% can be expected. Moreover, views result in significantly

better health. Lack of windows, however, result in an increase in fatigue and therefore, stress (Heschong Mahone Group, 2003a).

Views directly lower stress, as evidenced by work done in on inmates. Views of hills (nature landscape views) from a prison resulted in lower levels of stress than views of the prison quadrangle (West, M.L., in an unpublished thesis quoted by Kaplan, S. & Kaplan, R., 2003).

Various studies show people prefer complex views to simple views, and prefer nature views to urban views. Farley & Veitch (2001) found this preference documented in the literature to be consistent with their own findings, although no increase in productivity was found. Only an increased sense of well-being and reduction in perceived stress were found.

Florence Nightingale, in 1860, is said to have believed sunlight and natural views from windows to be of recuperative benefit. Views from windows are strongly associated with lighting, and therefore this is the next topic to be covered.

2.4.3 Lighting

Natural daylight illumination is an important part of the office environment. Natural lighting is beneficial in improving productivity and increasing health, as indicated by several studies. Where natural light creates glare, however, productivity decreases.

Lack of natural light is responsible for Seasonal Affective Disorder, SAD (Guillemette et al., 1998), especially in climates where there are vast differences in the amount of light available between summer and winter. This may not be prevalent to the same extent in South Africa, but the study does show the effect of a lack of natural light has an effect, which is likely to be present, but diminished, in South Africans who are not exposed to natural light in their work environments.

Attention span and short-term memory increase with increasing levels of natural (daylight) illumination. At higher levels of natural lighting, the increase in benefits tapers. The largest benefits due to differences in natural illumination are reaped at initial low levels of illumination. Combined effects of illumination, ventilation and temperature control, produce an increase in productivity of 2 to 5% (Heschong Mahone Group, 2003a).

Similar studies on scholars found an improvement of 7 to 18% in test scores (which translates to effectiveness) and a 20-26% increase in speed on tests (which translates to efficiency) with high levels of natural lighting. Blinds are effective in helping to reduce glare (and were found to significantly improve student performance). Glare has negative impacts on student scores where there is direct sunlight penetration on the paper or screen (Heschong Mahone Group, 2003b).

Over and above the effects of light, the ability to control levels of lighting yields gains in productivity. Croxton Collaborative Architects (2005) working on the World Trade Centre redesign estimate personal lighting control improves workforce productivity by 7.1%. Personal control over lighting levels provides the largest potential improvement in

workforce productivity. Personal control over other variables in the office environment also has significant benefits, as will be seen in subsequent sections.

2.4.4 Acoustics and Sound

In offices, there should be minimal sound travel, while in conference rooms, sound may need to travel further without reverberations.

Aside from designing the building and the choice of materials correctly, other options for noise reduction in existing buildings are also available. Environmentally Responsive Workstations (ERW's) produced by Johnson Controls Systems deliver "white noise" to counteract the effects of noise at each desk (Croxton, 2005). The "white noise" sends out sound waves which cancel the effect of nearby sound waves.

Architects and acoustics engineers study building and décor materials and the interior design of rooms for optimum sound distribution.

Acoustics, to the layman, simply means sound travel or noise. However, it is a far more complex subject involving sound waves, reverberations, deflection, and bouncing of waves, of pitches and decibels. Good acoustics management requires professional training. The Heschong Mahone Group (2003a) describe ODEON, a professional software used by acoustics engineers to analyse sound and noise. The software is capable of performing a multiple bounce interaction of sound in three dimensions. Reverberation time, sound waves and decibel levels are all part of the analysis done by the program.

Different people have different perceptions of noise. Proper interior design and personal control with Environmentally Responsive Workstations greatly reduce the variable amounts of stress caused. Another discomfort factor which causes stress and can be subjective due to different personal perceptions is temperature.

2.4.5 Temperature

Thermal comfort significantly affects the performance of an office worker. Within a band, if the temperature is too high or too low, productivity drops substantially. The graph below displays decreases in performance. Therefore, maximum performance is achieved in the trough.

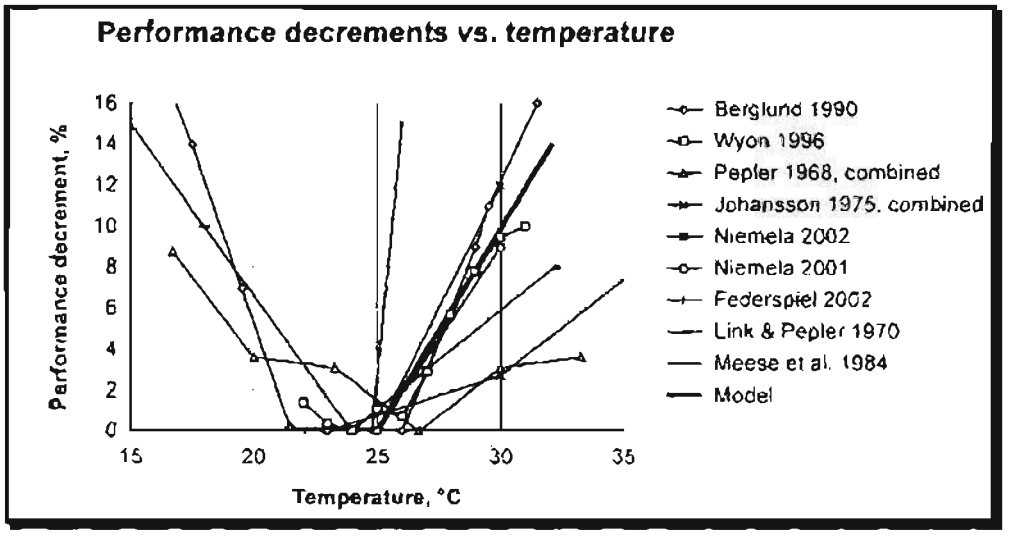


Figure 2.1 Summary of the studies on the effect of room temperature on decrement of performance and productivity.

Source: Seppänen O., Fisk W.J. & Faulkner D. (2004), *Control of temperature for health and productivity in offices, LBNL-55448*. Berkely, California, Lawrence Berkely National Laboratory.

At a call centre, the least complaints from office occupants were received in the range of 22.5°C to 23.9°C, which falls within the range where there is no significant impact on productivity, at 21.5°C to 24.75°C. This correlates with thermal comfort standards, which indicate 21°C to 25°C is the ambient temperature range at which most people feel comfortable. Dexterity of hands is notably reduced at 20°C to 22°C, with a 5-15% reduction in dexterity at 18°C relative to dexterity at 24°C (Seppänen, Fisk & Faulkner, 2004).

Croxton Collaborative Architects (2005) estimate personal thermal control improves the average workforce productivity by 1.2%. According to the ASHRAE (American Society of Heating, Refrigeration, and Air-conditioning Engineers) Standard 55-2004, as quoted by Croxton Collaborative Architects (2005), the factors affecting performance due to thermal factors are the occupants' metabolic rate and level of activity; insulation afforded by the type of clothing; the air temperature touching the occupant; the radiant temperature of nearby surfaces; the air speed flowing across the occupant; and the humidity. Personal control is a psychological stress reliever. When perceived temperatures approach the zone for optimum productivity, increases in productivity and stress reduction occur. One method of control for temperature and fresh air, is ventilation, as covered in the next section.

2.4.6 Ventilation

Ventilation is important for fresh air, and removal of contaminants due to breathing. A window opening, as defined by ASHRAE 62-2001 (Croxton Collaborative Architects, 2005), in an occupied space must be at least 4% of the floor area. This occupied space is

to be within 7.5 m of the window and is to be permanently open to it. Research shows an increase in tolerance to a broader spectrum of temperatures, for people who have control over operable windows.

Ventilation is associated with increased productivity. The Heschong Mahone Group (2003b), in their research for the Californian Energy Commission, found the highest efficiency periods in a call centre correlated most strongly with periods when there was the highest rate of external air. Ventilation is closely associated with indoor air quality.

Indoor air quality and ventilation are closely linked. Fresh air outside has a neutral charge, which means positive and negative ions are in balance. Inside the office environment, however, building materials, paints, wall papers and flooring are not designed to conduct electrical charge. Ambient air currents force air to brush across them, generating positive ions, which results in static charge. In 1972 Krueger was the first researcher to discover the effect of positive ions on serotonin levels. He coined it "Serotonin Irritation Syndrome." Positive ions deactivate the enzymes required to break down serotonin, and interfere with the membranes of the respiratory system, which is why people feel exhausted after being in a closed, stuffy room. Humans also give off positive ions, which is why a room full of people becomes stuffy, and the occupants become drowsy. The antidote to this is negative ions. Negative ions are required for the oxidative break down of serotonin. Numerous air-conditioning systems are available, supplying negatively charged ions. Portable ionisers to create negatively charged ions have also now become available commercially (Cause of, n.d.; Lewis, 2005 and Wallach, 1986).

Maximum natural ventilation is catered for in the design of green buildings. For green buildings, Croxton Collaborative Architects (2005) propose a further 1.8% improvement in worker productivity, with personal ventilation control to suit the individual. (Note this is different from personal thermal control).

Ventilation restores the balance of positive and negative ions, as well depletes the air of toxins, odours, bacteria and viruses released by humans. Indoor air quality, as a chemical intake into the body, is reviewed next, as part of the office environment.

2.4.7 Indoor Air Quality (Chemical Intake)

Indoor air quality can be costly. In Australia, the CSIRO estimated the cost of sickness and lost productivity due to be $ 12 billion per annum in 1998 (Aeris Technologies, n.d.).

The amount of research done annually on indoor air quality indicates the value and concern which indoor air quality generates. In 2002 at the Ninth International Conference on Indoor Air Quality and Climate, 726 papers were presented, with nearly 1100 participants world-wide. The conference is multidisciplinary, and occurs every 3 years (International Conference on Indoor Air Quality and Climate, 2002).

Highly ventilated buildings, as compared to buildings which meet the minimum standards for ventilation by ASHRAE, correspond to the lowest levels of Carbon dioxide, and the lowest number of building related illnesses. The study was performed over a four to five year period, on office buildings in the United States (Erdmann & Apte, 2004).

What constitutes "good indoor air quality"?

The South African National Standard requirements for compressed air quality in breathing apparati as specified in SANS 277:2004 (EN 12021:1998): "Respiratory Protective Devices – Compressed Air for Breathing Apparatus" are:

Table 2.2 Breathing Apparatus Air Quality Requirements

Component / Contaminant	**Requirement**
Oxygen (O_2)	21±1% (by volume of dry air)
Lubricants	< 0,5 mg/m3
Odour	None
Taste	None
Carbon Dioxide (CO_2)	≤500 ml/m³ (500 ppm)
Carbon Monoxide (CO)	<15 ml/m³ (15 ppm)
Water (H_2O) @ 40-200 bar nominal pressure	50 mg/m³
Water (H_2O) @ 200 bar nominal pressure	25 mg/m³
Oil Mist	0.5 mg/m³
Other Chemical Contaminants	Occupational Exposure Limit (OEL)

Source: SANS 277:2004 (EN 12021:1998), quoted in SAPREF HSE/BE Department (2005) *SAPREF Business management system: Supplied breathing air quality* [Intranet], Durban, SAPREF HSE/BE Department. Available from:

<http://corp.sapref.com/asc_bms/library/documents/approved/hsse/pr/hsse.pr.0015.doc>

[Accessed 22 August 2005].

Indoor air quality should at least meet similar standards to those in breathing apparati, for a healthy environment, and not minimum requirements.

The minimum office building ventilation rate recommended by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) is 10 litres/sec/person (quoted by Croxton Collaborative Architects, 2005). Translated, this means in an office which is 3 m in breadth, by 3 m in length, by 3 m in height, for a single person, there

should be at least one complete air change in 45 minutes. For three people sharing this office, there need to be at least four changes of air in one hour. The minimum ventilation approximates to a worst-case (maximum) steady state indoor CO_2 concentration of 870 ppm, if:

- the outdoor base level CO_2 concentration is 350 ppm and
- the rate of indoor CO_2 generation is 0.31 litres/min/person, which is 0.0052 litres/sec/person or 0.0186 m^3/hour/person (Erdman & Apte, 2004).

In an office environment where the building is empty overnight, it can be deduced the steady-state morning CO_2 levels should match outdoor CO_2 levels (350 ppm) and by the end of the 8 hour day, CO_2 levels should reach 870 ppm if the minimum recommended ventilation rate is used, but this final CO_2 level is greater than the 500 ppm for breathing apparati. It is therefore recommended higher ventilation rates be used than the minimum prescribed by ASHRAE.

Elevated CO_2 levels result in sick building symptoms (building related symptoms) such as fatigue, eye and/or nasal symptoms (dry eyes), headaches, and respiratory tract symptoms. In highly ventilated buildings (where concentration of indoor CO_2 matches outdoor CO_2 concentration) , these symptoms may be reduced by a maximum of 64-85%. This is due to other contributors to these symptoms, being both building and person specific (Erdmann & Apte, 2004).

Indoor air quality needs special management. Vaselli (2005) of the New York Indoor Environmental Quality Centre, illustrates indoor air quality particularly well. Vaselli

describes indoor air quality as being "more dangerous to human health than outdoor air". The diagram describes total indoor air quality and sources of contaminants.

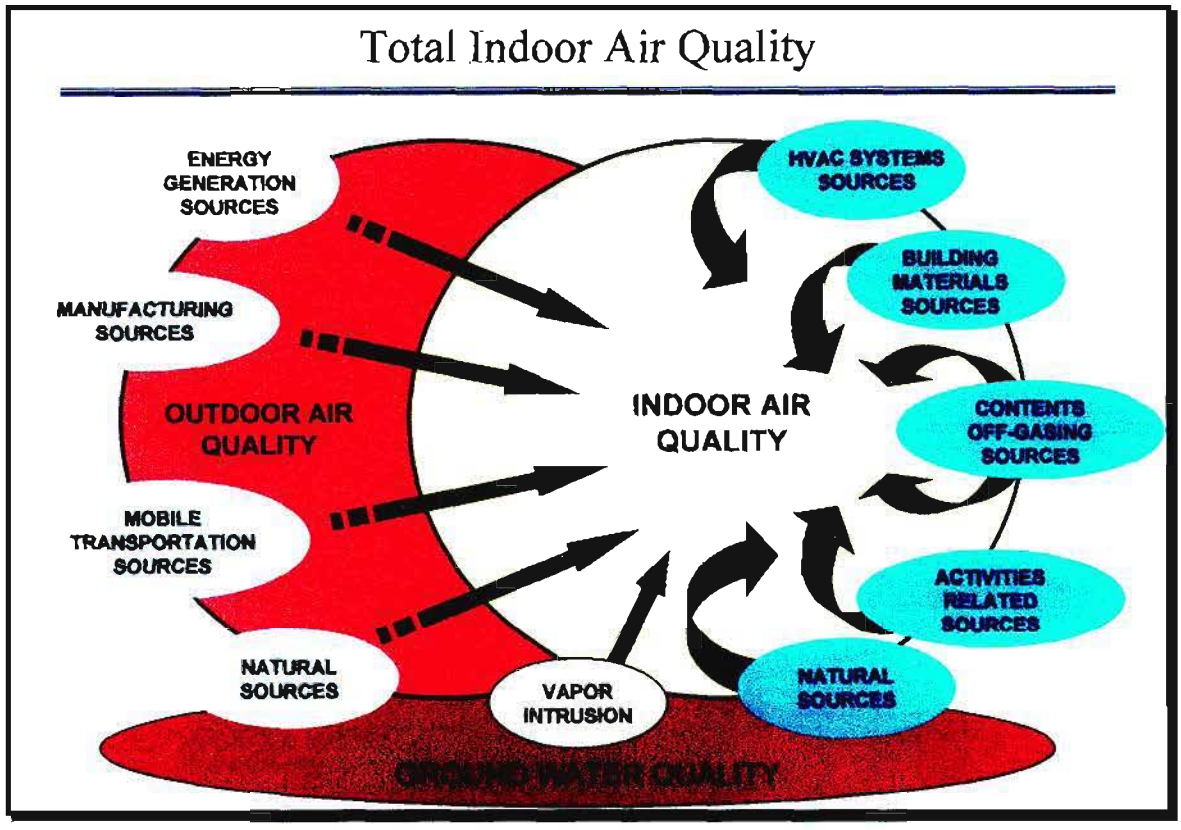


Figure 2.2 Total Indoor Air Quality.

Source: Vaselli, J.J. (2005) Indoor air quality and human health risk: need for more research and analysis. In: Upstate New York Society for Risk Analysis Symposium, June 2005. New York, New York, New York Indoor Environmental Quality Centre, pp.1-29.

From the diagram, not only do outdoor pollutants become the quality of indoor air, but indoor pollutants contribute, and concentrate over time, when ventilation is poor.

Particulate matter and biochemical contaminants are additional concerns in indoor air quality, over and above chemical pollutants. Particulate matter in the air is finer than in previous decades. In the twenty-first century particulates are smaller than 0.1 microns,

and therefore classified as ultrafine particles. The particles are not breathed out, once breathed in, being smaller than 0.1 microns. They are absorbed via the blood stream into organs and the brain, where they collect. These contaminants are linked to cardiovascular and pulmonary disease (Vasselli, 2005).

Biochemical contaminants are also of concern in indoor air quality. Over 100 species of mould are known, all of which produce a variety of mycotoxins. Some of these are listed by the Unites States Department of Defence as biological warfare agents of concern (Vasselli, 2005).

For these reasons, indoor air quality is classified as dangerous, requiring serious analysis and attention. Many companies readily measure outdoor air quality in South Africa due to pollution, although fewer companies seriously measure indoor air quality on as regular a basis (if at all).

Chemical intake in the office environment occurs not only through air, but also through food eaten. Food is often provided by canteen services. The effects of food on productivity and mood are discussed in the next section.

2.4.8 Food (Chemical Intake)

Food is an important part of the office environment. As a chemical intake, it affects the mood and anxiety level of workers. Neurotransmitters released by proteins and carbohydrates, during the two-hour period following ingestion, affect stress, alertness and calmness. Fats affect the digestive system, slowing it down. It is paramount for a

company to understand the impact of meals they supply or subsidise on overall maximum daily productivity of workers during the two-hour period following meals.

Deficiencies of brain serotonin have been linked to depression, agitation, anxiety, suicide, violent behaviour, PMS, obesity, insomnia, carbohydrate craving, SAD and migraines. Serotonin is synthesised when carbohydrates are consumed. The mechanism is as follows. The brain protects itself from potential toxins. All brain serotonin is therefore manufactured by neurons in the brain, from tryptophan. Tryptophan, an amino acid found in food, is selectively transported across the brain blood barrier into the brain, but competes with five other amino acids for this transporter. Of the amino acids found in food, tryptophan availability is usually significantly lower, at ten percent. Consuming carbohydrates raises insulin levels in the blood, which removes the other amino acids from the transporter, back into the blood and then converts them to fats. This allows tryptophan to be transported into the brain in abundant supply. Carbohydrates do not contain tryptophan, whilst protein foods do contain tryptophan. The irony is, despite containing tryptophan, protein foods lower tryptophan in the brain because they also provide other amino acids which compete for transport into the brain. The insulin rise from carbohydrate ingestion, however, offloads these competitors. Enzymes which depend on vitamins B3 and B6 convert the tryptophan into serotonin. The link between carbohydrate craving, obesity and serotonin then becomes apparent. Many people use carbohydrate as a stress coping mechanism, although, ultimately, this depletes tryptophan reserves (Dean, South & English, 1997).

Food affects the performance of people (via neurotransmitters released), as do circadian rhythms. Circadian rhythms determine whether people are night owls or early birds.

Different circadian rhythms therefore have different dietary requirements. Consider the table below, from Christie (2006).

Table 2.3 Diet-Mood Relationships Due to The Effect of Food on Neurotransmitter Production

Nutrient	Food sources	Neurotransmitter/mechanism	Proposed effect
Protein	Meat, Milk, Eggs, Cheese, Fish, Beans	Dopamine, Norepinephrine	Increased alertness, concentration
Carbohydrate	Grains, Fruits, Sugars	Serotonin	Increased calmness, relaxation
Calories	All Foods	Reduced blood flow to the brain	Excess calories in a meal are associated with decreased alertness and concentration after the meal

Source: Christie, C. (n.d.) *Nutrition and well-being A-Z - Mood-food relationships* [Internet], United States of America, Thomson Gale (part of the Thomson Corporation). Available from: <http://www.faqs.org/nutrition/Met-Obe/Mood-Food-Relationships.html> [Accessed June 2006].

Looking at the table above, an early bird has maximum alertness in the morning, but may require proteins in the afternoon whilst minimising carbohydrates, whilst night owls would need a source of protein and few carbohydrates in the morning to improve productivity in the first half of the day. Excess calories should be avoided in both groups, especially a diet high in fats, because blood is drawn away from the brain to the digestive system to process these fats. Chocolate provides a temporary because it is high in three components which produce brain happiness and stimulation, namely sugar, phenylethylamines and caffeine. Phenylethylamines produce a similar effect to endorphins. Chocolate contains high amounts of fat, ultimately increasing lethargy, and contains large amounts of sugar which stimulate insulin production to lower blood

glucose levels, and convert amino acids, not transported into the brain, into fats (Christie, 2006).

Ideally, a dietician should help to establish the different food requirements for different types of office workers. The food caterers should be primed of the different types of requirements, by working closely with the dietician. Food plays a substantial role in stress reduction and productivity.

2.4.9 Human Issues in Horticulture

Trees and plants have long been thought to be beneficial. Formal studies in this area, termed human issues in horticulture, have been conducted by many professors, among which is one of the leading researchers in this area, Professor Lohr.

When plants are added to the office environment, productivity increases by 12% and stress drops, as correlated by a drop in systolic blood pressure (Lohr, Pearson-Mims & Goodwin, 1996).

When plants are in the room, there is a lower perception of physical discomfort (a psychosomatic impact), which may allude to reductions in stress, although the method used appears to be subjective. Participants were requested to hold their non-dominant hand (left, for most people) in a bucket of ice water for at most five minutes, but to withdraw their hand sooner on onset of discomfort. 'Resilience' time was then used as an indicator of stress (Lohr & Pearson-Mims, 2000).

Plants contribute to views, and, in essence, bring the outdoors inside. Plants also affect the balance of oxygen and carbon dioxide, and are a symbol of healthy life and life outside the office. Plants provide people with an external perspective, often arousing interest in nurturing and maintaining the plants. The following topic, green buildings, leads on naturally from human issues in horticulture. Green buildings afford views, and natural sunlight, along with fresh air and healthy levels of ventilation. It is the exposure to natural resources which seems to reduce stress, increase health and promote productivity (Guillemette et al., 1998; Heschong Mahone Group, 2003a; Heschong Mahone Group, 2003b; Cause of, n.d.; Lewis, 2005; Wallach, 1986; Lohr, Pearson-Mims & Goodwin, 1996 and Lohr & Pearson-Mims, 2000).

2.4.10 Green Building Design

Green building design is used to increase the utilisation of and exposure to natural resources, and to improve productivity and reduce stress. Three types of Green Building design standards are used in California. The standard of interest where productivity and stress reduction are essential, is the Collaborative for High Performance Schools, which defines high performance schools as being comfortable, healthy, resource efficient, adaptable, easy to operate and maintain, safe and secure. The research done by the Sustainable Building Task Force and the State and Consumer Services Agency (2003) for the Californian government found high performance schools had better student test scores, an increased retention of quality teachers, an increased daily attendance rate, and reduced operating costs. Improved test scores and retention are of particular interest in this study, where stress reduction to improve productivity and staff retention is key.

The productivity and health benefits of green buildings are estimated at $3.43 to $5.14 per square metre, with a twenty-year net present value. Energy saving over conventional buildings are reduced by 25% to 30%. Green buildings further result in almost complete disappearance of sick building syndrome; minimisation of absenteeism; and improved worker morale (Croxton Collaborative Architects, 2005; Sustainable Building Task Force, 2003; Kats, 2003).

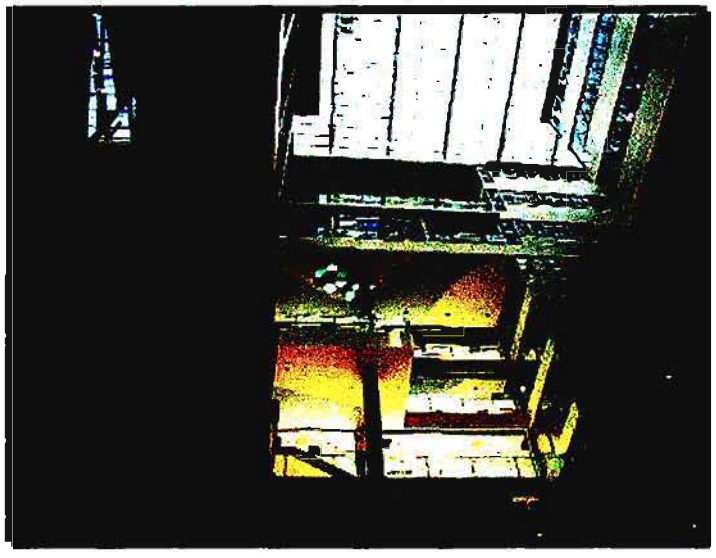


Figure 2.3 The Genzyme Corporation's recently completed office in Cambridge.

Source: Kats, G.H. (2003) *Green building costs and financial benefits*. United States of America, Massachusetts Technology Collaborative.

The full caption to this figure in the document by Kats (2003) is

"The Genzyme Corporation's recently completed office in Cambridge is a world-class example of green building construction, including advanced daylighting and thermal technologies. In addition to a photovoltaic installation funded by MTC, one of the most prominent features is a combined heliostat and reflective panel system designed to channel daylight deep into the 8-story building." (Kats, 2003).

The benefits of green buildings will be evident from the preceding sections on natural light, ventilation, air quality and temperature. Green buildings also return more than ten times the additional costs associated with building sustainability, over a twenty-year period (Kats, 2003). For major advances in productivity, health and cost savings due to the office environment, any company who is considering building an office building would be strongly urged to consider an architecturally designed green building, designed by a green building specialist. In the South African context, where there are large amounts of natural daylight available all year round, there should be few reasons not to 'go green'. The benefits and returns significantly outweigh the additional costs.

2.4.11 Personal Control

Croxton Collaborative Architects (2005), in their redesign of the World Trade Centre, implemented and studied the effect of personal control at West Bend Mutual Insurance Company.

Environmentally Responsive Workstations (ERW's) produced by Johnson Controls Systems were installed at each workstation. In their open plan office, the "desk-top integrated units" allow each employee control over both the temperature and flow rate at their personal desktop air registers. Further thermal comfort control was achieved with the installation of a radiant heating panel under each desk, designed to warm the lower body. Individual lighting control at each workstation and a "white-noise" generating device to block-out distractions further enhanced the sense of personal control. By doing step tests where these controls were implemented and removed, a 2.8% improvement in

worker productivity achieved (based on the total payroll) was achieved through personal control over just four environmental conditions (Croxton Collaborative Architects, 2005).

Other specific benefits of personal control have been covered under the relevant topics, in preceding sections (such as temperature and ventilation).

2.4.12 Change

Change in the internal environment is important for several reasons. Firstly, if office decor does not change, it becomes stale and tired. Secondly, change in the environment, is important as a visual signal. It can be used to stimulate people to respond positively to change.

The idea of change being important for companies in today's fast-changing climate is a widely accepted paradigm. Noe et al. (2000) support this succinctly in their chapter entitled "Strategically Managing the HR function" (where the 'HR function' is stressed as being the company's imperative through policies and line management function and not the responsibility of an HR department): "In today's fast-changing competitive world, firms need to both constantly change and develop a capacity for change." This capacity for change entails overcoming the inertial force of human beings, which resists change. It is achieved by developing and maintaining a culture continually exposed to change. "A deeply rooted culture well matched to strategy is a powerful lever for successful strategy execution" (Thompson, Strickland, 2003). Ideally companies should target a star rating, and keep adapting all aspects from performance to communication, and from service

levels to the physical environment quality, both indoors and outdoors, to match the targeted star rating.

In terms of matching the culture to strategy: when a firm desires to be a pace-setter in a competitive world by doing things differently and creatively, then it needs to be proactive in exposing its employees to changes and to creativity.

Change can bring about instability, and therefore it needs careful management in order to avoid destabilising the workforce and creating poor morale. A non-threatening way to highlight change visibly and to stimulate creative thinking is to change the internal working environment, and to change it on a reasonably frequent basis. Adults learn by experiential learning. Involving employees in choices regarding the changes is likely to help stimulate employees to overcome their inertia towards change, and to stimulate creativity.

Change in corporate culture takes time. "In a strong-culture company, values and behavioural norms are like crabgrass: deeply rooted and difficult to weed out" (Thompson, Strickland, 2003). This means persistent effort on the part of the company is required to develop a culture, designed to respond well to change and creativity. Changing the office environment, and not allowing it to become stale forms part of the change required.

2.4.13 Living Standards Measures

Before looking at living standards measures, it would be interesting to look at typical expenditure in the construction industry.

Table 2.4 Expenditure in the Construction Industry in South Africa in 2004

Type of construction	Purchases R million	Salaries and wages R million	Payments to sub-contractors R million	Depreciation provided for during the financial year R million	All repair and maintenance expenditure R million
Site preparation	697	591	169	122	152
Construction buildings	15 930	4 009	8 166	369	320
Construction of civil engineering structures	14 883	4 537	2 639	498	522
Construction of other structures	771	267	85	46	47
Construction by specialist trade contractors	1 888	761	451	77	89
Plumbing	979	442	231	47	35
Electrical contracting	3 051	1 055	394	105	87
Shop-fitting	405	177	64	13	9
Other building installations	4 294	1 739	877	106	70
Painting and decorations	797	400	117	35	28
Other building completions	4 778	1 757	1 796	220	218
Renting of construction or demolition equipment with operator	269	427	104	389	253
Total	**48 742**	**16 162**	**15 093**	**2 027**	**1 830**

Source: adapted from Statistics South Africa (2005) *Statistical Release P5001*. South Africa, Statistics South Africa.

The amount of money spent on painting and decorations is significantly smaller than other building costs in the building industry in South Africa. This data contrast sharply with data from the South African Advertising Research Foundation. Living standards measures are a way to classify people by the quality of goods and services in their lives outside of work time. Strictly speaking, LSMs do not necessarily correspond to an income level, although average household income does seem to be reasonably well-correlated with LSM group. The higher the LSM group, the greater the living standard. LSM 5 is the first of the lower LSM groups to spend income on decorating. This group earns ZAR 1459 per month and represents 15% of the population. The group spends

money on décor, but other maintenance expenditure is low. In LSM 6 (monthly income ZAR 2328, 13.8% of the population), 9% of the people spend more than ZAR 1000 on maintenance and 19% of the group decorated their homes, annually. In LSM 7 (monthly income ZAR 5071, 13.0% of the population), 16% of the group spends more than ZAR 1000 on maintenance and 21% decorated their homes. In LSM 8 (monthly income ZAR 9274, 13.0% of the population), 31% of the group spends more than ZAR 1000 on maintenance and 23% decorated their homes (Bureau for Economic Research, 2002). The data by LSM group indicates a substantial proportion of people who decorate their homes. The data for the 2006 third quarter Bureau of Economic Research report does not provide information about décor expenditure, and therefore the first quarter 2002 report was used as the source of data.

Translated, if 23% of people per annum in LSM 8 decorate their homes, then in five years, approximately 100% of people decorate their homes. In other words, nearly everybody in this group decorates every five years. This means people take pride in their home environments and actively choose to spend their money on décor. In many cases, for the higher LSM groups, this results in a home environment which contrasts sharply with the office environment.

Many companies provide equitable to generous remuneration packages in the hopes of attracting employees, whilst investing little in the office décor. Ironically, under these circumstances, the larger the remuneration package, the larger the likelihood there is for dissonance, which creates stress. This is explained further in the next two paragraphs.

Lending institutions grant approvals for mortgages based on the disposable income of the worker. They effectively reinforce the perceived (cognitive) buying power the worker has (ABSA, 2006). The buying power is therefore an indication of the living standard the worker can reasonably maintain, for his home environment outside of working hours.

A conflict or dissonance is created in the worker between the home and the office. What the bank affirms is a maintainable living standard and what the company provides as a living standard for the worker often contrast sharply. By definition, cognitive dissonance is the conflict between differing cognitions (known and accepted personal elements of knowledge), and the "uncomfortable tension that comes from holding two conflicting thoughts at the same time" (Wikipedia the Free Encyclopedia, 2006). Dissonance causes stress (ChangingMinds.org, 2002). The cognitive dissonance between the living standards of the two different quality environments therefore is a source of stress.

The five star rating system can be used to quantify the environment quality.

2.4.14 Five Star Rating

The five star rating system is a system used commonly by hotels and many other goods and service providers, to inform the public of what quality and service they can expect.

The five star rating system has many variations among providers of goods and services, and even between countries for the same goods and services. All systems are based on similar concepts, however. A five star rating is synonymous with quality and service which is of the best, while a one star service provides the basics. A one star rating does

not imply it is unworthy of a star. Even a one star quality and service has minimum entry requirements. Star ratings are awarded by bodies. Applications for star ratings by hotels and accommodation suppliers are purely on a voluntary basis (Automobile Association et al., 2005).

Consistency of service and quality is key. Quality is defined as the quality of décor, furnishings, furniture, cleanliness and hospitality, whilst service involves all service people from cleaners through to managers. In a five star establishment, there must be excellent quality décor and furnishings. There must be excellent quality interior design, and furniture must be excellent quality modern reproductions or original antiques. The list of specific requirements for each star rating, in every aspect of every room, is listed for each star rating criteria (Automobile Association Developments Limited, 2006). Star ratings are useful, because they can be applied to the office environment to rate the facilities provided.

Funding for research into the effects of the office environment on office workers has been fuelled by the growing interest from companies and governments in maximising productivity. The individual aspects of office environment quality all contribute individually to stress. The combined effects of office environment quality on productivity and stress are often greater than the sum of its parts. The unrecognised (subconscious and real) stress due to environment quality is of interest in this project, and therefore the following section of the literature review covers some of the psychosomatic effects of stress. The effects allude to the health implications of stress, which should be of great interest to companies, but also provide for the researcher some means of testing for the stress experienced under different conditions.

2.5 Survey of Literature Relating To Stress and Methodology

2.5.1 Introduction

At first glance it may seem unusual to combine the literature pertaining to the methodology and the dependent variable in one chapter. The psychosomatic effects of stress, however, are also the basis for the tests which are used to gauge what relative level of stress was experienced. These effects and potential testing methods are reviewed in the sections below.

2.5.2 The Psychosomatic Effects of Stress and Methodology

There are several forms of stress tests which can be used to gauge the relative stress experienced under different conditions. Studies in 'human issues in horticulture' have shown through various types of tests there is an increase in perceived stress and morale (gauged through questionnaires) and an increase in perceived physical discomfort (gauged by length of time which participants could keep there hands in an ice bucket before it became uncomfortable). The method of questionnaires was rejected because it only measures the recognised (conscious) portion of stress and not the subconscious response to stress.

2.5.2.1 Metabolism and Insulin Response: Blood Plasma Glucose Response Due to Stress

Under stress, there are several symptoms in the body, many of which can be used to test for stress responses. One of the easiest tests, from an ease of laboratory testing perspective is the effect on glucose in the blood, in non-diabetic people. The

metabolic rate of glucose in the blood stream is delayed under stress. It is not clear whether this is due to delayed gastric emptying or due to changes in insulin secretion, or other effects (Wing et al., 1985). The test were done using men and women, so it seems this test may be a reliable choice. Under conditions of no stress, the peak in glucose in the plasma phase appears somewhere near the 30 minute mark, possibly slightly less than 30 minutes after the start of the stress tests (measured in 30 minute intervals). Under stress, the peak is delayed to between the 30 and 60 minute period. This test is also preferred because both stress and no-stress conditions were tested, and the tests were applied on both women and men.

Vrijkotte, van Doornen & de Geus (1999) show over-commitment and vital exhaustion (stress) lead to insulin resistance, which impairs metabolic and fibrinolytic factors. This tallies well with the research done by Wing et al. (1985), and explains why the peak in glucose is delayed. If the metabolic function is impaired under stress, glucose is released into the blood stream slower. Moreover, if the insulin response is impaired, it will take longer before the glucose levels start to decline.

Stress affects the blood condition through numerous mechanisms.

2.5.2.2 Neurotransmitters, Hormones and Blood Cell Levels Due to Stress

Stress has effects on cell types, hormones and neurotransmitters in the blood. Under short-term psychological stress, natural killer cells (NK cells) increase in the blood and then return to normal fifteen minutes after the cessation of stress. An experiment performed on 50 male participants (and an additional control group of 36 male

participants) placed the 50 male subjects under mild psychological stress and tested for increases in the blood of leukocytes, lymphocytes, monocytes, T-cell subsets, natural killer (NK) cells, and B-cells. Only the normal killer cells increase during the period of stress (Brosschot et al., 1992). The increase in normal killer cells under stress was also observed by Herbert et al. (1994).

Similar studies by Pike et al. (1997) on 24 male participants show a redistribution of natural killer (NK) cells in peripheral blood and increases in the hormones epinephrine, norepinephrine, β-endorphin, adrenocorticotropic hormone, and cortisol under stress. The reason for both sets of testing being done on male participants only is not clear, unless the prospective female participants did not like the prospect of being pricked with needle for blood samples. (As will be seen in chapter three, similar problems were experienced in this research project, resulting in a predominance of male participants.)

Other bodily fluids can also be use to test for stress, namely the saliva.

2.5.2.3 Heart and Neurological Chemicals: Salivary Chromogranin A Levels Due to Stress

A second potential testing method for stress involves the use of the saliva. There are several tests involving the saliva. The nervous system secretes Chromogranin A into the saliva under stressful conditions. (Chromogranin A is a complex protein of the secretory granules of the chromaffin cells. The chromaffin cells of the adrenal medulla secrete epinephrine and norepinephrine, which are neurological chemicals.

They affect smooth muscle, cardiac muscle and glands (Mosby's Dictionary, 1990).) The elevation of Chromogranin A under stressful conditions in men is immediate, when subjected to oral presentations and car driving exercises (Nakane, 1999). The study did not cover the effect on women, however, and therefore the expected response in women would be unknown if used as a testing procedure.

2.5.2.4 Heart and Hormones: Salivary Cortisol Levels in Men and Women Due to Stress

The response to stress is known to be different between men and women. Adrenocortical responses differ between sexes under different conditions.

Cortisol is a hormone responsible for fighting stress and inflammation, which is why stress is linked to Crohn's disease, a major inflammation of the bowel. It also regulates cardiac function, and utilisation of fats, proteins and carbohydrates. It is secreted in response to any psychological or physical stress (Mosby's Dictionary, 1990). The cortisol released into the saliva is one and a half time higher in men than in women, when placed under psychological stress. Under physical stress conditions, however, there are no differences in cortisol released, although prior to both types of exercises, men experience high levels of cortisol release in anticipation of the exercise, possibly due to the psychological aspects of anticipation. Cognitive and emotional responses are therefore suggested to be different (Kirschbaum, Wust & Hellhammer, 1992). The studies by Kirschbaum et al. were done in four separate tests using approximately an equal number of men and women across the spectrum of the tests. The salivary cortisol peaks at approximately 30 minutes after the start of the

stress test. This is a possible choice of test for determining the different stress responses between men and women in different office environment conditions. It is not clear whether a delay in the cortisol peak should be expected if there are greater levels of stress, although from further studies, described in the following sections, it seems the peak concentration level may correspond to different levels of stress experienced.

This has similarities with the work by Nakane (1999) on salivary Chromogranin A levels under stress, which prove the body secretes elevated levels of certain chemicals into the saliva under stress. Larson, Ader & Moynihan (2001) report similar findings, although interestingly, the baseline cortisol levels are related to heart rate responses to stress. Of greater concern is the long-term effect of a short-term stressor, which they report. The long-term effects are changes to the neuroendocrine system.

The different levels of psychological stress under varying conditions are sought in this research project (low stress and high stress), which was not tested in the salivary cortisol study by Kirschbaum, Wust & Hellhammer (1992). The tests may be appropriate at a later stage, however, to distinguish the different responses of men and women once it has been established whether different office environment qualities induce different psychological stress responses.

2.5.2.5 Heart and Hormones: Salivary Cortisol Levels in Men Due to Repeated Stress

The response to repeated stress is important in the context of long-term exposure to the office environment. In further studies using salivary cortisol, this time on men only, it was found the response to repeated stress differs among types of participants. The tests were performed over five days. Two basic types of people, "high responders" and "low responders", respond to repeated psychological stress differently. High responders experience persistently high stress over the full period of stress, while low responders only experience stress on the first day or two, and then appear to adjust (Kirschbaum et al., 1995). The test is very similar to earlier work by Kirschbaum, Wust & Hellhammer (1992) which also shows there are elevated salivary cortisol levels under stress, although the stress tests were over a shorter period. The repeatability of the test is therefore good.

The study by Kirschbaum et al., (1995) may suggest repeated stress of the office environment quality over long periods will be more of a problem for some types of people than others. The study was only performed on men, so it is not clear how women will respond to repeated psychological stress.

Repeated psychosomatic stress due to visual and auditory stimuli is not covered in the literature. It is therefore not clear from the literature what the long-term effects of the stress due to the office environment quality on different types of responders will be, and could be an area for future research. The purpose would be study whether different people have different levels of stress responses to repeated exposure to more stressful visual and auditory stimuli.

Stress also affects the immune system.

2.5.2.6 Heart and Immune System Response to Stress

The immune system response is impaired under stress, although the response is temporal, especially in participants with the highest cardiovascular response to stress (Herbert et al. 1994). This has serious implications in Africa, where there is the highest prevalence of AIDS in the world. Stress reduction in every way possible, to reduce the effect on the immune function, is vital for prolonging life and promoting health in AIDS sufferers and therefore for the long-term economic stability of countries in Africa.

Stress also manifests visibly in the body, due to chemical responses in the blood, as will be seen by the effect of wound healing due to stress.

2.5.2.7 Wound Healing Delayed Due to Stress

Stress has numerous effects on the body. Wound healing takes 40% longer under stressful conditions. Dental students were tested at examination time and during the vacation, with a small incision in the palate. Initial stages of healing reveal the largest differences. The researchers attribute this as most likely due to cytokines affecting the pro-inflammatory response responsible for starting the healing process (Marucha, Kiecolt-Glaser & Favagehi, 1998).

In the South African context, where AIDS prevalence is high and therefore affects a significant portion of the working population, stress reduction measures to minimise the impact on healing time are crucial. Secondary infections, due to delays in wound healing, exacerbate the problem of a limited ability to combat infections, which. compromises the health of AIDS sufferers further.

This study is interesting because the tests are related to a longer term exposure, which would be typical of office environment exposure. The method of testing would be unsuitable, however, for this research project. The length of time required for healing, and the exposure time required for the tests with office workers, who have work which needs to be done back in their normal environments, prevent this method from being ideal. The pain inflicted would also cause further stress. People with AIDS would also need to be precluded, and this presents its own difficulties in terms of questioning about AIDS. For those who would be eligible, controlling for external sources of stress in adults would also be more difficult over the long periods, than it would be in students. Working adults generally have more commitments and responsibilities than students, with large potential for variation in stressors.

For working adults, cholesterol levels in the blood are a concern. The next section discusses cholesterol responses to stress.

2.5.2.8 Cholesterol Levels Due to Stress

Stress affects cholesterol levels. A sharp decrease in plasma volumes under stress (most likely by shifting the plasma from the blood into interstitial spaces and tissues)

causes the concentration of blood cells and plasma proteins to increase in a process known as hemoconcentration. Simultaneously, cholesterol concentrations in the blood increase due to the decrease in plasma volume (Patterson et al., 1993).

The findings of this study are supported by similar research done by Bachen et al. (2002). Increases in cholesterol are due to hemoconcentration, while increases in free fatty acid and triglyceride concentrations are due to metabolic effects.

The studies by Patterson et al. (1993) and Bachen et al. (2002) may explain why hypertension, high blood pressure, risk of heart failure and heart rate increase with increased levels of stress. The pressure of a fluid is directly proportional to its density. Due to a reduction in the plasma phase, the density of the blood increases under stress, resulting in a higher liquid pressure. Moreover, the viscosity would also increase with a reduction in the plasma fluid portion. Higher viscosity liquids require more energy and power to pump liquids through the same size conduits, namely veins and arteries. The heart, as a pump, would be required to do more work if the blood viscosity and density increased due to a reduction in plasma. Friction losses against the walls of the veins and arteries (which are the result of higher blood fluid viscosity and result in pressure losses) therefore require higher pump (heart) discharge pressures, which in turn require more work (energy). The heart, as a muscle, needs to be fit enough for the extra work. This work explains some of the common physical ailments of stress, which have dire health consequences.

It will be evident at this stage, stress has numerous psychosomatic affects on the body, many of which have the potential to be extremely harmful. Most of the stress tests were

only simple arithmetic tests and presentations in front of people, not unlike but slightly less than the daily stresses to which a typical office worker is exposed. The most important effect of stress is the compounding effect due to multiple simultaneous interdependent reactions in the body. Reducing stress therefore improves health in many different bodily functions simultaneously, allowing for better coping skills with unforeseen stresses, and allowing for a significant improvement in both productivity and social interactions. In turn, better social interactions and improved productivity further reduce stress. Stress is a downward spiral requiring positive intervention to halt it.

2.5.3 Worker Morale

A brief examination of a concept related to stress, 'worker morale' (emotional stress, which is psychological by its nature), yields key concepts for consideration. Two quotes fro different research papers will be examined.

Of particular interest is research done by doctors, Goetzel et al. (2002). "Further, low morale and poor attitudes about work can become contagious and infect fellow workers, further exacerbating individual problems and bringing about increased turnover and general organizational malaise." (Goetzel et al., 2002, p.322). Employers should be concerned about the contagious effects of low morale on other workers. It means stress not only has compounded effects on the bodily functions of an individual, but also spreads through the organisation. The need for intervention to turn the tide of stress and poor morale is vital for companies. However, on the positive side this does suggest any reasonable efforts targeted at improving the morale of each individual, being contagious, produces exponential benefits for the company as a whole.

Once again, research shows there are large and manifold potentially untapped benefits to be reaped by the company when the individual's total well-being receives focused. In their paper on Financial Concerns and Productivity, Williams, Haldeman & Cramer (1996, p.147) conclude "The employer's efforts in improving total well-being of employees contribute to better employee-employer relations, higher morale, retention rates, lower fringe benefit costs, lower transaction costs, and increased output." While this statement is broadly supported, in specifics there are some criticisms. A first criticism of this statement is the benefits in the financial paper appear to be separate concepts. However, in this research project it is proposed efforts expended by employers on décor and employee-wellness lead to related benefits of lower stress and higher morale of employees, from which the remaining tenets spin off, namely improved employee-relations, increased output, higher retention rates and lower costs.

A second criticism is 'fringe benefit costs' are not clearly defined anywhere in the article. In the South African climate where unions are reasonably strong, benefits cannot arbitrarily be cut. If these fringe benefits are in fact piece rates or performance-based incentives, then this contradicts work by Stowe (2006) where high morale results in the ability to base larger portions of the employee's total income on performance-based incentives. One of fringe benefit costs Williams, Haldeman & Cramer (1996) mention are counselling costs, but since the article motivates for counselling, it is unlikely a reduction in counselling costs (once the problem is solved) could be claimed as a positive spin off from introducing counselling to solve the problem. Therefore, the fringe benefit costs are most likely either travel, medical aid and retirement funding, or else performance-based incentives. Therefore, in the South African context, although a

reduction in fringe benefit costs are less likely in the South African context, most of the other benefits envisaged by Williams, Haldeman & Cramer (1996) are likely. Their paper supports focusing on total well-being of the individual, for benefits for the company.

The expression 'divide and conquer' can be applied positively to the workforce. By focusing on the total well-being of each individual, with compounded (and contagious) advances in stress reduction, worker productivity, morale and staff retention, the performance of the entire team is greatly massaged to higher levels.

The effects of stress on the body are widespread. The metabolism, insulin response, condition of the blood, the heart, neurotransmitters, hormones, cholesterol and wound healing ability are just some of the areas affected by stress. The observed effects of stress will be used to test whether differing levels of stress are experienced under different office environment conditions. The metabolism and glucose in the plasma phase of the blood (as per Wing et al. 1985) will be used to test which office environment is more stressful.

2.6 Survey of Literature That Relate To the Elimination of Problems Already Solved By Other Researchers

No studies to quantify the unrecognised (real) stress due to décor and the office environment were found. The separate topics relating to the subjects of unrecognised (real) stress and the office environment have been discussed in previous sections. This paper is the intersection of these two broad topics.

2.7 CONCLUSION

The literature is clear. There are many psychosomatic effects due to stress. It is reasonable to conclude stress affects every aspect of the body. Most stress tests used in the literature were nothing more than arithmetic tests and presentations in front of people, much like the typical work of an office worker, if not less stressful, and yet major and significant effects on the body were found. Stress therefore affects the short-term and long-term health of individuals. The office environment also has major effects on productivity (measured by effectiveness and efficiency), self-assessed (or recognised) stress and health. The intersection of these two fields of study, namely the psychosomatic effects of stress and the office environment, are investigated in this research project. Chapter three provides a discussion of the methodology employed.

Chapter 3

REVIEW OF THE METHODOLOGY

3.1 INTRODUCTION

By way of an overview, the following concept forms the basis for determining which of two environments is more stressful. When non-diabetic participants fast and are then fed a source of glucose, the glucose concentration in the plasma rises and peaks at some point in time, and then falls as the insulin response returns the glucose concentration levels back to similar starting (fasting) concentration levels. The time at which the glucose concentration peaks is delayed under stress. A brief overview of the testing, provided below, will be followed by more detail of the sampling testing and data collection.

Participants, who fasted the night before, were placed in two different environments and fed a source of glucose. Participants in both environments were subjected to identical mental stressors. Blood samples were taken from each participants at various times after ingesting the glucose source. The blood samples were then centrifuged to separate the platelets and the plasma phase. The plasma was analysed for glucose concentration. A plot of glucose concentration versus time, for each participant, yields the time at which the glucose concentration peaked. All participants, except for a control group, changed environments on the second day, and repeated the tests. The control group remained in the same environment on the second day and repeated the test. A comparison of the time of the peaks in the two environments defines which environment was more stressful. This chapter is a detailed review of the sampling, testing and data collection procedure followed. Chapter 4 describes the analysis of the data, and is where the time of the peak in

the plasma glucose concentration is established to determine which environment was more stressful.

3.2 Sample: Participant Selection and Number

The selection of participants was based on several criteria. The relevant population from whom the sample was drawn was office workers. Special parameters and eligibility requirements were applied and are listed in the subsections below. A natural cluster (area sampling) was used to minimise external sources of stress. The same geographic location was used during testing as the location from which the population was drawn. Stratified disproportionate probability sampling was applied to obtain a large enough sample from each stratum.

3.2.1 Relevant Population

The relevant population consisted of office workers, who were predominantly desk bound. The population from whom to draw the sample was restricted by geographic location, and eligibility criteria.

3.2.2 Special Parameter: Same Geographic Location

Area sampling (a natural cluster) was applied with a specific purpose. In order to minimise any additional source of stress from a change in the working environment, participants were office workers working in the same building at the same company.

Participants were reasonably familiar with both office environments used in the tests, which were located in the same administration building as their normal offices.

3.2.3 Sampling Frame: Eligibility

From a company perspective, participants were required to be selected from those on whom the day-to-day production did not depend. From a research project perspective, all participants were screened to meet eligibility criteria. They did not have diabetes, hyperglycaemia, hypoglycaemia, high blood pressure or heart conditions. This severely limited the eligible population from which to sample. Participants who were selected were also healthy and within 20 kg of their ideal weight for height.

3.2.4 Stratified Disproportionate Probability Sampling: Ethnic Group, Gender, Age and Income Bracket

Within each stratum, simple random sampling was applied.

Owing to differences in psychosomatic responses of different ethnic groups, as noted in psychosomatic journal articles, and owing to the ethnic diversity in the South African context, the group of participants was selected to represent a reasonable sample of each ethnic group. Sixteen participants were recruited: six black participants, five Indian participants and five white participants. The Indian potion of the population generally had a higher incidence of diabetes and blood pressure problems, which made recruitment from the available Indian portion of the population more difficult.

Every effort was made to recruit an equal number of male and female participants, although the company generally had more male employees. This was not successful, owing to the nature of the tests. Of the eligible female office workers, most chose not to participate. Unsurprisingly, being pricked with a needle five times on each of two consecutive days was a deterrent. Male members of the eligible population were more willing to participate. The group of recruited participants consisted of thirteen male participants and three female participants.

Every effort was made to include a range of ages. Participants ranged from 23 years to 55 years of age, which is a reasonable representation of the population under study.

Participants were recruited from a range of income brackets, from the level of a clerk to a senior manager.

On the first day of testing, two male Indian participants did not arrive and during the testing two participants withdrew (both from Room 2, the inferior environment), one of whom was a white male participant and the other of whom was a black female participant.

The final group of participants consisted of five black participants, three Indian participants and four white participants. The gender mix consisted of two female and 10 male participants. The age spectrum ranged from 27 years to 55 years of age.

3.3 TIME-FRAME

The time-frame accounts for two of the independent variables: the day of testing (the first and second days) and the minutes from the start of testing.

3.3.1 Days of Testing

The research was done cross-sectionally with two snapshots on two consecutive days, to minimise external sources of stress to which participants could be exposed. The test environments were only available on consecutive days at the required times, which was the second reason why the testing was done on consecutive days, rather than two days apart.

3.3.2 Time of Testing

Participants were requested to arrive at 07h00 having fasted from midnight the night before. The tests started early in order to minimise the stress of fasting and to minimise the impact on work time. The testing was intended to finish by 09h30, but was delayed on the first day due to problems with drawing the blood samples. The start time t_0 was set as the time at which participants drank the polycose solution in each office environment.

3.4 PREPARATION: SELECTION AND SET-UP OF ENVIRONMENTS

The office environment selection and decoration was important because this was the crux of the study. There were two different environments, of which participants would be

subjected to both. The discussion points below have been divided into two main categories, namely the interior design and the interior décor. (It is not always easy to separate the topics cleanly into 'interior design' and 'interior décor', as there is occasionally some overlap between them.) The following sections start with a definition of interior design and interior décor, and then proceed with a discussion of the topics in these categories.

3.4.1 Interior Design

Interior design, by definition, focuses on the lifestyle experience and environmental psychology of the occupants of the room. The structure and design of the rooms were important considerations for the interior design. Many studies have been done on individual aspects of interior design, proving differences in worker productivity directly attributable to these facets. Very little literature exists, however, relating these facets to the subconscious (unapparent and real) stress of the office worker. Since lower levels of stress are associated with increased productivity, facets resulting in poorer productivity were therefore used as criteria in the selection of the inferior environment to see if, collectively, they would yield an increase in stress. A similar philosophy was applied when decorating the rooms (see 3.4.2). Details of the differences between the rooms, with thumbnail pictures to illustrate the practical differences, follow. Two plates be found in the appendix.

3.4.1.1 Windows

The inferior office environment (Room 2) had no windows, while the superior office environment (Room 1) had four sets of fairly large windows on two of the four walls. This is shown in the two figures below.

Figure 3.1 Room 1 windows.

Figure 3.2 Room 2 without windows.

Windows are known to increase productivity by providing natural light, views and the sense of personal control of ventilation being possible, and therefore stress reduction was considered a likely probability. These benefits of windows are discussed in the next sections.

3.4.1.2 Views

Windows provide views. The types of views have an impact on productivity. The following pictures display the views from each room.

Figure 3.3 Room 1 garden views.

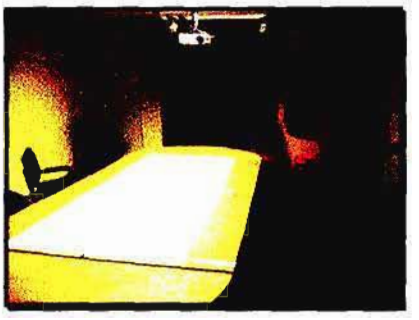


Figure 3.4 Room 2 without views.

Room 1 had views of a garden, trees, blue sky and to a lesser degree, the other part of the administration building. This type of view is classified as predominantly a complex nature view, with some simple urban views. Nature views, particularly complex nature views, have been proven to enhance productivity and decrease conscious levels of stress. Research in the field of human issues in horticulture have proved views of plants, both indoors and outdoors, reduce perceptions of physical stress. Urban views result in lower productivity than nature views.

Room 2 had no views at all.

3.4.1.3 Lighting

Room 1 had large amounts of natural light, with little dependence on artificial lighting, although the additional artificial lights were used. Lack of natural light has been proven to be responsible for SAD (Guillemette et al., 1998). Room 2 depended solely on artificial light, as there was no natural light, as seen in the next pictures

Figure 3.5 Room 1, natural lighting.

Figure 3.6 Room 2, artificial lighting.

Both rooms contained neon lights, but the lights in Room 1 had been recessed for a smarter look, and had covers to increase light diffusion. The lights in Room 2 created more glare, although the room was not as well lit.

3.4.1.4 Ventilation Control

Ventilation control is an important environmental psychological feature, as it allows for a greater feeling of control. Studies have shown increases in productivity with personal control over ventilation.

In Room 1, the windows could be opened by participants, while in Room 2 there were no windows for ventilation control. The air-conditioning unit in Room 2 recycles internal air, so there is no possibility for true ventilation control, even with the air-conditioning unit.

3.4.1.5 Temperature Control

Temperature control is as important or more important than ventilation control. Studies show high levels of sensitivity in productivity for small changes in

temperature. The tolerance band appears to be between 2° C to 4° C before changes in productivity occur.

In Room 1, the panel for temperature and ventilation control was visible. In Room 2, a cheaper looking unit had been installed, and the controls were not visible.

3.4.1.6 Ceiling Height

Ceiling height forms part of the volumetric room dimensions. The relative ceiling heights of the two rooms can be seen in the pictures below.

Figure 3.7 Room 1 higher ceiling.

Figure 3.8 Room 2 lower ceiling.

Room 2 had a lower ceiling height than Room 1. Room 1 had a reasonably high ceiling, with full-length curtains to accentuate the height. Room 2 therefore felt more claustrophobic, whilst Room 1 felt light and airy.

3.4.1.7 Floor Area Dimensions

Room 1 had approximately double the floor area of Room 2. This may only have had a small impact, as the number of participants in Room 1 was double the number of participants in Room 2 on the first day, resulting in similar amounts of floor space per person, although for each person the views of the room as a whole would have been larger for those in Room 1, creating less of a feeling of claustrophobia.

3.4.1.8 Electric Cabling

This is both a structural and decorating issue. The trunking for electric cables was visible in Room 2, whilst no electric cables or trunking were visible in Room 1.

Figure 3.9 Room 1, no cables.

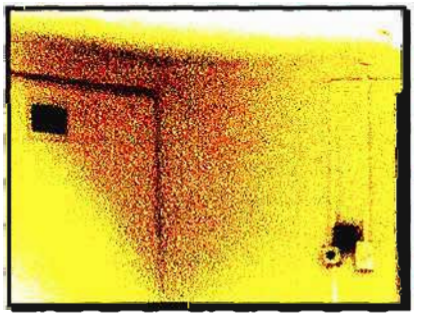


Figure 3.10 Room 2, trunking visible.

Room 1 was clearly designed as a meeting room with the cabling properly hidden at the time of building, whilst Room 2 appears to have been an afterthought, with the cabling done quickly and cheaply. (A five star establishment would have chased the cables into the walls, or placed them behind the prefabricated panels. Room 2 clearly does not qualify for five stars.)

The overall impression of Room 2 was of a room which was an afterthought with little design and care for the users of the room. Managers very seldom use this room in practice, and people outside the company are rarely exposed to it. It is only used for internal purposes. The impression of Room 1 was it seems to be designed for its purpose as a more luxurious meeting room, and is well-cared for because shareholders and managers use it on a frequent basis. The rooms were deliberately chosen for these qualities and impressions.

3.4.1.9 Areas within Areas

'Areas within areas' and 'nooks and crannies' are often used to create points of interest and variety, and to allow the room to be flexible in its use. In contrast, without these 'areas within areas', as a single space the room will be bland, with no choice of place for the occupants to retreat.

In Room 2, there was only one area. For testing purposes, the room was designed to be bland, with only one area in which participants could sit.

Room 1, however, was designed to be interesting, with five subtly separate areas. The entrance area was created by the use of a rug at the door, and plants flanking the rug to divide it from the rest of the room.

The two general seating areas took up most of the space in the room, as they were designed to be spacious and relaxing. These two areas were divided by using two

tables at different angles. Each table was placed near a separate set of windows. The division was further emphasised through the use of subtle 'barriers'. A rug was placed between the two tables, and each table was placed near two separate pieces of lattice work, with a plant and clock as further dividers, placed centrally between the two pieces of lattice work. The two seating areas were further emphasised as being two separate, albeit similar, areas by using different centrepieces for the two tables.

A fourth area, as a nook in a corner overlooking the garden with one chair at a table, provided a potential solitary retreat area, as a break from the other participants. It also allowed the individual to observe the other participants quietly without being involved. Participants did not feel the need to retreat, as observed, but the freedom and possibility of choice was offered. The nook consisted of a corner table covered with an embroidered white cotton table-cloth, with a telephone, a lamp and an old clock placed on the table. A single chair was placed next to the table, with a mirror hung on the wall. The mirror reflected the garden. A plant screened off the area, providing privacy from the entrance area and breakfast serving area.

The fifth area was where the nurses relaxed, separated from the participants, and where the breakfast was served. The long narrow table against the wall was used as a server for this purpose, although the breakfast was only brought into the room at the end of each session.

In summary, the interior design of Room 1 was clearly superior to the interior design of Room 2. Little care appears to be have given for the occupants of Room 2. A discussion of the interior décor follows.

3.4.2 Interior Décor

Interior décor is the decorating of a room, to provide evidence of a cohesive theme and style.

The five-star rating system for hotels has the following criteria: the higher the star rating, the greater the evidence of décor should be, and the more expensive and tasteful the furnishings should be. Service levels should also be higher, and every effort for convenience and comfort of the occupant should be made. The five-star rating principle was followed for Room 1, and deliberately avoided for Room 2.

Every facet of Room 1 was 'dressed' in a cohesive style, with every aspect designed to relax the occupants whilst providing interest through textures and either light reflectivity or absorption, focal points, and soothing sounds, with absorption of excess sound.

Service was also better in Room 1 than Room 2, with proper serving etiquette observed when serving and removing the glasses for the polycose.

The décor aspects are described below.

3.4.2.1 Theme and Style

The theme of a room can be used to create a mood, whilst the style may be follow a particular model typical of a setting, period or country. It is possible for a room to be devoid of theme and style. Consider the following pictures.

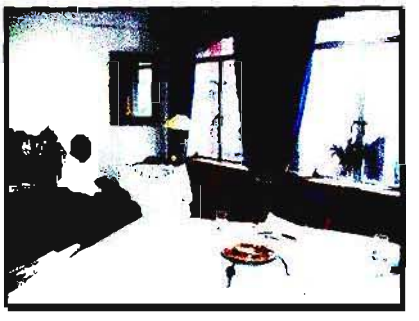


Figure 3.11 Room 1, cohesive theme.

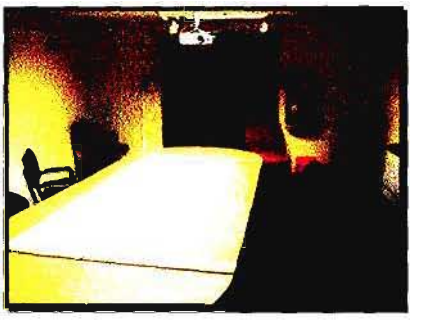


Figure 3.12 Room 2, no theme.

The overall theme of Room 1 was designed to create a mood of an upmarket homely dining room or lounge. The style was classic with modern touches, and was reminiscent of both Colonial décor with its elegant grace and crisp white cloths, and Norwegian décor with its wood panelling, and blue and white colouring. Room 2, in contrast, was functional, and devoid of décor, theme or style.

3.4.2.2 Colour

Room 1 predominantly had blue and white as its colours. The wooden furniture and panelling added warmth to the room, and complimented the blue colours. See figure 3.11, previously displayed, on page 81.

In contrast, Room 2 has no specific colour theme, with yellow as the predominant colour (as the colour of the walls), but with no other similar colours used elsewhere in the room. Pink, blue and burgundy chairs were used, with an orange plastic rubbish bin and a red fire hydrant prominently placed. See figure 3.12 on page 81.

3.4.2.3 Textures and Media

Textures either absorb or reflect light, and break any bland monotony. In Room 1, a range of textures and media were used for variation and interest.

Natural materials, such as loose stones, can be used to provide texture.

Figure 3.13 Room 1, white stones in a wave.

Figure 3.14 Room 1, white stones on sill.

White stones were placed in a curving uneven pattern, like a wave of water, on the server around the central picture and around the two vases of flowers which flanked the picture. Stones were also placed around a vase on the window sill.

Texture provides light and sound absorption, and softens the harshness of flat surfaces. The following figures display some of the textures used, apart from the rugs and stones.

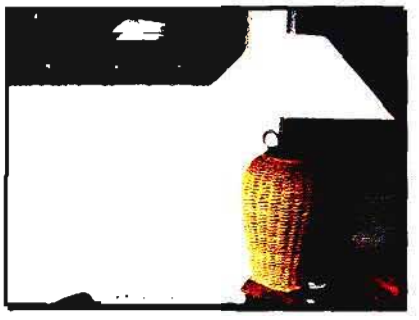


Figure 3.15 Room 1, wicker lamp.

Figure 3.16 Room 1, cotton throw.

For texture and absorption of light and sound, coarsely woven soft cotton, three textured rugs and a coarsely woven soft throw (on a coat-stand in the corner) were used. Some of the cushions placed on the chairs were also of a coarsely woven cotton. A wicker lamp added natural texture.

Glass and ceramics can be used to reflect light and create focal points. The follow pictures show light reflecting media.

Figure 3.17 Room 1, Ming vase.

Figure 3.18 Room 1, table centrepiece (ceramic balls in glass bell jar).

Figure 3.19 Room 1, table centrepiece (glass bowl with wood-shaving pot pourri, on blue and white table runner).

A mirror, pictures, glass table centre pieces and elegantly shaped drinking glasses were used for these purposes. A large Ming vase (of blue and white ceramic) was placed as an objet d'art on a wooden cubic coffee table. Two different centrepieces were used for the two tables. Blue and white ceramic balls were placed in a glass bell jar as one of the centre pieces. The other centrepiece was a glass bowl with wood-shaving pot pourri, on a blue and white table runner.

Fabric also provides texture, particularly if a pattern has been woven in, as can be seen in the next figure.

Figure 3.20 Room 1, white damask linen table cloth.

Good quality crisp smooth white linen damask cloths were placed on both of the tables, for a clean, fresh upper class look. Damask has a woven pattern, to provide texture in the fabric.

The furniture, panelling, window sills, frame of the mirror and coffee table cube were all made of wood, adding warmth through the use of a natural medium. The above figures for Room, starting with figure 3.1 display this consistently.

3.4.2.4 Sound

Sound has the power to alter the mood of participants, and is important for consideration in the décor and design of a room. Music can be soothing, or else emotive and jarring, depending on the choice of music. Classical music is generally devoid of drums or vocals, and considered to be soothing. Classical music has been known to stimulate the mental development of babies. The sound of water flowing is also said to be soothing.

In Room 1, light and very soft coffee-shop music was played. Speakers were hidden around the room for an even distribution of sound. In Room 2, no music was played.

3.4.2.5 Comfort

Comfort is important as it affects stress levels. Comfort is synonymous with care.

In Room 1, the chairs were already padded, but additional cushions were placed on the chairs for added comfort and flexibility, as can be seen below.

Figure 3.21 Room 1, cushions for added flexibility and comfort.

This allowed participants a greater sense of control over their comfort, and created a sense of care for their well-being. Surprisingly enough, this seemed to delight several of the participants, as gauged by their comments. In Room 2, the chairs were already padded to a lesser degree, and no cushions were provided.

3.4.2.6 Plants - Human Issues in Horticulture

Plants are interesting, as they are furnishings and therefore fall within the area of décor, but also have effects on environmental psychology, which is the domain of interior design. Studies in human issues in horticulture show plants result in lower

perceived levels of physical discomfort among the occupants in a room, and result in greater levels of productivity.

In Room 1, five plants of a variety of shapes and sizes were placed around the room at strategic points, and three vases of flowers provided more plants, with colour. Room 2 was devoid of any plant life.

3.4.2.7 Walls (and Windows)

Room 1 was already covered with blue-grey mottled wallpaper. One wall had wood panelling to the height of the window sill (approximately one third of the way up from the floor level). The wood panelling added warmth and broke the monotony.

Room 2 was painted plainly, with no dado rails, picture rails, paint effects or panelling to break the monotony.

Room 1 was decorated with properly framed pictures (all of which had several mountings in blue, plum, white and gold).

Figure 3.22 Room 1, 'Crazy Fish' painting on hand-made paper (by Harry Lock)

Figure 3.23 Room 1, framed print of donkey and cart (by F. Claerhout).

Two of the pictures were of 'crazy fish' hand-painted on hand-made paper, and the other was an artistic rural donkey and cart scene. Pictures were selected to depict nature and an outdoor slow pace of life.

A bevelled mirror (which is generally more expensive than a plain mirror) was placed near the widow, to reflect the natural light and extend the garden view.

Figure 3.24 Room 1, studded wooden frame bevelled mirror, reflecting the garden.

All pictures and the mirror had smooth glass to increase light reflectivity.

The garden concept was extended from the outside to the inside, whilst adding texture.

Figure 3.25 Room 1, lattice work with clock and palm.

Two large panels of unpainted wooden lattice work were mounted against one wall 'to bring the outdoors inside' and to provide texture on the walls. The wooden-framed clock was placed between the pieces of lattice work.

The blinds were opened and pulled back to allow in the maximum amount of light. The curtains were drawn back and tied back elegantly with tiebacks.

Any company propaganda, not matter how well-framed, was removed in favour of décor items.

In Room 2, the few pieces of paper and the laminated posters which had been stuck on the wall with Prestik were removed, to make the room devoid of any possibility for fascination. The walls were left blank, apart from a single clock.

3.4.2.8 Floors

Flooring is an equally important part of the décor and design. It has aesthetic value, as well as the potential for light and sound absorption or reflection.

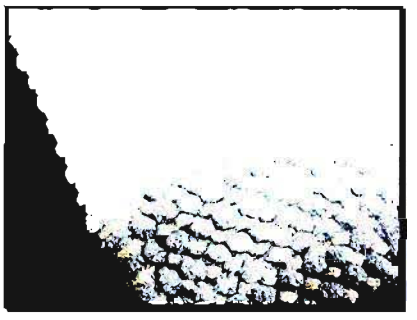


Figure 3.26 Room 1, textured blue rug on patterned neutral carpet.

Figure 3.27 Room 2, heavy duty carpet.

Room 1 already had a soft, patterned, thick-pile neutral carpet, which is excellent for sound absorption. The addition of roughly woven rugs added texture and colour.

Room 2 had a rough cheaper quality heavy duty dark carpet (stuck down in squares), in blue, although it was fairly clean. The sound absorption was fair.

The carpet in Room 1 was clearly a more expensive softer plush carpet with better sound absorption than the carpet in Room 2.

In Room 1, three soft but highly textured blue rugs were laid down. The rugs were used at the entrance to the room, as 'welcome mats', and as a discreet but soft division between the two main tables in the room.

In Room 2, no rugs or decorations were used for the floor.

Dustbins are not only functional, but contribute to the décor.

Figure 3.28 Room 1, wooden dustbin.

Figure 3.29 Room 2, plastic dustbin.

In Room 1, only clean wooden dustbins were used. In Room 2, old, slightly dirty and functional (ugly) metal and bright orange plastic dustbins were visible.

In summary. it will be apparent from the descriptions and pictures, great care was made, through the use of décor, to make Room 1 a restful, elegant and comfortable environment where participants felt the care and effort taken. It will also be apparent how devoid of décor, comfort and interior design Room 2 was. The impression of low levels of care taken for the occupants in this room was immediately apparent.

3.5 TESTING

A brief overview of the testing procedure is provided here, before proceeding with the details. Participants were separated into groups and placed in different rooms on each of the two days. The source of glucose used to obtain a peak in the plasma glucose concentration was polycose. The polycose was ingested as a solution. Several blood samples were drawn from each participant, one of which was drawn from each participant immediately prior to ingesting the polycose. The remainder of the blood samples were

drawn after the polycose solution had been drunk and the mental stressor had been completed. Immediately after ingesting the polycose, participants took part in a competition, as the mental stressor. The blood samples were analysed at a laboratory, where the blood was centrifuged and the plasma phase was tested for glucose concentration. This is discussed below, in more detail.

3.5.1 Organisation of Participants in Groups

Participants were initially organised into two groups of eight. The groups were separated and placed into Room 1 and Room 2. However, two participants who were intended to be placed in Room 2 did not appear on the first day, and two participants withdrew, also from Room 2, after the first blood sample. This left only four participants in Room 2.

Based on the first day's events, the selection of the control group was modified. In order to have an equal number of people in each group and to obtain a large enough sample who would change rooms on the second day, the control group size was reduced to two people.

The reasons for the withdrawal of the two participants and the information provided by this withdrawal will be discussed under section 3.5.5 Blood Sampling.

In future, if the tests were to be repeated, it would be desirable if more female participants could be recruited, to investigate whether there are significant differences between the stress responses of men and of women to the décor and design of the environment.

3.5.2 Organisation of Participants in Rooms

Participants 1 through to 8 were in Room 1 on the first day. Two of these participants remained in Room 1 as a control group on the second day, namely participants 5 and 8. The remainder of the participants (1, 2, 3, 4, 6 and 7) moved across to Room 2 on the second day. Participants 11, 12, 13 and 15 were in Room 2 on the first day, and then moved to Room 1 to join Participants 5 and 8 on the second day. For the discussion on data analysis in chapter 4, the following table can consulted if necessary, as a summary of the participation on the two days in Room 1 and Room 2.

Table 3.1 Participation by room and day

Participant	Day 1		Day 2	
	Room 1	Room 2	Room 1	Room 2
1	●			●
2	●			●
3	●			●
4	●			●
5	▼		▼	
6	●			●
7	●			●
8	▼		▼	
11		○	○	
12		○	○	
13		○	○	
15		○	○	

The upside-down triangle designates the control group, consisting of participant 5 and participant 8, who stayed in Room 1 on both days. The remainder of the bullets represent the two groups of people who experienced either poor (with a star rating of 0 to 0.5) or superior (with a star rating of 4) office environment conditions. The tests were presented

in a counterbalanced order for the two groups. They changed environments on the second day.

3.5.3 Polycose (Glucose Source)

Each participant was given a 40 g of polycose dissolved in 175 ml non-nutritively sweetened lemonade to drink. Diet Sprite was used as the solvent.

Polycose is a powder, which is water-soluble and mixes to a very sticky clear liquid, similar to glucose. It is a high caloric supplement, often used by sportsmen. It should not be used by diabetics, as it is a source of carbohydrates. The other name for polycose is glucose polymer.

As a record for other researchers who wish to repeat the testing for further research, some minor difficulties were experienced initially during the preparation phase of the polycose solution. The polycose powder provided a surface for the bubbles of the carbonated lemonade to coalesce (similar to sugar in a fizzy drink), which meant the polycose needed to be added to the Sprite reasonably slowly. The effervescence resulted in a flat liquid. In future, a non-carbonated solvent would be advisable, purely for ease of mixing. Polycose was observed, by the cloudiness of the solution, to have a lower solubility at room temperature. The Sprite (solvent) therefore needed to be warmed before the polycose would dissolve easily, which meant decanting some of the liquid into another vessel was required, in order to heat the solution gently in a microwave. Once the heated solution had been thoroughly mixed, it needed to be refrigerated overnight to make it pleasant and cool enough to drink. It is important to allow sufficient time for mixing and

cooling, and to have on hand heat resistant glassware. (Pyrex was used in this preparation procedure.) Chilling the solution to a constant temperature for both rooms on both days also is important to eliminate gastric absorption effects at elevated temperatures.

3.5.4 Standardised Mental Stressor

The standardised mental stressor consisted of arithmetic tests, conundrums (word unscrambling), story puzzles and puzzles requiring shape and colour recognition. The combination of tests was designed to subject both left-brained and right-brained participants to mental stress. The inclusion of right-brain tests is an improvement on the tests in the literature.

Within each room, participants were split into two groups. Participants competed for prizes within their smaller groups. Seven tests were administered in a half-hour, on each day, in each room. The participant with the highest mark in each group won ZAR 5 per mini-test and therefore up to a maximum of ZAR 35 per day for seven mini-tests. (The current purchasing power of ZAR 5 is approximately a standard 40 g chocolate sweet, or else one and a half loaves of bread.) The mental stress tests lasted three minutes each, with a one minute break in-between.

The identical tests were administered in Room 1 and Room 2 on the first day, and the identical tests were administered in Room 1 and Room 2 on the second day. The tests on the first and second days were almost identical.

3.5.5 Blood Sampling

Blood samples were intended to be drawn from each participant thirty minutes apart, but there were several problems experienced, all of which needed to be factored into the analysis, and which can provide learnings for future researchers.

There were two nurses and one doctor on hand to draw the blood samples. Initially it was planned to leave a needle with a butterfly valve in each participant, and withdraw samples quickly and easily at thirty minute intervals. The pathology laboratory had never been requested to do such testing before (and neither had another laboratory who had been contacted initially). The blood clotted in the valves, making it impossible to draw subsequent samples. Back-flushing with saline solution was also not possible, due to the risk of the clot reaching the heart. Eventually this method was discarded and samples were drawn at each interval by pricking the participants afresh. In some cases, the veins were not easy to find, and so the participants were jabbed several times. The testing itself was stressful, although most participants were good-natured about it.

Only two participants withdrew (after the first sample on the first day), and these participants were both in Room 2. This may correspond with studies done in 'Human Issues in Horticulture' at American universities, which found participants experienced greater perceived levels of discomfort in rooms where there were no plants visible. No plants were visible in Room 2, which may account for an increase in perceived discomfort. The overall poor décor may also have contributed to the increased perception of discomfort, although this cannot be stated for sure and therefore provides a possible area for further research in environments where physically demanding work is required.

Not all five samples could be drawn in each room on each day. There were large delays in the sampling schedule, caused by the difficulties experienced initially with blood sampling. The most crucial part were the samples at t = 0, t = 30, t = 60 minutes and t = 90 minutes. The peak glucose concentration should occur between 0 and 60 minutes, with the glucose concentration having nearly completed its tapering at 90 minutes.

The effects of the stressful testing can be seen in the analysis, and will be discussed in chapter four.

Unfortunately, the lack of experience with the testing resulted in such a large delay in sampling in Room 1, to the point where the peak in glucose concentration had been missed. It was possible to gauge the time of the peaks by fitting fifth order polynomials through the data, as will be discussed further in chapter four. The group performance also gave some indication of the average stress, as the samples were spread across a wide time span.

For future tests of similar nature, it would be advisable for the nurses to perform a trial run of the sampling in practice, in advance on a person who will not be participating in the tests, to see what is required in terms of a procedure, and what medical supplies will be required.

It would also be advisable to use more nurses for the blood sampling in the future, if possible, to allow for similar blood sampling times of the participants.

Moreover, more frequent sampling between t = 0 and t = 60 would also be advisable. Ideally, 15 minute intervals should be used. The glucose concentrations appear to peak between 15 and 45 minutes. At least one or two samples, between these times and at these boundary times should be drawn.

3.5.6 Laboratory Analysis: Plasma Glucose Concentration

A Beckman Glucose Analyser, Synchron CX, was used to analyse the plasma glucose concentration. The glucose concentrations were presented in molar concentrations, as mmol/litre. The plasma glucose concentrations for each participant were recorded at the different times, in each room on each day.

3.6 Data Collection

The data for the glucose concentrations in plasma were printed by the pathology laboratory, on separate sheets for each participant, with results recorded for the various samples at the various times. The results were personally delivered by the company in an envelope for each day. The room numbers, and which participants were in which rooms, were recorded by the researcher. The time at which participants drank the polycose solution was also recorded during the testing sessions. Validity and reliability of the data are important criteria to check, and will be examined in the following sections.

3.7 VALIDITY

Four types of validity were achieved. Content validity, predictive validity, construct validity, and freedom from bias were achieved.

The instrument was designed for content validity. Content validity, by definition, is achieved when all relevant items are catered for (Cooper & Schindler, 2003). The aim was to establish whether a difference in environment quality affects the psychosomatic stress responses of individuals. Content validity was achieved by perturbing the office environment quality variable, and collecting data regarding the psychosomatic stress responses. All the relevant variables were tested and collected, thereby achieving content validity.

The research instrument was designed for predictive validity. Predictive validity is established when a condition consistently occurs before the effect is observed, and can be used to predict whether or not the effect will be present. If there is no condition present, the effect should not be present (Cooper & Schindler, 2003). A better quality office environment was predicted to lower stress levels, while a poorer quality office was predicted to increase stress levels. Predictive validity was established by presenting the tests in a counterbalanced order. One group experienced a superior quality environment on the first day and then experienced an inferior quality environment on the second day, while another group experienced the inferior environment on the first day and then the superior environment on the second day. A control group experienced no change in office environment quality by remaining in Room 1, to check for consistency of results (and to check no effect was observed where none was expected). As will be seen from the

statistical analysis, the relative quality of the office environment does indeed predict the relative stress levels experienced. Predictive validity was achieved.

Freedom from bias is an important criterion for validity. Bias occurs when not all participants have an equal opportunity in the testing (Cooper & Schindler, 2003). Freedom from bias is therefore the absence of bias and was achieved by subjecting all of the participants to the same conditions, and by subjecting them to both better and poorer quality environments (except for the control group). By having two differing office environments, there were clear reference points for comparison, thereby avoiding bias. There was also no discrimination in the choice of conditions to which individual participants were subjected, thereby also ensuring freedom from bias.

For construct validity, all of the important constructs must be taken into account, and the measurement methods for these constructs must be known (Cooper & Schindler, 2003). Construct validity was achieved by taking into account the two constructs of stress and office environment quality, and the theory surrounding how they could be measured. Construct validity for the first measurement, namely the measurement of stress, was achieved by using a researched and documented measure of psychosomatic stress response, namely the delay in the peak glucose concentration under stressful conditions. Other variables relating to stress were minimised, to ensure only the one source of stress response was compared. The second day of testing yielded signs of additional stress due to the actual tests, but the effects of this were successfully isolated. This is discussed in depth in section 4.8 The tests were performed over a short time period (two to three hours on each day) and within one to two days of each other, to minimise external work, social and financial stressors. Only the office environment variable was perturbed as the potential

stressor. Construct validity of the second construct, the quality of the office environments, was established by employing the well-known Five Star Rating scale used in the hospitality industry. Facets of environments, which have been proved in the literature to improve productivity, were used as additional considerations to differentiate the two office environment qualities. The measurability of the two constructs, stress and the quality of the office environment, ensured construct validity.

Based on the above criteria, which have been met, valid data was collected. Reliability, which can only be established once validity has been achieved (Cooper & Schindler, 2003), is discussed in the next section.

3.8 RELIABILITY

Since validity has been established, reliability of the data can be claimed if the conditions for reliability have been met. Reliability was established through stability and equivalence.

Stability is an important criterion for reliability. Stability, by definition, means the test instrument yields stable results for the same tests (Cooper & Schindler, 2003). A control group was used for this purpose. The control group was subjected to stability tests, via a test-retest method. The control group remained in Room 1, with superior décor and interior design (Room 1), on both days and experienced no change in office environment quality. They were tested on two days with the same test, to measure the involuntary response to stress experienced. Consistent (stable) deviations were found between the first and second days of testing, for the control group and for the average performance of the other two groups, as will be discussed in section 4.8. Stability was therefore achieved.

Equivalence, by definition, is established when equal rating scales and interrater reliability can be established (Cooper & Schindler, 2003). Reliability through equivalence was obtained by using a Beckman Glucose Analyser, Synchron CX, to measure the glucose concentration in the plasma phase. There was therefore no need to establish a human inter-rater reliability. The reproducibility of the instrument is known. Equivalence of times at which samples were taken was relative to the time at which the tests began, which eliminated problems with differences in times displayed on the clocks in the room.

Since stability and equivalence were achieved, and since the data collected was valid, the data can be said to be reliable.

3.9 Economics: Budget and Costs

The expenditure was within the expected budget. The expense items included blood sampling and analysis by the pathology laboratory; the polycose solution; prize money for competitions; the provision of breakfast for participants; and decorating.

3.10 Conclusion

The testing has been discussed in detail above, and hopefully the discussion will provide some guidelines for future researchers who wish to extend these studies. The blood sampling during the tests was observed to be stressful and this should be borne in mind as an external source of stress for the following analysis phase. The rooms were sufficiently discrepant to expect, if interior décor and interior design do have any impact on office

workers, there will be observable differences in the psychosomatic responses of the participants due to the difference in office environment quality. The analysis of the data, and a discussion thereof are presented in the next chapter.

Chapter 4

DATA ANALYSIS: DO SUPERIOR OFFICE DÉCOR AND DESIGN REDUCE STRESS?

4.1 INTRODUCTION

Do superior office décor and design reduce stress? What follows is a discussion of the analysis leading to an answer to this question, and the interesting further observations. Firstly, though, an overview of the approach to be adopted is presented below.

4.2 THEORETICAL APPROACH AND OVERVIEW TO EXAMINING THE DATA

4.2.1 Raw Data

The raw data will be examined and graphs will be drawn. Further analyses will be required before useful statistics can be calculated to draw conclusions.

4.2.2 Further Calculations and Analyses

The raw data must be converted to meaningful information by further calculations and analyses. The time of the peak in each concentration versus time profile is important. The steps for the calculation and analyses thereof are laid out below.

1. Calculate $T_{max\_glucose}$: $T_{max\_glucose}$ is a scalar dependent variable, measured in minutes. It can only be deduced through calculation. Regression analysis will be used to calculate $T_{max\_glucose}$, in a two step process.

- The glucose concentration versus time relationship must be described via equations for each participant on each day. Fifth order polynomials will be fitted through the five glucose concentration points. Time will be the independent variable and the glucose concentration will be the dependent variable. The later glucose concentration points, at higher values of time (t), will be replicated at similar times, in order to ensure a flat profile at the end of the testing period. This is because where no additional source of glucose is ingested, a flat or possibly slowly decreasing glucose concentration in the plasma phase should be expected, yielding the flat shape of the curve at high values of (t)). There will be several points through which to fit a fifth order polynomial, in order to describe the glucose-time relationship.

- The peak glucose concentration is where the rate of change in glucose concentration is zero, and in other words where the derivative of the fifth order polynomial is zero. The value of (t) at which the glucose concentration peaks (which is called $T_{max\_glucose}$ in this study) can then be calculated from the zero value of the derivative.

2. Analyse $T_{max\ glucose}$ checking significance of the room and day: The $T_{max\_glucose}$ values will be used to analyse which room was more stressful. As per Wing et al. (1985), lower $T_{max\_glucose}$ values indicate lower stress, while higher $T_{max\_glucose}$ values indicate higher stress, although the actual $T_{max\_glucose}$ values were not calculated in the study by Wing et al. (1985).

$T_{max\_glucose}$ will then be analysed with the room and day as between-subject factors to check for significance of the room and day of testing. $T_{max\_glucose}$ for the control group, who will stay in the same room on both days of testing, will be used to check if the testing itself caused any stress. The only between-subject factor for the control group will be the day of testing.

In order to check

- in which room greater levels of stress were experienced on each day, the $T_{max\_glucose}$ for participants will be compared across the two rooms.
- on which day greater levels of stress were experienced in each room, the $T_{max\_glucose}$ for participants will be compared across the two days. This will be done to check whether the tests themselves would have caused any stress.
- stress due to the testing, the $T_{max\_glucose}$ for the control group will be compared across the two days. (The control group will stay in the same room on both days.)

$T_{max\_glucose}$ will be analysed statistically with tests for significance, for the two between-subject factors, room and day. Graphical representation will also be provided.

3. Analyse glucose concentration, checking the significance of the room, day and time: Glucose concentration (the second within-subject factor) will be analysed statistically with tests for significance, for the three between-subject factors, room, day and time.

4. Post hoc tests: Post hoc tests using Bonferroni, a modified Bonferroni (Sidak) and Tukey's Honestly Significantly Different tests will be conducted using $T_{max\_glucose}$ as the

within-subject factor, and the room and day as the between-subject factors. The room and day factors will be combined into one factor, room_day, now with four possible combinations, to allow for three degrees of freedom. (The online tutorial of the statistical package, SPSS version 13, was used to provide guidance on statistical tests.)

If significance of the room is established, and post hoc tests confirm there are significant differences between homogeneous groups, which are grouped by room only (and if there are no other significant factors accounting for variance in the data), this will assist in establishing causality. It will enable the questions from 1.5.4 to be answered.

Validity of the null hypothesis or the alternate hypotheses can then be established. What follows is the practical application of the theoretical approach which has been presented. A discussion of the raw data follows.

4.3 Raw Data

The raw data for each participant consist of

- the room in which the testing took place (a nominal independent variable),
- the day on which the testing occurred (a nominal independent variable) and
- the plasma glucose concentration (a scalar dependent variable) at
- various times (a scalar independent variable).

The raw data are presented in the following table with t representing the time of the sample in minutes and g representing the glucose concentration in mmol/litre.

Table 4.1 Raw Data, Plasma Glucose Concentrations at Various Times (t in minutes, g in mmol/L)

Participant	Room	Day	Glucose concentrations at various times				
1	1	1	t = 0, g = 5.3	t = 40, g = 5.4	t = 90, g = 4.0		
2	1	1	t = 0, g = 4.6	t = 35, g = 5.4	t = 95, g = 3.5		
3	1	1	t = 0, g = 4.2	t = 60, g = 3.9	t = 100, g = 3.5		
4	1	1	t = 0, g = 4.3	t = 50, g = 3.6	t = 105, g = 2.6		
5	1	1	t = 0, g = 5.0	t = 40, g = 6.4	t = 110, g = 4.4		
6	1	1	t = 0, g = 5.7	t = 25, g = 9.4	t = 105, g = 7.4		
7	1	1	t = 0, g = 4.6	t = 45, g = 3.9	t = 65, g = 2.5		
8	1	1	t = 0, g = 6.3	t = 75, g = 4.6	t = 110, g = 4.2		
11	2	1	t = 0, g = 5.1	t = 55, g = 7.5	t = 85, g = 5.7	t = 115, g = 4.9	t = 145, g = 4.8
12	2	1	t = 0, g = 5.4	t = 35, g = 7.8	t = 75, g = 5.8	t = 105, g = 4.3	t = 135, g = 2.8
13	2	1	t = 0, g = 5.3	t = 55, g = 7.7	t = 95, g = 6.4	t = 125, g = 3.6	t = 155, g = 2.8
15	2	1	t = 0, g = 5.3	t = 40, g = 9.1	t = 70, g = 7.3	t = 100, g = 6.6	t = 135, g = 5.5
5	1	2	t = 0, g = 4.9	t = 35, g = 8.1	t = 65, g = 5.8	t = 100, g = 3.6	
8	1	2	t = 0, g = 6.0	t = 30, g = 7.9	t = 60, g = 7.0	t = 97, g = 6.0	
11	1	2	t = 0, g = 5.1	t = 38, g = 5.7	t = 65, g = 4.4	t = 105, g = 4.1	
12	1	2	t = 0, g = 5.1	t = 30, g = 7.7	t = 60, g = 7.2	t = 98, g = 6.6	
13	1	2	t = 0, g = 5.2	t = 33, g = 8.2	t = 65, g = 6.8	t = 110, g = 5.8	
15	1	2	t = 0, g = 5.1	t = 45, g = 9.4	t = 69, g = 6.9	t = 110, g = 6.5	
1	2	2	t = 0, g = 5.6	t = 30, g = 9.7	t = 60, g = 6.3		
2	2	2	t = 0, g = 4.8	t = 45, g = 7.6	t = 75, g = 6.3		
3	2	2	t = 0, g = 4.4	t = 30, g = 7.0	t = 80, g = 5.1		
4	2	2	t = 0, g = 4.6	t = 35, g = 7.6	t = 95, g = 2.2		
6	2	2	t = 0, g = 5.4	t = 45, g = 11.3	t = 70, g = 10.9		
7	2	2	t = 0, g = 4.3	t = 30, g = 5.7	t = 105, g = 4.5		

The table of raw data displays, for each participant, in which room they were placed, on what day, and their plasma glucose concentrations at various times on each day. A more detailed explanation of the table follows.

There were two rooms used on two days. Participants 1 to 8 were in Room 1 (the superior quality environment) on the first day, whilst, simultaneously, Participants 11, 12, 13 and 15 were in Room 2 (the inferior quality environment). On the second day, Participants 5 and 8 were used as a control group. They remained in Room 1. The remainder of the participants changed rooms. Participants 1, 2, 3, 4, 6 and 7 were in Room 2 on the second day, whilst the remainder of the participants, Participants 11, 12 , 13 and 15 joined the control group in Room 1. These group arrangements and environment quality conditions are displayed in the first three columns.

Blood samples were drawn at various times to measure glucose concentrations in the plasma phase, starting with a fasting glucose concentration at t = 0, prior to the start of the standardised mental stressors. The time (t) is measured as the minutes from the the start of the standardised mental stressor, when participants drank the polycose solution. The times (t), measured in minutes, and the glucose concentration in the plasma phase at those times, measured in mmol/litre, are displayed in the last five columns on the right. A maximum of five samples were taken.

A graphical representation of the raw data follows.

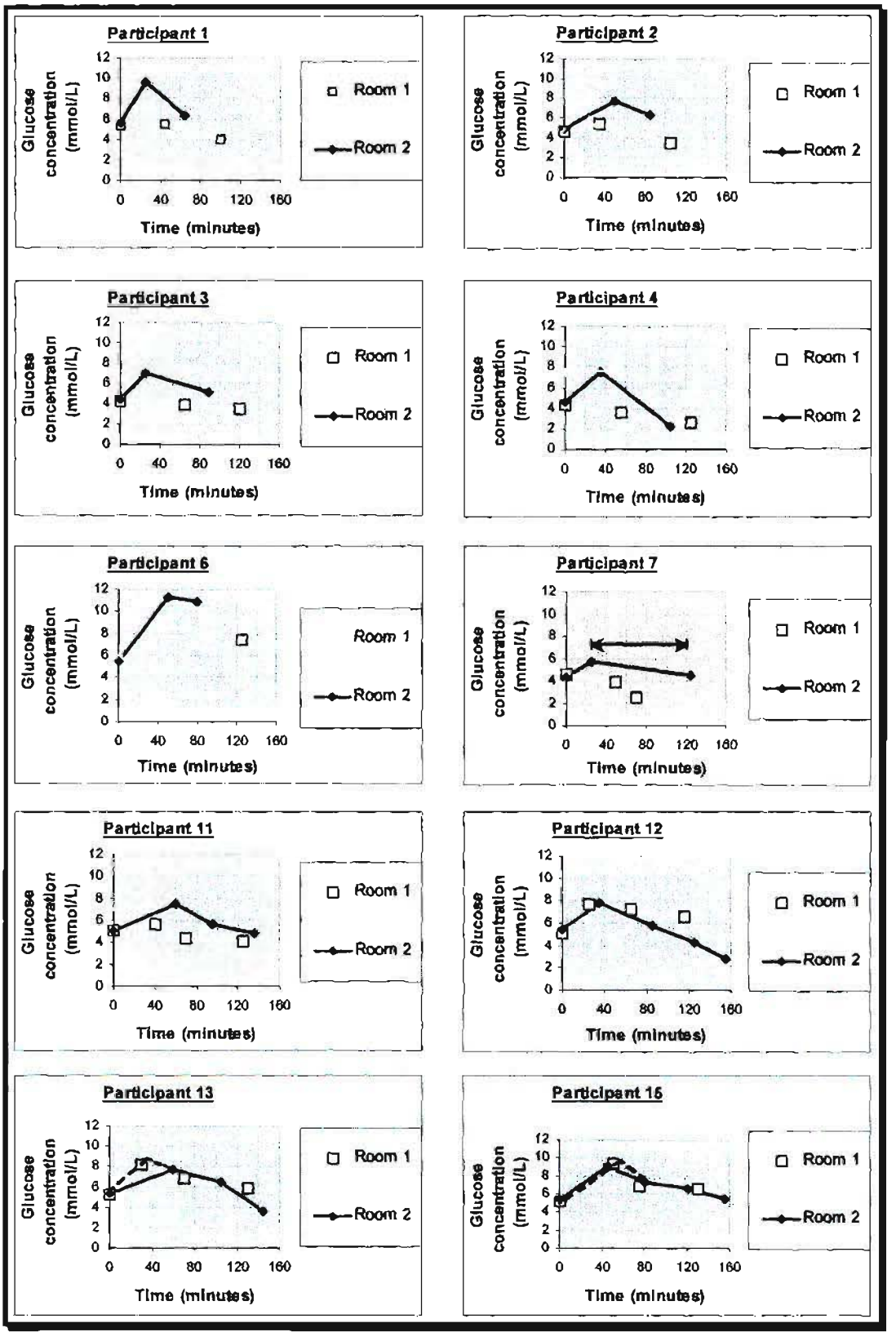


Figure 4.1 Raw data for each participant in each room.

The graphs are plotted for each participant, and display the glucose concentrations in the plasma phase, sampled at the recorded times, for each room. The glucose concentrations in plasma for Room 1 are displayed in white in the graphs, while the concentrations for Room 2 are displayed in black.

Generally, the white lines (Room 1) flatten out earlier than the black lines (Room 2). This indicates a higher or faster insulin response was achieved, and implies the peak concentration was reached was earlier. The measurement of the times for the data to peak are an important consideration in evaluating which room was more stressful.

The expected curve for each line is:

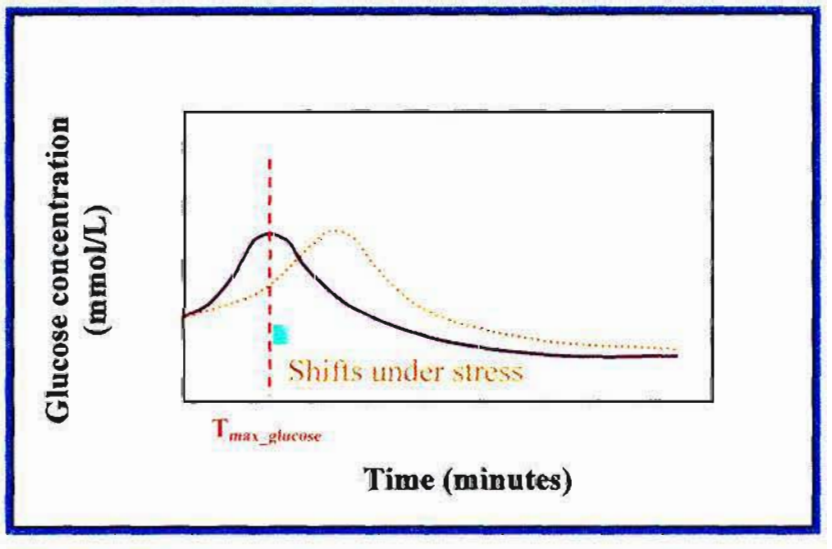


Figure 4.2 Expected glucose concentration versus time curve.

The curve shows the expected response to gastric emptying (increasing glucose concentration in the plasma phase, left of the dotted line). The glucose concentration decreases, right of the dotted line, as the insulin response reduces the glucose in the blood stream. The glucose concentration flattens out at larger values of time, as the insulin returns the glucose to normal stable levels. An earlier flattening of the concentration

profile, as seen in the white lines of the previous graphs, indicates the peak in glucose concentration occurred earlier, for similar insulin responses.

$T_{max\_glucose}$ (measured in minutes) is the time at which the glucose concentration in the plasma phase peaks. The work done by Wing et al. (1985) shows $T_{max\_glucose}$ is delayed under stress. The aim is to check whether the peak (at $T_{max\_glucose}$) is delayed for participants in either room. The value of $T_{max\_glucose}$ can only be found if all the points along the curve are known. The best method of obtaining an estimate of these points along the curve is through regression analysis, which will be discussed in section 4.4.

4.4 Statistical Analysis of Raw Data

Means, medians and modes can be calculated on the raw data, although this yields meaningless information where there is a curve or peak. In many cases, the median is approximately the fasting glucose concentration at t = 0 minutes. Statistical analysis on the unregressed raw data does not yield meaningful information, as the raw data could not be extracted from each participant at identical points in time. More meaningful results are obtained by regressing the raw data, in order to calculate the time at which the glucose concentration ($T_{max\_glucose}$) peaks in the plasma. The comparison of $T_{max\_glucose}$ between Room 1 and Room 2, on Day 1 and Day 2, provides information about which room and which day was comparatively more stressful. Large values of $T_{max\_glucose}$ indicate higher levels of stress experienced.

4.5 Regression Analysis

Regressing the data provides far more information about the intermediate points, between the measured concentration points, and allows for meaningful statistical analysis and post hoc tests to be done.

The choice of whether to use fourth, fifth or sixth order polynomials was based on the profile of the curves obtained. In all cases, almost identical values of $T_{max\_glucose}$ were obtained using fourth, fifth and sixth order polynomials for each curve, although the actual glucose concentration peak heights varied. In other words, the time of the peak did not vary between the three orders of polynomials. Only the size of the peak (the glucose concentration) varied. Fifth order polynomials produced similar and realistic peak heights for each curve, compared to the other curves.

The curves (for fourth, fifth and sixth order polynomials) oscillate increasingly at higher values of t (time), where there are only a few points. In order to simulate the return of glucose concentrations to stable levels after the insulin response, a flat profile is required at higher values of time (t). To strengthen the prediction at higher values of t, the concentration results at larger values of t were repeated for similar values of t. In other words, the glucose concentration at, for example, 140 minutes should be very similar to the glucose concentration at 150 minutes, as participants were not allowed to ingest anything other than the polycose given to them at the beginning of the test. This provided extra points, which assisted to supply at least the six data points required to fit a fifth order polynomial, and strengthened the end profile prediction where the curve needed to be flatter. In most cases, more than six points were provided to strengthen the correlation. A

good fit was achieved in all cases, with Pearson correlation coefficients (R^2) between 0.99 and 1.00.

Prior to fitting the fifth order polynomial curves to each set of data, it was interesting to examine the raw data. Room 1 and Day 1 concentration profile for all participants is shown below, with a minimum and maximum curve for the group fitted using a fifth order polynomial.

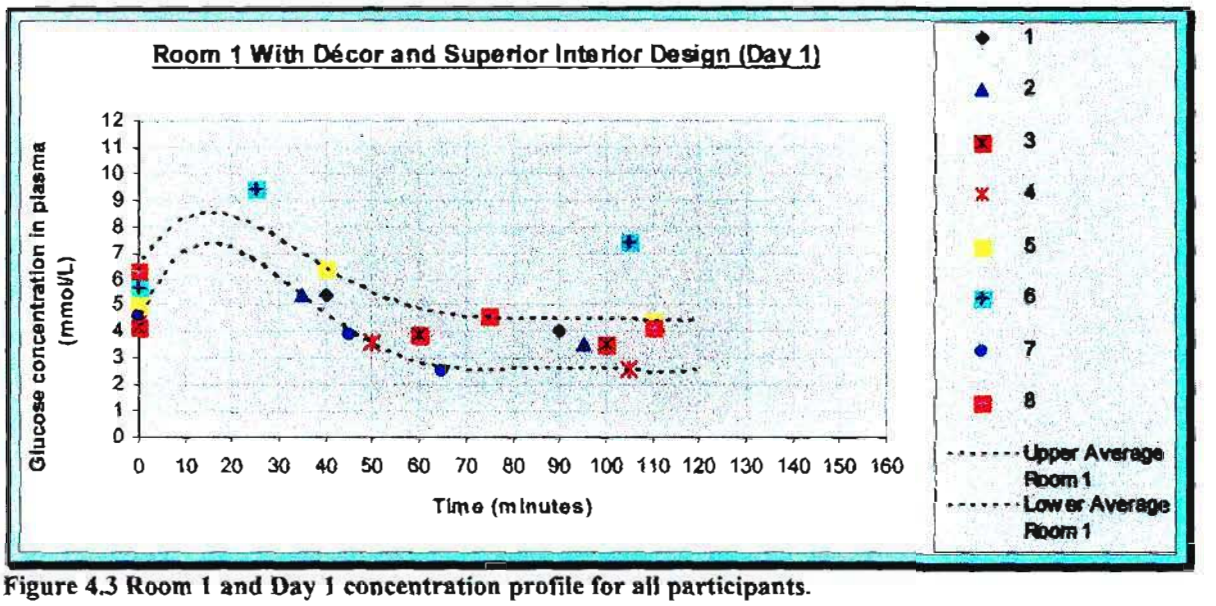


Figure 4.3 Room 1 and Day 1 concentration profile for all participants.

The combined data show some clear trends. It will be noted the data for participant 6 have not been included in the trend. The data for participant 6 show a similar pattern on Day 2, whereby there appears to be a low insulin response, although there is a normal initial fasting sugar (glucose) level. The peak response times for participant 6 were included in all the analyses, however. It was excluded only for illustrational graphical purposes here. The following graphs are the concentration versus time profiles for the regressed data, for each participant on each day in each room. Four figures, grouped by room and day are presented. The concept of $T_{max\_glucose}$ is also explained here, and a rough estimate of the

values can be read off the graph, although the actual values will be calculated from the derivatives of the fifth order polynomials in section 4.6.

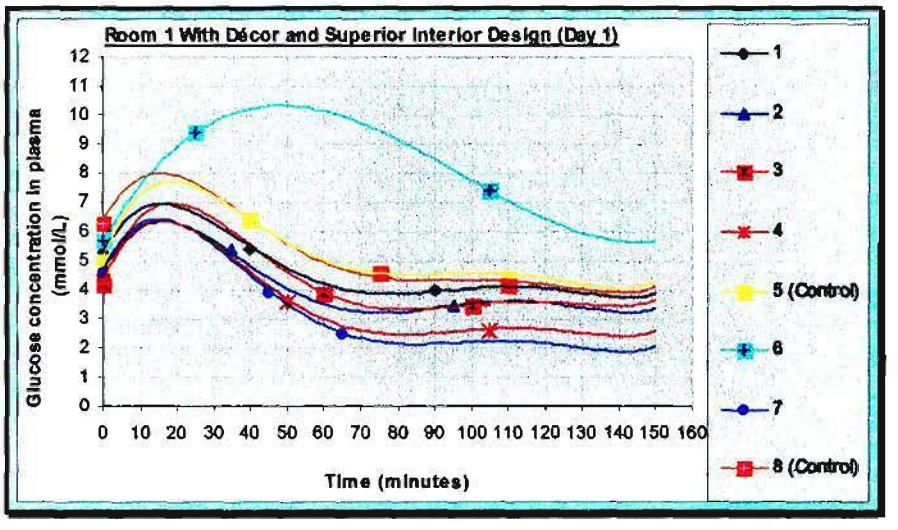


Figure 4.4 Room 1 With Superior Decor and Interior Design (Day 1).

The shapes of the concentration profiles yield the expected curve. Reasonably similar stress responses can be seen in most participants. The time of the glucose concentration peaks are close together in Figure 4.4. They peak mostly between 15 and 20 minutes, with the exception of participant 6, whose insulin response was discussed previously. The time of the peak is the $T_{max\_glucose}$, which is used to compare which environment is more stressful, will be calculated in section 4.6. Higher values of $T_{max\_glucose}$ indicate higher levels of stress experienced.

Compare Figure 4.4 above, with the next graph, Figure 4.5 on page 116. The delay in the peak time illustrates the higher stress response of participants in Room 2 on Day 1.

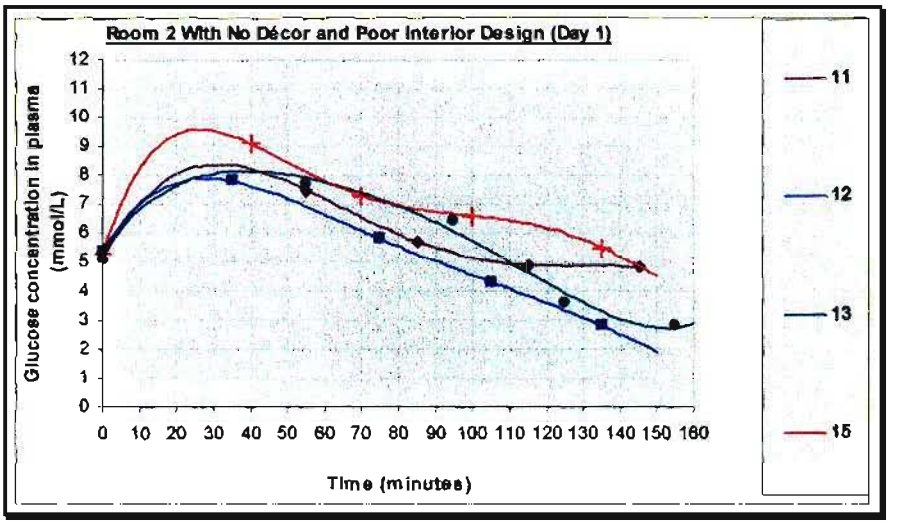


Figure 4.5 Room 2 With Inferior Decor and Interior Design (Day 1).

The concentration profiles, created with fifth order polynomials, are reasonably close to the expected profile shapes. The $T_{max\_glucose}$ ranges between 27 minutes and 38 minutes.

On the Day 2, participants repeated the exercise, although most participants changed rooms, with the exception of participants 5 and 8 who were the control group. Participants 5 and 8 remained in Room 1 on the second day. The following graph shows the concentration profile and the peaks in concentration in Room 1 on the second day.

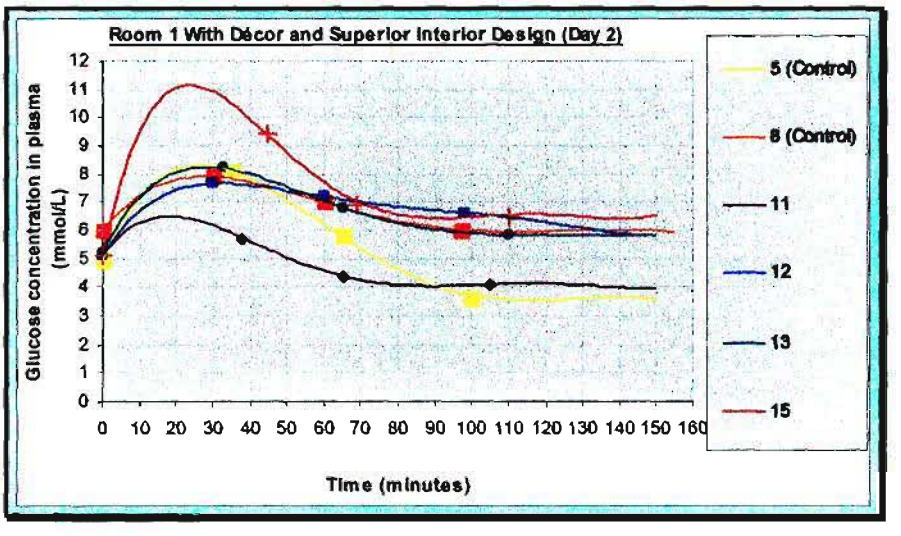


Figure 4.6 Room 1 With Superior Decor and Interior Design (Day 2).

Once again, the normal profile shapes have been achieved for Room 1 on the second day, with fifth order polynomials. $T_{max\_glucose}$ ranges between approximately 18 and 30 minutes in Room 1 on the second day

The next graph is interesting. Participant 7 had a meeting with his boss, who is the managing director of the company, between t = 30 and t = 100. The graph shows the stress of participant, in the delay of the peak. This was factored into the analysis.

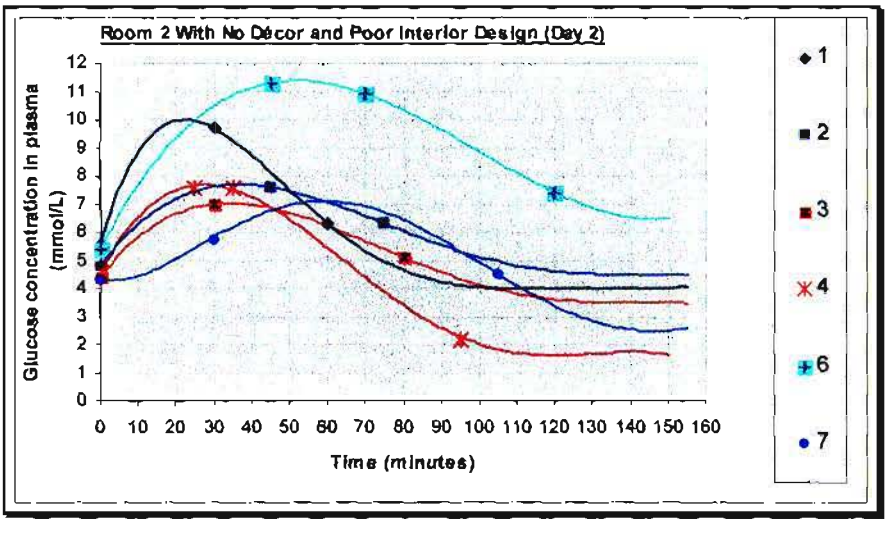


Figure 4.7 Room 2 With No Decor and Poor Interior Design (Day 2).

With the exception of participants 6 and 7, most of the concentration profiles for participants in Room 2 on the second day peaked between approximately 28 and 36 minutes. From the graphs, it can be seen Room 1 consistently yields an average lower stress response in participants than Room 2. The $T_{max\_glucose}$ values for each participant in each room will be calculated and discussed in more detail in section 4.6.

The graphs display the expected shape to the concentration profile curves generated with fifth order polynomials, and correlate well with the raw data (R^2 values of between 0.99 and 1.00 were obtained for each curve). The fifth order polynomial equations are given in Table A2. 1 in the appendix.

Regression analysis allows plasma glucose concentrations to be calculated at the same times, for participants in each room. This allows for meaningful statistical analysis. Statistical analysis of the regressed data and a discussion thereof follows.

4.6 Statistical Analysis of Regressed Data

The values of concentration were analysed as differences from the base fasting glucose. The variance due to various factors is presented in the table below.

Table 4.2 Total Variance of Glucose Concentrations Due to Within Subject Factors

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Room	25.615	77.622	77.622	25.615	77.622	77.622	13.371	40.519	40.519
Day	3.870	11.726	89.348	3.870	11.726	89.348	10.260	31.090	71.609
@25	2.059	6.240	95.588	2.059	6.240	95.588	7.913	23.979	95.588
@30	.950	2.878	98.466						
@33	.363	1.099	99.565						
@35	.119	.360	99.926						
@38	.025	.074	100.000						
@40	1.15E-15	3.49E-15	100.000						
@45	9.51E-16	2.88E-15	100.000						
_@145	-9.55E-16	-2.90E-15	100.000						
@150	-4.37E-15	-1.32E-14	100.000						

Extraction Method: Principal Component Analysis.

The eigenvalue for the room condition is significantly higher (25.6) than any of the other eigenvalues. This indicates the room condition accounts for 77.6% of the variance, where the day of testing, as a variable, accounts for 11.7% of the variance. The room condition factor is the strongest variable accounting for differences in glucose concentration observed. Although 11.7% variance is not as large as the variance for the room condition, it is still large enough to indicate there is some impact due to the day of testing. The fairly large eigenvalues for the times at 25, 30 and 35 minutes indicate there are significant differences at these early points, between the concentrations. The combined variance of the concentrations at these times is 10.2%. This will be discussed further in section 4.7, because it relates to $T_{max\_glucose}$.

The unrotated component matrix is presented in the (abbreviated) table below.

Table 4.3 Component matrix for room and day factors

	Component	
	Room	Day
Room	.280	.771
Day	.369	.063
@25	.715	.230
@30	.808	.288
@33	.850	.314
@35	.871	.328
@40	.908	.347
@45	.927	.351
@50	.935	.343
@60	.940	.300
@70	.945	.229
@80	.954	.129
@90	.962	.002
@100	.960	-.147
@110	.941	-.293
@120	.907	-.406
@130	.868	-.470
@140	.824	-.508
@150	.752	-.582

Extraction Method: Principal Component Analysis.

The above unrotated component matrix indicates a very strong correlation between room number (and therefore room condition) and the glucose concentration in plasma at various times, with all of these correlation values higher than 0.715 and most of these correlation values well above 0.900 for the room. The correlation between glucose concentrations at times and the day of testing correlate less well.

Although the day of testing factor does not correlate as well (with the glucose concentrations at various times, the correlation effects being -0.6 to 0.3) as the room condition correlates with concentrations (all above 0.718), the reasonably high correlation of testing day with room number (0.771) indicates there is some impact due to the day of testing. The most likely reason for this is the stress induced by the test itself. This will be discussed further in section 4.7.

The crux of the study is presented in the following two sections.

4.7 Derivatives of Fifth Order Polynomials ($T_{max\_Glucose}$)

The comparative times at which the glucose concentration peaks ($T_{max\_glucose}$) indicate the comparative levels of stress experienced. In order to deduce which room was more stressful, and whether the room condition had any impact on the time of the glucose concentration peak, it is necessary to calculate $T_{max\_glucose}$.

The peak occurs at a time when the rate of change in the concentration profile becomes zero, as shown graphically below in Figure 4.8. The time of the peak is $T_{max\_glucose}$.

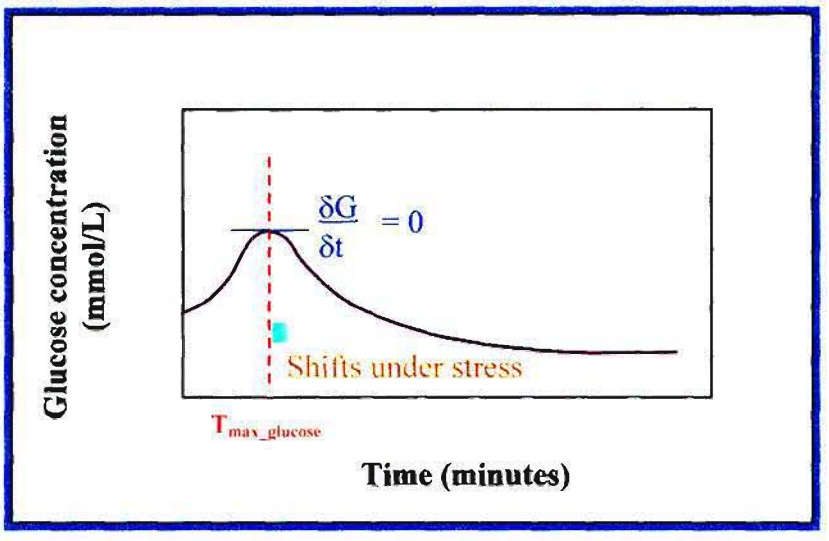


Figure 4.8 The time at which glucose concentration peaks, $T_{max\_glucose}$

As is displayed in the graph, the time of the peak ($T_{max\_glucose}$) is the time when the derivative of the curve is zero. Each of the fifth order polynomials describing the glucose relationship with time was therefore differentiated. The resulting fourth order polynomial (the derivative) was solved for zero, to obtain the $T_{max\_glucose}$. The calculated $T_{max\_glucose}$ values are displayed in Table 4.4.

Table 4.4 $T_{max\_glucose}$ values for each participant

Participant	Day 1		Day 2	
	Room 1	Room 2	Room 1	Room 2
1	15.9			22.4
2	15.9			36.7
3	18.7			34.1
4	16.1			27.4
5	18.7		26.6	
6	48.2			51.7
7	15.0			59.1
8	15.7		27.7	
11		31.4	18.0	
12		28.0	31.9	
13		39.1	28.0	
15		26.4	23.6	
Mean	20.5	31.2	26.0	38.6

The values for the control group (participants 5 and 8) who remained in Room 1 are displayed in blue. The analysis of $T_{max\_glucose}$ is discussed in the next section.

4.8 STATISTICAL ANALYSIS OF $T_{MAX\_GLUCOSE}$

Prior to beginning the statistical analysis, it is useful to look at the results graphically to check the statistical analysis.

The mean $T_{max\_glucose}$ values for each room and day are displayed graphically in Figure 4.9.

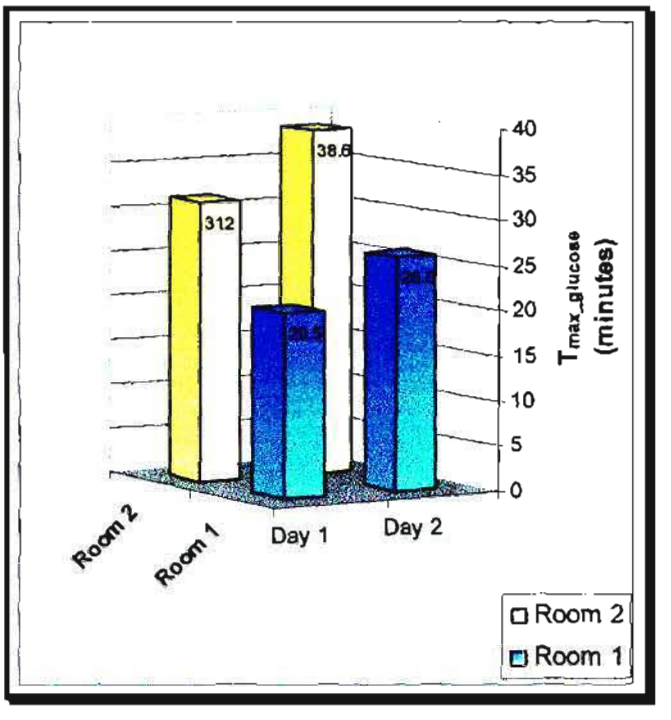


Figure 4.9 Mean $T_{max\_glucose}$ values.

Figure 4.9 clearly shows the mean $T_{max\_glucose}$ values for Room 1 on both days are lower than the mean $T_{max\_glucose}$ values for Room 2 on both days. On Day 1, the difference in $T_{max\_glucose}$ between Room 2 and Room 1 was 10.7 minutes. On Day 2, a similar trend was

observed. The difference in $T_{max\_glucose}$ between Room 2 and Room 1 was 12.6 minutes. This shows Room 2 was consistently more stressful than Room 1 on both testing days, by similar amounts. Looking at the differences in stress due to the day of testing, the higher $T_{max\_glucose}$ values on Day 2 are consistent for both rooms. This is most likely due to the stress of testing, as will be explained below.

On the first day, and at early stages of testing, participants had only been pricked with a needle once before the glucose concentrations peaked. The second samples were taken soon after the peak in glucose concentration. On the second day, however, the memory of being poked with a needle five times on the day before (along with the problems experienced due to clotting of the blood in the butterfly valves), and once already on that morning, would have contributed to stress. If this was the case, then the control group who stayed in Room 1 on both days should have experienced an increase in $T_{max\_glucose}$ from Day 1 to Day 2. The $T_{max\_glucose}$ values for the control group are displayed below.

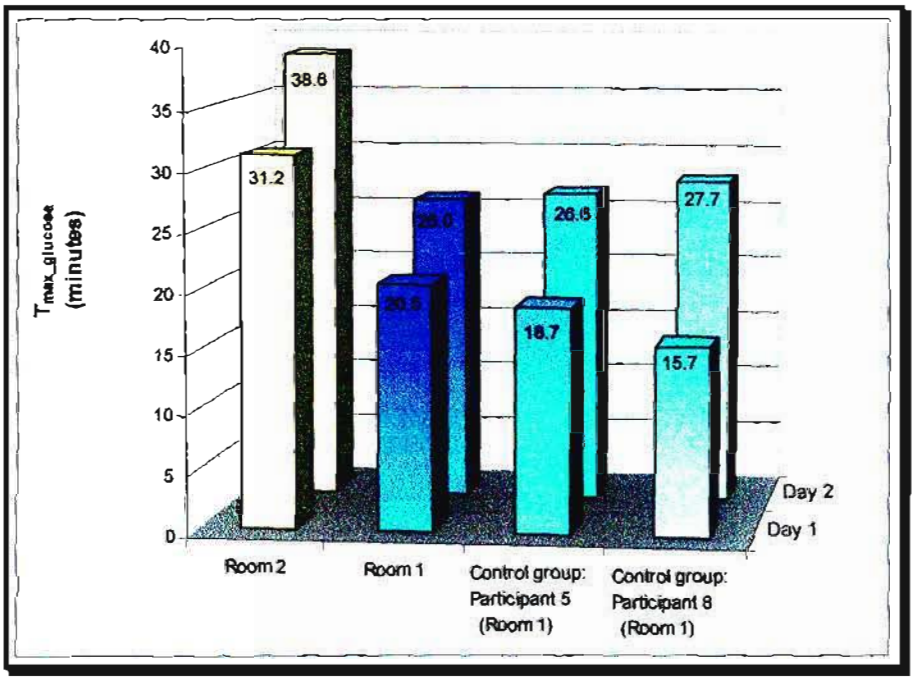


Figure 4.10 Mean $T_{max\_glucose}$ values for the group by room and day, and the control group in Room 1.

Indeed, the control group did experience higher levels of stress on the second day of testing. The $T_{max\_glucose}$ for participant 5 was delayed 7.86 minutes while the $T_{max\_glucose}$ for participant 8 was delayed 12.07 minutes. The stress experienced due to testing would vary from participant to participant, because it would depend on how easy their veins were to find, and on their natural pain thresholds.

The average perceived stress due to physical discomfort appears to be greater in Room 2 as compared to Room 1.

Statistical analysis confirms the high significance of the room factor on $T_{max\_glucose}$. Table 4.5, below, displays multivariate tests for the significance of the room and day of testing.

Table 4.5 Multivariate tests of significance on $T_{max\_glucose}$

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.995	470.622(a)	6.000	15.000	.000	.995
	Wilks' Lambda	.005	470.622(a)	6.000	15.000	.000	.995
	Hotelling's Trace	188.249	470.622(a)	6.000	15.000	.000	.995
	Roy's Largest Root	188.249	470.622(a)	6.000	15.000	.000	.995
Room	Pillai's Trace	.726	6.620(a)	6.000	15.000	.001	.726
	Wilks' Lambda	.274	6.620(a)	6.000	15.000	.001	.726
	Hotelling's Trace	2.648	6.620(a)	6.000	15.000	.001	.726
	Roy's Largest Root	2.648	6.620(a)	6.000	15.000	.001	.726
Day	Pillai's Trace	.576	3.402(a)	6.000	15.000	.025	.576
	Wilks' Lambda	.424	3.402(a)	6.000	15.000	.025	.576
	Hotelling's Trace	1.361	3.402(a)	6.000	15.000	.025	.576
	Roy's Largest Root	1.361	3.402(a)	6.000	15.000	.025	.576
Room * Day	Pillai's Trace	.659	4.829(a)	6.000	15.000	.006	.659
	Wilks' Lambda	.341	4.829(a)	6.000	15.000	.006	.659
	Hotelling's Trace	1.931	4.829(a)	6.000	15.000	.006	.659
	Roy's Largest Root	1.931	4.829(a)	6.000	15.000	.006	.659

a Exact statistic
b Design: Intercept+Room+Day+Room * Day

Based on the multivariate tests above, the room factor is highly significant with $F(6;15) = 6.620$ ($p=0.001$ at $\alpha = 0.05$). This high level of significance is confirmed by a high Pillai's trace value (0.726), and a low Wilk's lambda (0.274). Hotelling's trace is significantly larger than Pillai's trace, which means the room factor is highly significant. The partial eta squared for the room condition is high at 0.726, indicating a large amount of variance is accounted for by the room. This is displayed in the table above.

Notice the effect of the day of testing is not as significant as the room ($F(6;15) = 3.402$ ($p=0.025$ at $\alpha = 0.05$)), although it still significant and therefore contributes to the variance. This confirms the previous discussion about the stress effect on the second day, due to testing.

Psychosomatic journals have noted differences in psychosomatic responses among different ethnic groups and between genders. For interest, a brief analysis is included.

Table 4.6 Change in $T_{max\_glucose}$ by gender and ethnic group

Participant	Change in $T_{max\_glucose}$ (Room 2 minus Room 1)	Gender	Ethnic Group	Mean, excl Ptcpt 6	Variance in change in $T_{max\_glucose}$ excl Ptcpt 6
2	20.8	Female			
3	15.4	Male			
4	11.3	Male			
7	44.1	Male			
13	11.1	Male	Black	14.7	20.84
6	3.5	Male			
8	Control group	Male			
15	2.8	Male	Indian	3.1	0.234
1	6.4	Female			
5	Control group	Male			
11	13.4	Male			
12	-4.0	Male	White	5.3	76.34

The apparent stress due to the quality of the office environment is higher in black participants than in white or Indian participants, with a mean change in the time of the peak glucose concentration of 14.7 minutes (higher in Room 2 than in Room 1). The data for Participant 7 were excluded. As discussed previously, participant 7 was under additional stress due to a meeting with his boss, the managing director, 30 minutes after the testing had started. The variance amongst black participants (excluding participant 7) is moderately low (20.8) and therefore indicates reasonably consistent results. The higher levels of stress indicated by the psychosomatic responses in black participants may relate to their natural sensitivity towards art, since decorating is an art-form, although this is purely a suggestion. It may also relate to physiological differences. The observation provides an interesting area for future research by other researchers, and would be valuable for retention strategies in the current South African context, where retention of black staff is vital for companies who still need to achieve their employment equity targets.

There were too few female participants to draw conclusions relating specifically to women or men. There does not appear to be any gender-specific correlation in the data, limited though they may be.

This same table, Table 4.6, also indicates all participants but one experienced more stress in Room 2 than in Room 1.

The following table, is similar to Table 4.6, although it shows the additional stress (the change in $T_{max\_glucose}$) in Room 2, after being adjusted for the stress of testing. This table

therefore is a representation of the additional stress (in Room 2) only due to the poorer quality office environment.

Table 4.7 Change in (adjusted) $T_{max\_glucose}$ by gender and ethnic group

Participant	Change in (adjusted) $T_{max\_glucose}$ (Room 2 minus Room 1)	Gender	Ethnic Group	Mean excl Ptcpt 6	Variance in change in $T_{max\_glucose}$ excl Ptcpt 6
2	13.1	Female			
3	7.6	Male			
4	3.5	Male			
7	36.3	Male			
13	18.6	Male	Black	10.7	43.32
6	-2.6	Male			
8	Control group	Male			
15	10.6	Male	Indian	4.0	86.9
1	-1.3	Female			
5	Control group	Male			
11	21.3	Male			
12	3.9	Male	White	7.9	140.1

When the average effect of stress due to testing is accounted for, as seen in the table above, the trends do not change significantly, although the means and the variances become smaller. Only two participants apparently experienced higher levels of stress in Room 1, although this could be due to adjusting all of the stresses on the second day by an average number. This adjustment does not account for people with high or low stress responses. It is simply an average adjustment. The majority of the group still experienced more stress in Room 2. The mean adjustment for the effects of stress due to testing matches the differences in stress observed in the control group, who remained in Room 1, and also brings the mean stress, experienced by the rest of the participants on the second day, to similar levels for each room on the first day.

A principal component analysis shows the room to be the principal component which correlates with the room (which is the office environment quality).

A component analysis gives an indication of which are the principal factors accounting for variance. This is displayed in the following table.

Table 4.8 Component Matrix for $T_{max\_glucose}$

	Component
	Room
Room	.782
Day	.600
$T_{max\_glucose}$	.868

Extraction Method: Principal Component Analysis.
a 1 components extracted.

Only one component has been extracted as the principal component, namely the room. $T_{max\_glucose}$ correlates well with the room condition. The day correlates reasonably well with the room, which indicates stress due to the testing procedure (since all other variables were held constant).

The data were re-examined after correcting the curves on the second day for the effects of the stress due to testing. The curves were adjusted by shifting all the data, except the fasting glucose levels, to an earlier time.

The ANOVA tests assume there is equal variance across the data. Levene's test of equality of error variances can be used to check whether this assumption is valid for the adjusted glucose concentrations, before calculating the adjusted $T_{max\_glucose}$.

Table 4.9 Levene's test of equality of error variances

	F	df1	df2	Sig.
Glucose	1.647	35	180	.019

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Levene's test of equality of error variances for glucose concentrations at different points in times has a significance of 0.019, which is lower than the required significance level of 0.05. This means the data meet the requirements for ANOVA testing, because there is an equal variance across the glucose concentrations over time.

$T_{max\_glucose}$ values for the second day of testing were recalculated for each participant, from derivatives of the adjusted curves for glucose concentration versus time. The adjustment decreased $T_{max\_glucose}$ for each participant on the second day by the desired 7.8 minutes (which was the smaller of the stress levels indicated by the control group). The result of this adjustment was the average adjusted $T_{max\_glucose}$ values for Day 2 were then similar to the values for Day 1. The gap between the stress on Day 1 and Day 2 also reduced for the control group, participants 5 and 8. This is displayed in Figure 4.11.

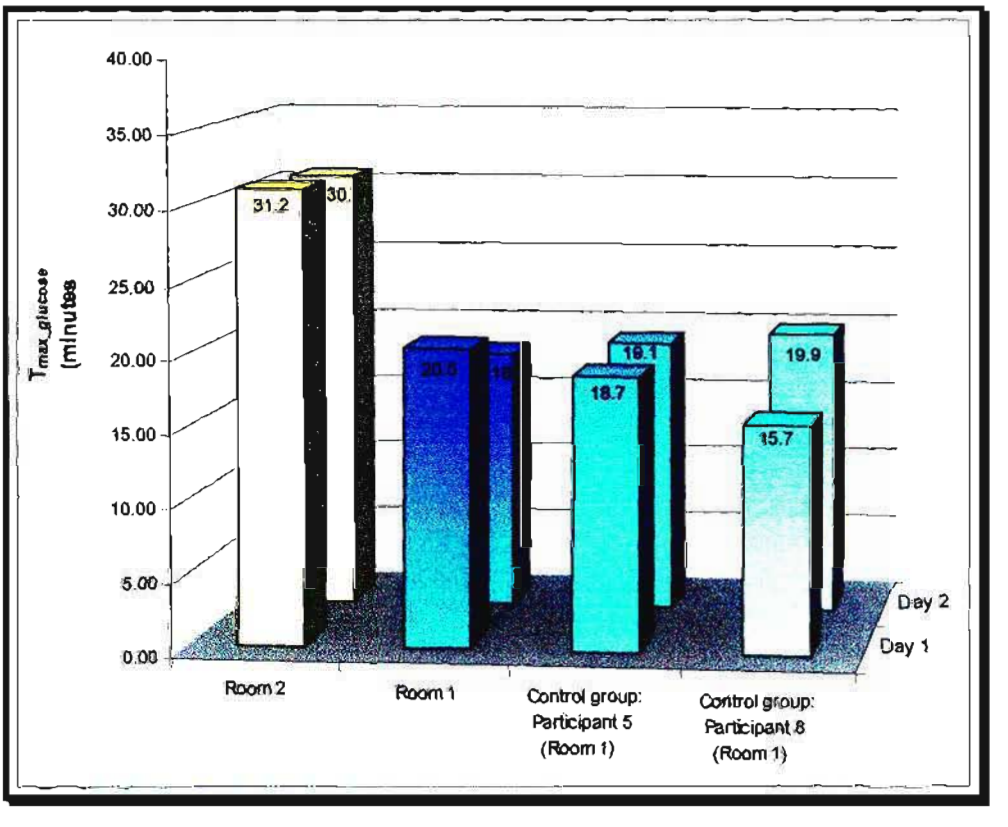


Figure 4.11 Adjusted $T_{max\_glucose}$ on Day 2, to eliminate stress due to testing.

From the graph above, the data now show even more clearly the consistent distinction between the stress experienced in Room 2 and in Room 1. All participants experienced higher levels of stress in Room 2 than in Room 1, regardless of the day of testing. This will be checked statistically with a principal component analysis, and in section 4.9 with post hoc analyses.

A principal component analysis was performed once again, using the adjusted $T_{max\_glucose}$ values for Day 2 now, as is presented in Table 4.10.

Table 4.10 Principal Component Analysis for adjusted $T_{max\_glucose}$

	Component
	Room
Room	.875
Day	.294
$T_{max\_glucose}$	.832

Extraction Method: Principal Component Analysis.
a 1 component extracted.

The component matrix for the principal component analysis shows, with adjusted t-max values, still only one component (out of the two components, room and day) was extracted as a principal component, namely the room condition. This was expected. The correlation between the room and $T_{max\_glucose}$ hardly changed from 0.868 to 0.832. However, the correlation between the room and the day dropped substantially from 0.600 to 0.294. This reduction in the significance of the day of testing was the desired result of eliminating stress due to testing from the $T_{max\_glucose}$ values for the second day. The room condition is now well correlated with $T_{max\_glucose}$ only, and is not well correlated with the day.

The effect of stress (which is seen in the principal component analysis as the significance of the day of testing) has been effectively removed (through reducing $T_{max\_glucose}$ for each participant by a fixed value of 7.8 minutes to account for the stress of testing) without compromising the significance of the room as a principal component.

A spread versus level plot was used to examine the variability in the data, and is presented in Figure 4.12. The results from the principal component analysis are also clear in the plot. The performance across the two rooms is clearly distinct, as indicated by the similar $T_{max\_glucose}$ means.

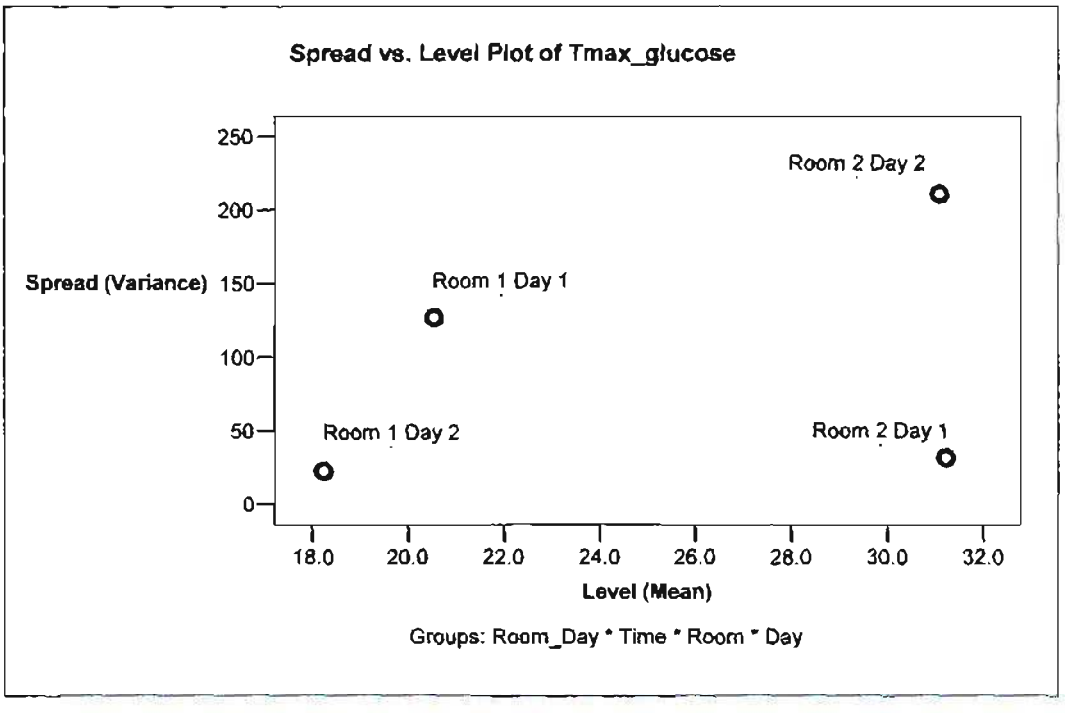


Figure 4.12 Spread versus level plot of adjusted Tmax_glucose.

The spread versus level plot of the adjusted $T_{max\_glucose}$ values shows the variance is high for Participants 1 to 4, and 6 to 7 (these participants were in Room 1 on Day 1, and Room 2 on Day 2). This is not surprising, and is the result of the low insulin response of participant 6, resulting in significantly different $T_{max\_glucose}$ values from the rest of the

group. On Day 2, the variance for this same group of participants is even higher, in Room 2. This is due to the stress responses from both Participant 6 and Participant 7. Participant 7 had a meeting with the managing director on Day 2 during the later part of the testing. It was thought there would be sufficient time for the glucose peak to have occurred before the meeting occurred, although the stress of the impending meeting proved otherwise. The $T_{max\_glucose}$ value for Participant 7 was closer to the $T_{max\_glucose}$ of Participant 6 on this second day. This accounts for the large variances observed on Day 2. Excluding these participants from the analysis did not alter the values or outcomes significantly, because both Participant 6 and the other participants had experienced a similar trend in higher stress in Room 2. A post hoc analysis follow in the next section.

4.9 Post Hoc Analysis

Post hoc analysis was done using Tukey's Honestly Significantly Different test, Scheffe, Bonferroni and Sidak (modified Bonferroni) tests. The data were tested using both the unadjusted and the adjusted $T_{max\_glucose}$ values. Four groups were created, by combining the room and the day, since the tests require more than two groups.

As can be expected, based on the above analysis in previous sections, for the unadjusted $T_{max\_glucose}$ values, the tests revealed three of the four subsets were similar. When the data were tested for the adjustment due to the stress of testing on Day 2, there were two homogenous subsets. This is presented in Table 4.11.

Table 4.11 Post hoc tests for homogenous subsets using adjusted $T_{max\_glucose}$ values

	Room_Day	N	Subset	
			1	2
Tukey HSD(a,b,c)	12	54	18.2423	
	11	72	20.5400	
	22	54		31.0795
	21	36		31.2225
	Sig.		.680	1.000
Scheffe(a,b,c)	12	54	18.2423	
	11	72	20.5400	
	22	54		31.0795
	21	36		31.2225
	Sig.		0.743	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = 107.786.
a Uses Harmonic Mean Sample Size = 50.824.
b The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c Alpha = .05.

The two subsets found by the tests correspond to the rooms. Subset 1 contains the values for Room 1 on Day 1 and Day 2, while Subset 2 contains the data for Room 2 on Day 1 and Day 2. This means there are significant differences between the rooms used for testing, but no significant differences in the days of testing. The subsets (rooms) are both highly significant, ranging from 0.680 to 1.00, for an alpha of 0.05.

The data for the multiple comparison tests can be found in Appendix 3 on page 159. The table confirms the homogeneous subsets in Table 4.11. The difference in $T_{max\_glucose}$ for each pair of means ranged from (positive and negative) 10.54 to 12.98 where there were significant differences, and ranged from (positive and negative) 0.14 to 2.30 where there were homogeneous subsets. The two homogenous subsets were Room 1 (on Day 1 and Day 2) and Room 2 (on Day 1 and Day 2).

4.10 CONCLUSION

The aim of the data analysis was to check whether the peak (at $T_{max\_glucose}$) is delayed for participants in either room. Regression analysis of the raw data was done using fifth order polynomials, the derivatives of which were used to calculate $T_{max\_glucose}$. The room accounts for 78% of the variance in the glucose concentrations. The day of testing accounts for 12% of the variance, and this was due to the stress of the actual testing procedure. This additional source of stress was evident in the difference in the average $T_{max\_glucose}$ values for each Room on the second day, as well as in the control group. Multivariate tests on $T_{max\_glucose}$ show the room factor is highly significant. The room factor on the stress response of individuals (measured by $T_{max\_glucose}$) is highly significant with $F(6;15) = 6.620$ ($p=0.001$ at $\alpha = 0.05$).

The effects of the stress on the second day, due to testing, were removed for further analysis. The stress due to the testing reduced significantly, and the room remained highly significant as a factor.

Post hoc tests using Tukey's Honestly Significantly Different test and Scheffe's test, once the effects of stress due to testing were removed, show there are two homogeneous subsets, each of which corresponds to each room.

From the data analysis, it would seem the room factor is significantly responsible for the differences in stress experienced in two different environments, with the tests being presented on two days in a counterbalanced order. In order to establish causality and thereby test the hypotheses, it will be necessary to answer the interim critical questions from section 1.4.

Chapter 5

HYPOTHESES TESTING

5.1 INTRODUCTION

Three hypotheses were proposed in the first chapter on page 5, namely the null hypothesis H_{01}, and the two alternate hypotheses H_{A1} and H_{A2}. The answers to the interim critical questions from section 1.4 will assist in establishing which hypothesis is true. The following sections will therefore first answer the interim critical questions, and then proceed to establish which of the three hypotheses is true.

5.2 INTERIM CRITICAL QUESTIONS FOR CAUSALITY

Three categories specifics topics are required to establish causality. The three categories are covariance, sequence of events and no other causes for change.

5.2.1 Covariance

There are three questions requiring answers to establish covariance.

1. When the office environment quality varies in the clinical trial, do the psychosomatic responses of the office workers vary?

Yes. The participants were subjected to different office environment qualities on different days. Two office environments were used. Room 1 was superior and had an

approximate star rating of between three and four, while Room 2 was inferior and had a star rating of between zero and one. The psychosomatic stress responses varied in accordance with the room, and the room factor was found to be highly significant. $F(6;15) = 6.620$ ($p=0.001$ at $\alpha = 0.05$). When the effects of stress on the second day were removed, Tukey's Honestly Significantly Different test returned two homogeneous subsets corresponding to the rooms, Room 1 and Room 2.

2. If the office environment quality does not vary, do the psychosomatic responses remain constant?

A control group was used to test for stability in the psychosomatic responses, as well as the average group responses for each room on the two days of testing. In both sets of data, stress due to testing was observed on the second day. This was corrected by adjusting the data for the minimum additional stress effect observed in the control group on the second day. After the adjustment, the control group and the average group results remained constant across the days, for each office environment. So, after accounting for the stress of testing, the answer is yes. The psychosomatic responses remain constant when the office environment quality does not change.

3. When the office environment quality improves and deteriorates, does the stress response, indicated by the psychosomatic response, decrease and increase?

Yes. The tests were presented in a counterbalanced order. One group experienced a deterioration in the environment quality, whilst the second group experienced an improvement in the environment quality. Consistent results were achieved. The superior room induced a lower stress response than the inferior room, which induced a higher stress response.

Since the answer to the above three questions is yes, covariance has been established.

5.2.2 Sequence of Events

The sequence of events is a criterion for causality.

1. Does the order of the change in the office environment quality correspond to the order of the change in stress responses in the office workers?

Yes. When the inferior office environment was used, participants experienced higher stress levels. When the superior office environment was used, participants experienced lower stress levels.

The 'sequence of events' criterion has therefore been met.

5.2.3 No Other Causes for the Change

No other causes for the change in psychosomatic responses should be possible, in order to establish causality of the office environment quality.

1. Are there other possible causes for the changes observed?

No, once the effect of the stress of testing had been removed, the only changed variable was the room condition. Statistical tests confirmed the room factor was the only principal component, and it was highly significant. Therefore, there were no other possible causes for the changes observed.

Since all three criteria have been met, causality has therefore been established. In essence, the room condition caused the change in stress response. An improvement in the room condition causes a reduction in stress levels, whilst poor office quality results in increased levels of stress. The hypotheses will now be examined.

5.3 ALTERNATE HYPOTHESES

The alternate hypotheses must both be rejected in order to establish the truth of the null hypotheses. The alternate hypotheses will be examined.

5.3.1 H_{A1}

H_{A1} states: "Higher levels of stress, as indicated by psychosomatic responses of office workers in clinical trials, are experienced by office workers in better quality office environments, with better décor and better interior design, than by office workers in inferior quality office environments."

This statement is false. Lower levels of stress were experienced by office workers in better quality environments, than by office workers in poorer quality environments. The statistical mean $T_{max\_glucose}$ values by room prove this. The spread versus level plot in Figure 4.12 on page 131, and the three dimensional bar charts on pages 122, 123 and 129 illustrate this graphically. Thus H_{A1} cannot be true.

5.3.2 H_{A2}

H_{A2} states: "No difference in levels of stress, as indicated by psychosomatic responses of office workers in clinical trials, are experienced between office workers in better quality office environments, with better décor and better interior design, and office workers in inferior quality office environments."

This statement is also false. The room condition was proven to be highly significant in its effect on stress levels, with $F(6;15) = 6.620$ ($p=0.001$ at $\alpha = 0.05$), and therefore the room condition could not have resulted in no difference in stress level. Once again, the three dimensional bar charts on pages 122, 123 and 129 illustrate this graphically, as well as the spread versus level plot in Figure 4.12 on page 131. Post hoc tests, using Tukey's Honestly Significantly Different test and Scheffe's test, show the data contains two homogeneous subsets which relate directly to the room condition. Therefore differences in stress levels were found, and so the alternate hypothesis H_{A2} must be rejected.

Both alternate hypotheses have been rejected, which means the null hypothesis must be true. Nevertheless, the null hypothesis will be tested.

5.4 NULL HYPOTHESIS

The null hypothesis, H_{01} is: Lower levels of stress, as indicated by psychosomatic responses of office workers in clinical trials, are experienced by office workers in better quality office environments, with better décor and better interior design, than by office workers in inferior quality office environments.

This statement is supported by statistical analyses. The quality of the office environment was proven to be highly significant in its effect on stress levels, with $F(6;15) = 6.620$ ($p=0.001$ at $\alpha = 0.05$). Post hoc tests, using Tukey's Honestly Significantly Different test and Scheffe's test, show two homogeneous subsets related to the room condition. A principal component analysis extracted the room as the only component causing variance among $T_{max\_glucose}$ values. The spread versus level plot shows the mean stress is low for the superior quality room, and the mean stress is high for the inferior quality room.

5.5 CONCLUSION

Thus, through the rejection of the alternate hypotheses, which cover all alternatives, the null hypothesis is proved true. The statement of the null hypothesis also supported by the statistical analyses, although it is the rejection of the two alternate hypotheses which ultimately proves the null hypothesis to be the truth.

Chapter 6

FUTURE RESEARCH, IMPROVEMENTS AND LIMITATIONS

6.1 INTRODUCTION

Previously in the document, several comments and suggestions were made regarding future areas of research, and improvements to the methodology, should other researchers wish to perform similar tests. These are discussed in the following sections of this chapter.

6.2 LIMITATIONS OF THE PROJECT

At least two limitations are envisaged. These are the specific or relative value added by the investment for a knowledge worker and the period of the study.

6.2.1 Establishing a Relative Value of the Project

Attaching upper and lower bounds of relative values to the outcomes of the research is a limitation, for the following reasons. The current value an office worker brings to the company is often inestimable and could be highly variable (A McKay, 2006, pers. comm.) and so to attach a value, or relative portion of the current value, when the current contribution of an office worker to the margins is unknown, makes valuation of the added investment in the office difficult to quantify. Moreover, because décor is an art form and the value of art is subjective, it is the quality gained by the expenditure, and not the quantity of money spent, which produces results. The five star rating system and the guidelines provided by research into specific aspects (such as plants, and many other

aspects detailed in the literature review and in the chapter on the methodology), should assist when investing in décor. Nevertheless, the exact monetary value gained is not easy to quantify.

There are many financial models which attempt to attach a value to 'intangibles' such as marketing and investing in human capital. These intangibles often have associated costs in the short-term, with benefits reaped only in the long-term. Economic Value Added (EVA), as a planning concept, increases the horizon of financial planning by moving the thinking of companies away from short-term cost-cutting, towards consideration of immediate and continued investment for the longer-term. Cost-cutting, or lack of investment, may result in a temporary increase in margins but be detrimental to the value of the company in the long run. EVA underscores the need for a company to consider investment as opposed to cost-cutting in order to add value to a company. Investment in stress reduction mechanisms is vital if a company wants to increase its value, and become one of the top 100 companies for which to work. The benefits of investing in stress reduction are reaped through an increase in worker productivity, an improvement in the health of workers and an increase in worker satisfaction (and therefore staff retention), all of which add value to the company.

It is not the aim of this research project to quantify the value of an investment in the office environment, save only to prove there is some benefit. The aim of the research is to show improving the office environment yields a reduction in the stress levels of office workers, thereby adding value to the workers, which in turn adds value to the company.

6.2.2 Period of Testing

The period of the study is a second limitation. The short-term impacts on stress in the research project have been studied, but longer-term studies may provide a more accurate view of the long-term reduction of stress. The drawback of a longer-term study is in the difficulty associated with controlling the subjects' exposure to extraneous sources of stress, diet and other environment variables. Nevertheless, the benefits of stress reduction measures over a long period will result in better health of employees and an improved ability to cope with unforeseen stresses. The longer-term benefits should be greater than the short-term benefits implied by this study, and therefore the period of study is not a serious limitation. If anything, the long-term benefits have probably been understated.

6.3 FUTURE IMPROVEMENTS

The following areas for improvements or learning were noted during the course of the research, and will be useful to any researcher who wishes to undertake similar research.

6.3.1 Polycose (Glucose Polymer)

In its powder form, glucose polymer is not readily soluble at room temperature, as evidenced by the cloudy solution initially obtained. Heating the solvent assisted to dissolve the glucose polymer to a clear, thick, sticky liquid. This is advisable in future.

The solvent used was a carbonated diet Sprite (non-nutritively sweetened lemonade). The powder particles of the glucose polymer provided surfaces on which the carbon

dioxide bubbles coalesced, causing effervescence. It would be advisable to use a non-carbonated drink in future.

6.3.2 Blood Sampling

In order to reduce the time between sampling of blood from participants, it would be advisable to have many nurses on hand. Ideally one nurse should be used per participant, but the costs may prohibit this. At worst, one nurse should be used for every three participants.

Ideally the blood sampling frequency should be higher than one sample in 30 minutes between t = 0 and t = 60. The glucose concentrations appear to peak between 15 and 45 minutes. It would be advisable for seven samples to be taken at t = 0; t = 15; t = 30; t = 45; t = 60; t = 90 and t = 120 minutes.

The nature of this testing is different to the standard procedure used for a glucose tolerance test. The nurses were therefore initially unfamiliar with how to do repeated frequent testing. It would be advisable for the nurses to practice on a person who would not be participating in the tests. Ideally, practising on another nurse would provide good combined insight and experience.

The medical supplies required for unforeseen circumstances also contributed to delays in sampling. It would be advisable to have a clear procedure drawn up by the nurses, with ample medical supplies available in the same room as the testing (and not in a nearby clinic, when the timing of samples is crucial).

6.3.3 External Sources of Stress

The testing itself was an external source of stress. Although the use of a control group allowed data to be collected, which assisted in minimising the impact of the external source of stress on the data, the ideal situation would be to eliminate additional sources of stress. If the number of times the participants were pricked with a needle could be minimised, this would substantially assist in reducing the testing as a source of stress. The nurses tried using butterfly valves, but this was unsuccessful, because the blood clotted in the valves. Thought needs to be given as to how to solve the problem of stress caused by repeated jabs o the needle. (Chemical means, such as anaesthetisation, should preferably be avoided, as the impact of chemicals in the blood stream may introduce further sources of error.) Alternatively, use painless salivary tests methods indicated by Nakane (999), Kirschbaum, Wust & Hellhammer (1992) and Kirschbaum et al. (1995).

6.4 FUTURE RESEARCH

Previously in the document, several suggestions were made for future areas of research. These were borne out of observations during the testing and analysis phases. This chapter collates those proposals and questions for ease of reference.

6.4.1 Gender-based Research on the Effect of the Office Environment on Stress

Several gender-related observations have been made in the course of the research. With regard to men, the high proportion of male managers and recruitment of men into

managerial positions, especially in the manufacturing sector, was noted. Could the quality of the office environment be used as a tool to reduce the stress among managers?

It was also noted there was a low proportion of female participants.

- Are there differences in the perceived stress experienced by different genders, due to the quality of the office environment?
- Are the stress effects exacerbated in married women who have stressful jobs, with children? In other words, could the office environment be used as a tool to help reduce stress among married women?

The tests to measure salivary cortisol in men and women under stress (Kirschbaum, Wust & Hellhammer, 1992), referred to on page 57, may be useful. This would also eliminate the stress and time delays caused by blood sampling, since the saliva is painless to gather.

6.4.2 Ethnic-based Research on the Effect of the Office Environment on Stress

In the South African context where Employment Equity targets make it vital for companies to retain their good black employees, companies can ill-afford to lose these black employees. It was noted in the analysis from the table on page 125, there appears to be a higher level of stress experienced in black people due to the quality of the environment. This could relate to physiological differences, or, since decorating is an art-form, it could relate to the psychological (mental) stress due to their natural artistic inclinations. The disharmony of a poorly decorated room may have a greater impact on different ethnic groups. The data is limited, and therefore it would be advisable to investigate the effects with more participants.

6.4.3 The Impact of a Poor Quality Work Environment Where Physically Demanding Work Is Required

This research project only studied the impact on workers who remain predominantly sedentary during the course of the day. It was noted there appeared to be an increase in perceived physical discomfort in the room with inferior décor, during the blood sampling (as observed by the two participants who left Room 2, the inferior environment, on the first day). The effect of poor décor on stress and perceived discomfort is a possible area for further research in environments where physically demanding work is required.

6.4.4 Repeated Studies Using Other Methods and Longer Time-frames

Researchers who wish to repeat the tests, to study the psychosomatic effect of stress caused by the office environment quality, should consider the use of the salivary Chromogranin A tests (Nakane, 1999), or the salivary cortisol tests (Kirschbaum, Wust & Hellhammer, 1992, and Kirschbaum et al., 1995). The salivary tests would be painless and should therefore reduce the stress caused by the blood sampling test methods.

The response of high responders and low responders to stress (Kirschbaum et al., 1995) can also be tested over several days to check the response to the office environment quality longitudinally. Installing the participants in the office environments with their computers and telephones would be of assistance in studying the long-term effects of the stress caused by the office environment.

6.5 CONCLUSION

None of the above limitations and recommendations for improvement significantly affected the outcomes of the study. The effect of the office environment quality on the stress of the office workers was highly significant. This chapter was included, not only for a critical assessment of the project, but also in the hopes of smoothing the way for other researchers, and of providing ideas for future research.

Chapter 7

CONCLUSIONS, MODEL AND RECOMMENDATIONS

7.1 INTRODUCTION

The results of the study are significant and conclusive. After testing, collecting the data and statistically analysing them, causality was established which assisted in examining the hypotheses. The alternate hypotheses were rejected, leaving only the null hypothesis as true. The conclusions reached allow for the development of a model, both of which are presented below. Practical recommendations arising from these conclusions and the model are presented thereafter.

7.2 CONCLUSIONS

The office environment quality significantly affected the stress of participants, who were office workers. The comparative stress due to being in a poor quality office environment, with a star rating of between zero and one (versus being in a superior quality environment, with a star rating of approximately four) was

- more than the stress of being poked with a needle five times on two consecutive days to draw blood, and
- for one participant, roughly equivalent to (or only slightly smaller than) the additional stress due to a meeting with the boss, who is the managing director.

The stress response due to office quality was engendered by a difference in office quality of approximately four points in star rating.

Based on the findings of this study, a model relating the office environment quality to stress has been developed. This is presented below.

7.3 Model of Stress Response to the Office Environment Quality

Causality was established in chapter five, and as a result, the null hypothesis was established as being true. It can now be said the office environment quality causes a difference in levels of stress experienced. This statement facilitates the development of a model, which is presented below.

The development of a model depends on the ability to measure the independent and dependent variables, and the establishment of a causative relationship between these two variables.

- The stress response, as the dependent variable, can be measure via $T_{max\_glucose}$ (or by some other means, for example cortisol levels in saliva or Chromogranin A levels in saliva).
- The office environment quality, as the independent variable can be measured via a star rating system.
- The causative relationship between the office environment quality and stress has been established in chapter five.

These three points allow for the development of a model. The following model is proposed and represented graphically and textually below.

Model: The stress experienced due to the office environment quality is negatively correlated with the star rating of the office environment quality.

In other words, an increase in star rating results in a decrease in stress.

This is represented graphically.

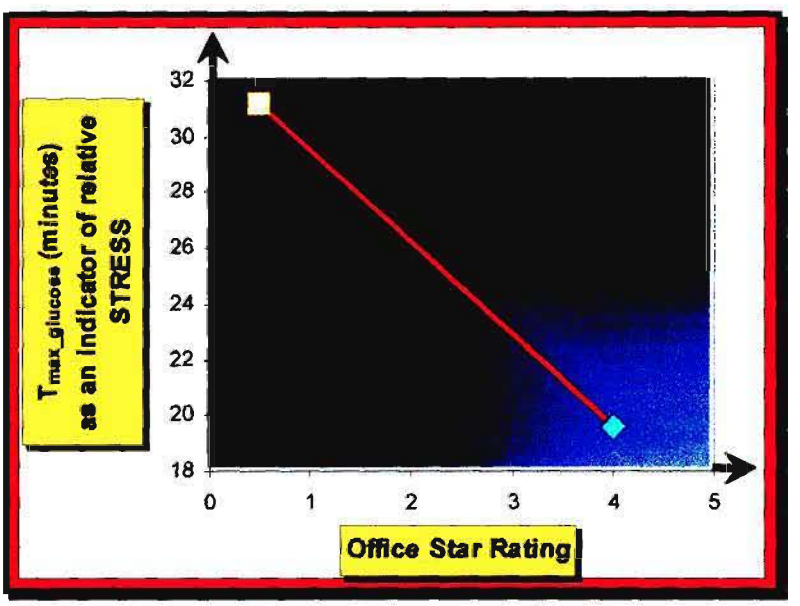


Figure 7.1 Model of the relationship between the stress experienced due to the office environment quality, and the office environment quality.

The numbers in the figure above are provided only for illustrative purposes to provide orders of magnitude, and are based on the results of the study. The graph is a plot of mean $T_{max\_glucose}$ values in different environments (as an indicator of the relative stress experienced) and the actual office star ratings in those environments. A low star rating causes high levels of stress, while a high star rating substantially reduces stress.

The model provides people with a tool for predicting the effects of office quality (and hence interior décor and interior design) on stress. The model can be used as part of an overall stress management program, in which the office environment quality can be used to significantly reduce stress. Based on the conclusions and model, the following recommendations are made.

7.4 RECOMMENDATIONS

This study has proved, through involuntary psychosomatic responses, the office environment quality affects the stress of participants. Moreover, stress has psychosomatic impacts, affecting the health of workers. Therefore the office quality affects the health of the worker. Based on these studies and the results of this research project, the following suggestions are recommended, especially to companies in the manufacturing sector, to increase company value. The recommendations have been segregated into three strategies, namely corporate, financial and people strategies.

Corporate strategy:

Compare the office environments of the top 100 companies for which to work, in order to decide whether the office environments should be upgraded. (It would be of little value to ask workers whether the office environment would decrease stress and increase retention and morale, since it would appear the office environment quality is an unrecognised source of stress.)

Decide on what star rating the company would like to target for performance in the business world, and apply this star rating internally in a consistent manner across the company, including internal service levels and indoor environment quality. In the opinion

of the author, the office environment quality sets the tone for all interactions within and with the company.

Create a separate department dedicated to employee wellness, who reports directly to the managing director or the chief executive officer of the company. For this department, consider employing one or more wellness contractors, or even permanent employees, whose sole function it is to look after the well-being of employees through office environment quality, and musculoskeletal and ergonomic functions. At the very least, an interior decorator and a chiropractor (or physiotherapist) should be in the employ of the company, consulting on a regular basis with employees. For smaller companies, this can be outsourced.

Financial strategy:

Use EVA principles: the economic value added principle is based on long-term wealth of the company. Cost cutting drives may reap immediate improvements in margins, but destroy value in the long term. Intangible assets frequently do not reap benefits at the time of expenditure, but only reap benefits at some point in the future. The EVA principle should be applied to the office environment, as part of an investment in human capital for the long-term wealth of the company.

Move the budget for employee wellness and office décor and design (which includes all office furniture, maintenance, plants and office cleaning) away from the finance department to a separate wellness department, where cost cutting drives cannot affect decisions except at a senior or board level.

Realistic budgets should be set. Consultation with people specifically trained in décor, ergonomics and musculoskeletal functions will be the most appropriate people to assist in forming appropriate budgets.

People strategy:

At the recruitment stage, only applicants with the apparent service levels and calibre of the targeted company star rating should be employed.

Employees' appraisals should be linked to the measurement of office environment quality and service levels. This measurement should be compared with the targeted star rating. Employees have a dual role of being both service providers and internal customers. A four or five star rating environment requires the treatment and service level of a four of five star establishment from each employee towards each other. In the opinion of the author, the star rating forms the basis for measuring the corporate culture, and for this reason it is important to link this to appraisals.

In terms of training, the star rating system includes not only physical décor, but also services. All service providers and company employees should be trained to treat each other with the level of service expected of the targeted star rating.

Use the model developed as a tool in a stress reduction program. Other factors may contribute to stress, but reducing one known source of stress has huge effects, because the effects of stress are compounded rather than linear. The effects of stress caused by office environment quality were significant in size when compared to being pricked with a needle five times on two days and a meeting with the boss.

Food forms part of the office environment as a chemical intake, and can dramatically affect the performance and stress of workers. Consider the provision of three to four star meals in consultation with a dietician, if the target is a three to four star establishment. (If the target is a five star establishment, then provide five star meals. Be consistent.) Individual circadian rhythms and dietary requirements should be considered, for optimal worker

performance and longevity. The catering company should be under the direction of the dietician, who should report to the employee wellness department.

In terms of employee retention, a good quality environment is essential. A high star rating means service levels and working environments are of a good quality, resulting in low levels of stress and a better corporate culture. All strategies should be aligned for improved retention and performance. Employees are like guests who need to be encouraged to stay.

In summary, targeting an overall office star rating and modifying the corporate structure to achieve this target is recommended. The financial EVA approach to workers, as human capital requiring investment, is also advocated with professional advice required for the relevant budgets. Practical suggestions using the office environment and star rating system to lower the stress of workers, and simultaneously improve corporate culture, were made.

7.5 Final Closing Words

Remuneration packages can only increase so far in a country before the limit is reached and other factors need to step in to engender employee satisfaction. Companies who do not invest in the office environment, effortlessly and vigorously reinforce the daily visual message proclaiming they have little interest in investing in the working conditions or long-term welfare of their workers. Becoming one of the top 100 companies for which to work takes effort and care. Companies should target a star rating, and then apply this consistently in every way possible, from the physical environment to the service levels. Employees will only behave on a four of five star level if they are given the all-round four of five star treatment. "As ye sow, so shall ye reap."

Appendix 1

EMPLOYED MANAGERS AND RECRUITMENT INTO MANAGEMENT BY GENDER IN SOUTH AFRICA 2000

The unmanly stigma attached to décor, and the high proportion of male managers, may explain why office décor and environment quality has typically not received specific focus.

Table A1. 1 Management Gender Trends in South Africa, 2000

	Employed Managers		Recruitment into Management	
	Male%	Female%	Male%	Female%
Accounting and other financial services	72.2	27.8	59.1	40.9
Banking	71.8	28.2	67.4	32.6
Chemical and allied industries	76.8	23.2	74.5	25.5
Clothing, textiles, leather and footwear	73.0	27.0		
Construction	91.4	8.6	100.0	0.0
Defense	92.8	7.2		
Education, training and development practices	47.2	52.8	62.8	37.1
Energy	88.2	11.8		
Food	83.1	16.9	76.7	23.4
Forestry, furniture, pulp and paper, board , wood products	90.0	10.0	82.9	17.2
Health and welfare	13.6	86.4		
Information systems, electronics and telecommunications technology	77.1	22.9	87.8	12.1
Insurance	72.4	27.6	62.4	37.6
Local government, water and related services	69.5	30.5	65.1	34.8
Media, publishing, printing and packaging	66.6	33.4	56.3	43.9
Metal, plastics, motor retail, auto manufacture, tyres	88.6	11.4	54.4	45.5
Mining and minerals	93.3	6.7	87.2	12.7
Police, justice, security and correctional services	80.5	19.5		
Primary agriculture	79.5	20.5	90.0	10.0
Public sector	31.8	68.2		
Secondary agriculture	89.4	10.6	80.0	20.0
Services	67.3	32.7		
Tourism and hospitality	62.9	37.1	74.1	25.9
Transport	79.4	20.6	66.7	33.3
Wholesale and retail	72.7	27.3	62.5	37.6

Source: adapted from Horowitz, F.M. & Bowmaker-Falconer, A. (2003) *HRD review 2003 - human resource development review: managers*. South Africa, HSRC.

The table above illustrates the predominance of male managers in South Africa in 2000. Continued high levels of recruitment of males into managerial positions indicate the trend is stable.

Appendix 2

FIFTH ORDER POLYNOMIALS OF RAW DATA

Table A2. 1 Fifth Order Polynomials of Raw Data

Participant	Room	Day	Fifth Order Polynomials (Concentration Profiles) y = glucose concentration in plasma (mmol/L); x = time (minutes)
1	1	1	$y = 0.000000002438339138 62x^5 - 0.000001058701061533 44x^4 + 0.000166023974063068 00x^3 - 0.010973356636583300 00x^2 + 0.239557907192875000 00x + 5.307729712924070000 00$
2	1	1	$y = 0.000000002709354922 29x^5 - 0.000001171597118973 09x^4 + 0.000182584916628536 00x^3 - 0.011958874440100700 00x^2 + 0.259969037767860000 00x + 4.605712663901500000 00$
3	1	1	$y = 0.000000002868290671 03x^5 - 0.000001274930184111 92x^4 + 0.000207008653835272 00x^3 - 0.014428955775411400 00x^2 + 0.353928048192415000 00x + 4.200975561831510000 00$
4	1	1	$y = 0.000000002780028893 65x^5 - 0.000001216601227431 19x^4 + 0.000193137964848406 00x^3 - 0.012971610230401600 00x^2 + 0.286971481849520000 00x + 4.367775743233610000 00$
5	1	1	$y = 0.000000002948023286 94x^5 - 0.000001271426793720 76x^4 + 0.000200269150425259 00x^3 - 0.013628860146198500 00x^2 + 0.331555985035266000 00x + 5.118502912939110000 00$
6	1	1	$y = 0.000010296616963283 50x^3 - 0.002986179252845890 00x^2 + 0.216219095719088000 00x + 5.700000000000270000 00$
7	1	1	$y = 0.000000002737011835 80x^5 - 0.000001194158737790 42x^4 + 0.000188893633806864 00x^3 - 0.012592898841878900 00x^2 + 0.265958207235400000 00x + 4.705736557459030000 00$
8	1	1	$y = 0.000000002393569534 62x^5 - 0.000001038321414557 38x^4 + 0.000163857021505953 00x^3 - 0.010989336098550200 00x^2 + 0.238909281621034000 00x + 6.384513045098170000 00$
11	2	1	$y = -0.000000119206588030 95x^4 + 0.000045830783360539 80x^3 - 0.005856402681015280 00x^2 + 0.246933387510524000 00x + 5.099999999975960000 00$
12	2	1	$y = 0.000000000571774245 49x^5 - 0.000000311652018081 25x^4 + 0.000063736508662093 30x^3 - 0.006069897356571370 00x^2 + 0.215444674503374000 00x + 5.399999999794070000 00$
13	2	1	$y = 0.000000000725187556 95x^5 - 0.000000288879654388 16x^4 + 0.000047107456182471 40x^3 - 0.004373509963727430 00x^2 + 0.186588561589815000 00x + 5.325521611495840000 00$
15	2	1	$y = 0.000000001807419351 55x^5 - 0.000000890209206104 62x^4 + 0.000160433095185653 00x^3 - 0.012875285404362600 00x^2 + 0.405664859529452000 00x + 5.300000000780050000 00$
5	1	2	$y = 0.000000000360854152 67x^5 - 0.000000302623572256 97x^4 + 0.000079849694665346 00x^3 - 0.008463947576579760 00x^2 + 0.302711863085051000 00x + 4.898389598884880000 00$

Participant	Room	Day	Fifth Order Polynomials (Concentration Profiles) y = glucose concentration in plasma (mmol/L); x = time (minutes)
8	1	2	$y = 0.000000000309955782 84x^5 - 0.000000204101274236 57x^4 + 0.000047381257282319 60x^3 - 0.004669236624245340 00x^2 + 0.166171760316274000 00x + 5.999392711426940000 00$
11	1	2	$y = 0.000000001310220174 39x^5 - 0.000000609237115626 12x^4 + 0.000103233381166801 00x^3 - 0.007461594243270750 00x^2 + 0.181797369712456000 00x + 5.103438004220830000 00$
12	1	2	$y = 0.000000000959396009 95x^5 - 0.000000440225262428 49x^4 + 0.000076300075123492 10x^3 - 0.006164641920086920 00x^2 + 0.212639883169231000 00x + 5.103569858147640000 00$
13	1	2	$y = 0.000000000869928547 30x^5 - 0.000000455600030483 53x^4 + 0.000089733782930645 50x^3 - 0.007916382314625990 00x^2 + 0.269718056496231000 00x + 5.200211707915000000 00$
15	1	2	$y = 0.000000003583070663 39x^5 - 0.000001665275634224 37x^4 + 0.000286730098340460 00x^3 - 0.021777099599091800 00x^2 + 0.631154010222417000 00x + 5.101764675065740000 00$
1	2	2	$y = 0.000000002084198015 35x^5 - 0.000001050410209337 69x^4 + 0.000196575316242953 00x^3 - 0.016082692577001000 00x^2 + 0.468865101438837000 00x + 5.600167820717500000 00$
2	2	2	$y = -0.000000000164302252 36x^5 + 0.000000005638330941 03x^4 + 0.000017553300349249 00x^3 - 0.003425141845582400 00x^2 + 0.180968186126847000 00x + 4.799999777011620000 00$
3	2	2	$y = -0.000000000138742420 38x^5 - 0.000000008039510002 17x^4 + 0.000020076919639677 70x^3 - 0.003577403698500350 00x^2 + 0.176249059713882000 00x + 4.399999623066360000 00$
4	2	2	$y = -0.000000000428483766 16x^5 + 0.000000017303393984 14x^4 + 0.000035364834431228 50x^3 - 0.006063015712072680 00x^2 + 0.252495267781569000 00x + 4.592040115159250000 00$
6	2	2	$y = 0.000011513227513227 30x^3 - 0.003425608465608470 00x^2 + 0.261949206349200000 00x + 5.400000000000350000 00$
7	2	2	$y = -0.000000001087761539 68x^5 + 0.000005339522390099 1x^4 - 0.000086487561458681 30x^3 + 0.004735450014528910 00x^2 - 0.027857065325747500 00x + 4.322907750188510000 00$

Appendix 3

POST HOC TESTS, MULTIPLE COMPARISONS

Table A3. 1 Post hoc tests, multiple comparisons, for adjusted $T_{max\_glucose}$

Dependent Variable		(I) Room D	(J) Room D	Mean Difference (I-	Std. Error	Sig.	95% Confidence Interval	
							Lower	Upper
$T_{max\_glucose}$	Tukey HSD	11	12	2.2977	1.86897	0.609	-2.5489	7.1443
			21	-10.6825*	2.11922	0.000	-16.1780	-5.1870
			22	-10.5395*	1.86897	0.000	-15.3861	-5.6929
		12	11	-2.2977	1.86897	0.609	-7.1443	2.5489
			21	-12.9802*	2.23385	0.000	-18.7730	-7.1874
			22	-12.8372*	1.99802	0.000	-18.0185	-7.6560
		21	11	10.6825*	2.11922	0.000	5.1870	16.1780
			12	12.9802*	2.23385	0.000	7.1874	18.7730
			22	0.1430	2.23385	1.000	-5.6498	5.9358
		22	11	10.5395*	1.86897	0.000	5.6929	15.3861
			12	12.8372*	1.99802	0.000	7.6560	18.0185
			21	-0.1430	2.23385	1.000	-5.9358	5.6498
	Scheffe	11	12	2.2977	1.86897	0.680	-2.9767	7.5722
			21	-10.6825*	2.11922	0.000	-16.6632	-4.7018
			22	-10.5395*	1.86897	0.000	-15.8140	-5.2650
		12	11	-2.2977	1.86897	0.680	-7.5722	2.9767
			21	-12.9802*	2.23385	0.000	-19.2844	-6.6760
			22	-12.8372*	1.99802	0.000	-18.4759	-7.1986
		21	11	10.6825*	2.11922	0.000	4.7018	16.6632
			12	12.9802*	2.23385	0.000	6.6760	19.2844
			22	.1430	2.23385	1.000	-6.1612	6.4472
		22	11	10.5395*	1.86897	0.000	5.2650	15.8140
			12	12.8372*	1.99802	0.000	7.1986	18.4759
			21	-0.1430	2.23385	1.000	-6.4472	6.1612
	Bonferroni	11	12	2.2977	1.86897	1.000	-2.6882	7.2837
			21	-10.6825*	2.11922	0.000	-16.3360	-5.0290
			22	-10.5395*	1.86897	0.000	-15.5254	-5.5536
		12	11	-2.2977	1.86897	1.000	-7.2837	2.6882
			21	-12.9802*	2.23385	0.000	-18.9395	-7.0209
			22	-12.8372*	1.99802	0.000	-18.1674	-7.5071
		21	11	10.6825*	2.11922	0.000	5.0290	16.3360
			12	12.9802*	2.23385	0.000	7.0209	18.9395
			22	0.1430	2.23385	1.000	-5.8163	6.1023
		22	11	10.5395*	1.86897	0.000	5.5536	15.5254
			12	12.8372*	1.99802	0.000	7.5071	18.1674
			21	-.1430	2.23385	1.000	-6.1023	5.8163
	Sidak	11	12	2.2977	1.86897	0.776	-2.6743	7.2697
			21	-10.6825*	2.11922	0.000	-16.3202	-5.0448
			22	-10.5395*	1.86897	0.000	-15.5115	-5.5675
		12	11	-2.2977	1.86897	0.776	-7.2697	2.6743
			21	-12.9802*	2.23385	0.000	-18.9229	-7.0376
			22	-12.8372*	1.99802	0.000	-18.1525	-7.5219
		21	11	10.6825*	2.11922	0.000	5.0448	16.3202
			12	12.9802*	2.23385	0.000	7.0376	18.9229
			22	0.1430	2.23385	1.000	-5.7997	6.0857
		22	11	10.5395*	1.86897	0.000	5.5675	15.5115
			12	12.8372*	1.99802	0.000	7.5219	18.1525
			21	-.1430	2.23385	1.000	-6.0857	5.7997

Based on observed means.

* The mean difference is significant at the .05 level.

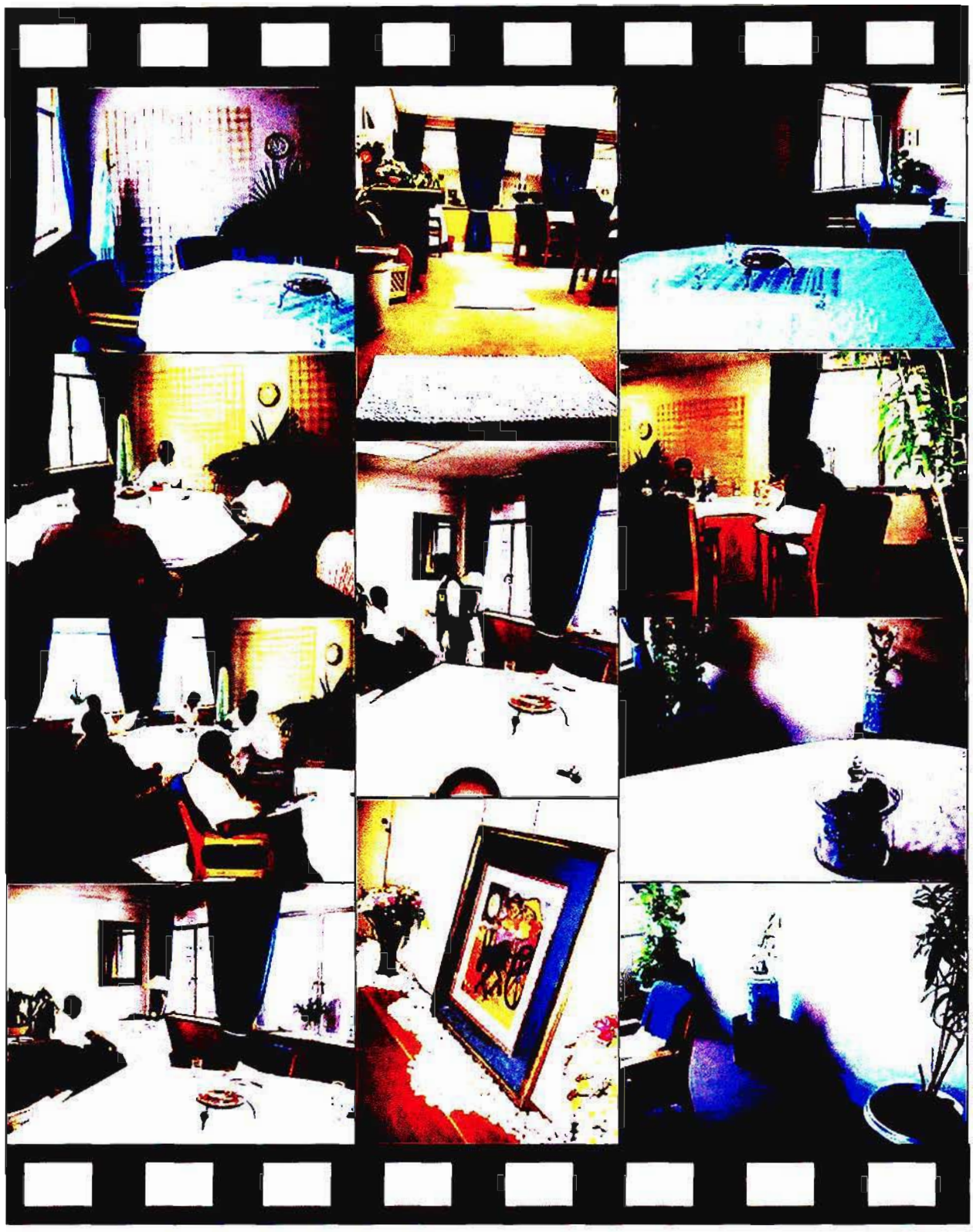
Appendix 4

COLOUR PLATES

Plate 1: Room 1

Plate 2: Room 2

Room 1



Room 2

Appendix 5

PERMISSION TO CONDUCT RESEARCH

-----Original Message-----

From: Govender, Siva (Technology)

Sent: 04 November 2005 11:16

To: Kruger, Melanie

Subject: RE: Ethical clearance for MBA dissertation

Melanie

Confirm that I will have no objection to you carrying out this study.

Here is my challenge, please think through how do you expect SAPREF will benefit from this study and ensure that you close the loop.

Good luck!

Siva

Appendix 6

ETHICAL CLEARANCE

UNIVERSITY OF
KWAZULU-NATAL

RESEARCH OFFICE (GOVAN MBEKI CENTRE)
WESTVILLE CAMPUS
TELEPHONE NO.: 031 - 2603587
EMAIL: xmbap@ukzn.ac.za

03 NOVEMBER 2006

MS. MC KRUGER (9313713 42)
GRADUATE SCHOOL OF BUSINESS

Dear Ms. Kruger

ETHICAL CLEARANCE APPROVAL NUMBER: HSS/0360/06

I am pleased to confirm that ethical clearance has been granted for the following project:

"The art of measuring a Science: Investigating psychosomatic responses of Office Workers to changes in office environment quality"

PLEASE NOTE: The research data should be stored in the School for a period of 5 years.

Yours faithfully

MS. PHUMELELE XIMBA
RESEARCH OFFICE

cc: Faculty Officer (Graduate Studies)
cc: Supervisor (Ms. Vezelis)

Appendix 7

CONCEPT MATRIX (FOR BIBLIOGRAPHY)

Table A1. 2 Concept Matrix (with acknowledgement to Prof. Rembrandt Klopper and Prof. Sam Lubbe for the concept matrix idea)

Concepts / References (with additional notes where necessary)	Office Quality (Independent Variable)									Home Quality		Office Worker State of Being (Dependent Variables)					Tests and Measurements		Management Policies for Office Quality			Diss-ert-ation
	Lighting	Change	Temperature	Ventilation	Indoor Air Quality (GAS CHEMICAL INTAKE)	Food and Neurotransmitters (LIQUID AND SOLID CHEMICAL INTAKE)	Plants (HUMAN ISSUES IN HORTICULTURE)	Views	Green Buildings	Living Standards Measures	Five Star Rating	Morale	Health and medical	Stress	Productivity	Sick Building Syndrome	Tests	Measurements	Economic Value Added and Cost-Benefit Ratio (FINANCIAL MANAGEMENT)	Remuneration	Corporate Management Aspects	Dissertation
Aeris Technologies (Indoor Air quality)					✓																	
April, E.W., (Anatomy)													✓									
Automobile Association Developments Limited											✓											
Automobile Association, Royal Automobile Club, VisitBritain, VisitScotland & Wales Tourist Board											✓											
Bachen, Muldoon, Matthews & Manuck														✓			✓	✓				
Brosschot, Benschop, Godaert, De														✓			✓	✓				

Concepts / References (with additional notes where necessary)	Office Quality (Independent Variable)									Home Quality		Office Worker State of Being (Dependent Variables)					Tests and Measurements		Management Policies for Office Quality			Diss-ert-ation
	Lighting	Change	Temperature	Ventilation	Indoor Air Quality (Gas Chemical Intake)	Food and Neurotransmitters (Liquid and Solid Chemical Intake)	Plants (Human Issues in Horticulture)	Views	Green Buildings	Living Standards Measures	Five Star Rating	Morale	Health and medical	Stress	Productivity	Sick Building Syndrome	Tests	Measurements	Economic Value Added and Cost-Benefit Ratio (Financial Management)	Remuneration	Corporate Management Aspects	Dissertation
Smet, Olff, Heijnen & Ballieux																						
Bureau for Economic Research										✓												
Cause of (Serotonin Irritation Syndrome)				✓	✓																	
Christie						✓																
Collins (definitions)												✓	✓	✓								
Croxton Collaborative Architects	✓		✓	✓					✓													
Dean, James& English						✓																
Department of Health and Human Services & National Institutes of Health (size of trials)																	✓					
Erdmann & Apte					✓								✓									
Farley& Veitch								✓														
FUSE (lighting wavelength)	✓																					
Goetzel, Ozminkowski, Sederer & Mark																			✓		✓	
Guillemette J., Hebert M., Paquet J. & Dumont M. (depression and natural light)	✓											✓										

Concepts / References (with additional notes where necessary)	Office Quality (Independent Variable)									Home Quality		Office Worker State of Being (Dependent Variables)					Tests and Measurements		Management Policies for Office Quality			Diss-ert-ation
	Lighting	Change	Temperature	Ventilation	Indoor Air Quality (GAS CHEMICAL INTAKE)	Food and Neurotransmitters (LIQUID AND SOLID CHEMICAL INTAKE)	Plants (HUMAN ISSUES IN HORTICULTURE)	Views	Green Buildings	Living Standards Measures	Five Star Rating	Morale	Health and medical	Stress	Productivity	Sick Building Syndrome	Tests	Measurements	Economic Value Added and Cost-Benefit Ratio (FINANCIAL MANAGEMENT)	Remuneration	Corporate Management Aspects	Dissertation
Herbert, Cohen, Marsland, Bachen, Rabin, Muldoon & Manuck (Psychosomatic response to acute stressor, heart rate and blood pressure)														✓			✓	✓				
Heschong Mahone Group (a)	✓			✓				✓														
Heschong Mahone Group (b)	✓			✓				✓														
Horowitz & Bowmaker-Falconer (male manager prevalence)																					✓	
Indoor Air 2002					✓																	
Kaplan & Kaplan								✓														
Kats									✓													
Kirschbaum, Prussner, Stone, Federenko, Gaab, Lintz, Schommer & Hellhammer														✓			✓	✓				
Kirschbaum, Wust & Hellhammer														✓			✓	✓				
Knuckey, Leung-Wai & Meskill (Investment in Human Capital)																					✓	
Larson, Ader & Moynihan (Psychosomatic response to acute stressor, heart rate and blood pressure)														✓			✓	✓				
Lewis (Ions)					✓																	
Lohr & Pearson-Mims							✓										✓					

Concepts / References (with additional notes where necessary)	Office Quality (Independent Variable)									Home Quality		Office Worker State of Being (Dependent Variables)					Tests and Measurements		Management Policies for Office Quality			Diss-ert-ation
	Lighting	Change	Temperature	Ventilation	Indoor Air Quality (Gas Chemical Intake)	Food and Neurotransmitters (Liquid and Solid Chemical Intake)	Plants (Human Issues in Horticulture)	Views	Green Buildings	Living Standards Measures	Five Star Rating	Morale	Health and medical	Stress	Productivity	Sick Building Syndrome	Tests	Measurements	Economic Value Added and Cost-Benefit Ratio (Financial Management)	Remuneration	Corporate Management Aspects	Dissertation
Marucha, Kiecolt-Glaser &Favagehi														✓			✓	✓				
Mosby													✓	✓								
Nakane,														✓			✓	✓				
Noe, Hollenbeck, Gerhart & Wright		✓																				
Patterson, Gottdiener, Hecht, Vargot & Krantz														✓			✓	✓				
Pike, Smith, Hauger, Nicassio, Patterson, McClintick, Costlow & Irwin														✓			✓	✓				
SAPREF HSE/BE Department					✓																	
Seppannen, Fisk, Faulkner			✓																			
Statistics South Africa																					✓	
Stowe (Morale, classical agency model)												✓								✓		
Sustainable Building Task Force					✓				✓													
The Back Shop																			✓			
Thompson, Strickland		✓																			✓	
UC Pancreatic Disease Centre (definition)													✓									
Vasselli					✓																	

Concepts / References (with additional notes where necessary)	Office Quality (Independent Variable)									Home Quality		Office Worker State of Being (Dependent Variables)					Tests and Measurements		Management Policies for Office Quality			Diss-ert-ation
	Lighting	Change	Temperature	Ventilation	Indoor Air Quality (GAS CHEMICAL INTAKE)	Food and Neurotransmitters (LIQUID AND SOLID CHEMICAL INTAKE)	Plants (HUMAN ISSUES IN HORTICULTURE)	Views	Green Buildings	Living Standards Measures	Five Star Rating	Morale	Health and medical	Stress	Productivity	Sick Building Syndrome	Tests	Measurements	Economic Value Added and Cost-Benefit Ratio (FINANCIAL MANAGEMENT)	Remuneration	Corporate Management Aspects	Dissertation
Vrijkotte, van Doornen & de Geus														✓			✓	✓				
Wallach (Serotonin Irritation Syndrome)				✓	✓																	
Williams																			✓		✓	
Wing, Epstein, Blair & Nowalk (Psychosomatic response to acute stressor using polycose)														✓			✓	✓				

BIBLIOGRAPHY

Automobile Association Developments Limited (2006) *Quality standards for AA guest accommodation – HSP25.* Hampshire, RG21 4EA, Automobile Association Developments Limited.

Automobile Association, Royal Automobile Club, VisitBritain, VisitScotland & Wales Tourist Board (2005) *Common standards for guest accommodation - P113/05.* Wales, Automobile Association, Royal Automobile Club, VisitBritain, VisitScotland & Wales Tourist Board.

Bachen, E.A., Muldoon, M.F., Matthews, K.A. & Manuck, S.B. (2002) Effects of hemoconcentration and sympathetic activation on serum lipid responses to brief mental stress. *Psychosomatic Medicine,* 64, pp.587-594.

Brosschot, J.F., Benschop, R.J., Godaert, G.L.R., de Smet, M.B.M., Olff, M., Heijnen, C.J. & Ballieux, R.E. (1992) Effects of experimental psychological stress on distribution and function of peripheral blood cells. *Psychosomatic Medicine*, 54 (4), pp.394-406.

Bureau for Economic Research (2002) *Retail trade first quarter 2002.* Stellenbosch, Bureau for Economic Research.

Collins' English Dictionary. (2003) 6th ed. Glasgow, HarperCollins Publishers Limited.

Cooper, D.R. & Schindler, P.S. (2003) *Business research methods.* 8th ed. New York, U.S.A., McGraw-Hill Higher Education.

Croxton Collaborative Architects (2005) *Sustainable design guidelines reference manual, World Trade Centre redevelopment projects - personal control - IEQ-10.* New York, Croxton Collaborative Architects.

Department of Health and Human Services & National Institutes of Health (2005) *RFA-AI-05-002: Units for HIV/AIDS Clinical Trials Networks*. Maryland, Department of Health and Human Services and National Institutes of Health

Erdmann, C.A. & Apte, M.G. (2004) Mucous membrane and lower respiratory building related symptoms in relation to indoor carbon dioxide concentrations in the 100-building BASE dataset. *Indoor Air*, 14 (8), pp.127-134.

Farley, K.M.J. & Veitch, J.A. (2001) *a room with a view: a review of the effects of windows on work and well-being – IRC-RR-136*. Canada, National Research Council Canada - Institute for Research in Construction.

Goetzel, R.Z., Ozminkowski, R.J., Sederer, L.I. & Mark, T.L. (2002) The business case for quality mental health services: why employers should care about the mental health and well-being of their employees. *Journal of Occupational & Environmental Medicine* [Internet], April 2002, 44 (4) pp.320-330.

Guillemette, J., Hebert, M., Paquet, J. & Dumont, M. (1998) Natural bright light exposure in the summer and winter in subjects with and without complaints of seasonal mood variations - A clinical perspective. *Biological Psychiatry*, 44 (7), pp.622-628.

Herbert, T.B., Cohen S., Marsland, A.L., Bachen, E.A., Rabin, B.S., Muldoon, M.F. & Manuck, S.B. (1994) Cardiovascular reactivity and the course of immune response to an acute psychological stressor. *Psychosomatic Medicine*, 56, pp.337-344.

Heschong Mahone Group (2003a) *Windows and classrooms: a study of student performance and the indoor environment - P500-03-082-A-7*. California. California Energy Commission.

Heschong Mahone Group (2003b) *Windows and offices: a study of office worker performance and the indoor environment - P500-03-082-A-9*. California, California Energy Commission.

Horowitz, F.M. & Bowmaker-Falconer, A. (2003) *HRD review 2003 - human resource development review: managers*. South Africa, HSRC.

International Conference on Indoor Air Quality and Climate, 9. 2002. Monterey, California, (2002). *Proceedings from Indoor Air 2002*, Indoor Air. Santa Cruz, California, Indoor Air.

Kaplan, S. & Kaplan, R. (2003) Health, Supportive environments, and the reasonable person model. *American Journal of Public Health*, 93 (9), pp.1484-1489.

Kats, G.H. (2003) *Green building costs and financial benefits*. United States of America, Massachusetts Technology Collaborative.

Kirschbaum, C., Prussner, J.C., Stone, A.A., Federenko, L., Gaab, J., Lintz, D., Schommer, N. & Hellhammer, D.H. (1995) Persistent high cortisol responses to repeated psychological stress in a subpopulation of healthy men. *Psychosomatic Medicine*, 57 (5), pp.468-474.

Kirschbaum, C., Wust, W. & Hellhammer, D. (1992) Consistent sex differences in cortisol responses to psychological stress. *Psychosomatic Medicine*, 54 (6), pp.648-657.

Knuckey, S., Leung-Wai, J. & Meskill, M. (1999) *Gearing up. A study of best manufacturing practice in New Zealand. Firm capability team.* New Zealand, Ministry of Commerce.

Larson, M.R., Ader, R. & Moynihan, J.A. (2001) Heart Rate, neuroendocrine and immunological reactivity in response to an acute laboratory stressor. *Psychosomatic Medicine*, 63, pp.493-501.

Lohr, V.I., Pearson-Mims, C.H. & Goodwin, G.K. (1996) Interior plants may improve worker productivity and reduce stress in a windowless environment. *Journal of Environmental Horticulture* 14 (2), pp.97-100.

Marucha, P.T., Kiecolt-Glaser, J.K. & Favagehi, M. (1998) Mucosal wound healing is

impaired by examination stress. *Psychosomatic Medicine*, 60 (3), pp. 362-365.

Mosby's Dictionary: Medical, Nursing and Allied Health. (1990) 3rd Ed. St. Louis, Missouri, The C.V. Mosby Company.

Nakane, H. (1999) Salivary Chromogranin A as Index of Psychosomatic Stress Response. *Biotechnological Studies for Environmental Applications and Human Monitoring* (in Japanese), 34 (3).

(Original article in Japanese, with only the abstract available in English.) <http://www.tytlabs.co.jp/english/review/rev343epdf/e343ab_nakane.html> [Accessed December 2006]

Noe, R.A., Hollenbeck, J.R., Gerhart, B. & Wright, P.M. (2000) *Human resource management: gaining a competitive advantage*. 3rd ed. U.S.A., McGraw-Hill Higher Education.

Patterson, S.M., Gottdiener, J.S, Hecht, G., Vargot, S. & Krantz, D.S. (1993) Effects of acute mental stress on serum lipids: mediating effects of plasma volume. *Psychosomatic Medicine*, 55 (6), pp.525-532.

Pike, J.L., Smith, T.L., Hauger, R.L., Nicassio, P.M., Patterson, T.L., McClintick, J., Costlow, C. & Irwin, M.R. (1997) Chronic life stress alters sympathetic, neuroendocrine, and immune responsivity to an acute psychological stressor in humans. *Psychosomatic Medicine*, 59 (4), pp.447-457.

Seppänen O., Fisk W.J. & Faulkner D. (2004) *Control of temperature for health and productivity in offices, LBNL-55448*. Berkely, California, Lawrence Berkely National Laboratory.

Statistics South Africa (2005) *Statistical Release P5001*. South Africa, Statistics South Africa.

Stowe, J. (2006) Incorporating morale into a classical agency model: incentives, effort and

organisation. M.B.A. thesis, Duke University.

Sustainable Building Task Force and the State & Consumer Services Agency (2003) *Building better buildings: an update on state sustainable building initiatives.* California, Sustainable Building Task Force and the State & Consumer Services Agency.

Thompson, A.A. & Strickland, A.J. (2003) *Strategic management: concepts and cases.* 13th ed. New York, U.S.A., McGraw-Hill Irwin.

Vaselli, J.J. (2005) Indoor air quality and human health risk: need for more research and analysis. In: *Upstate New York Society for Risk Analysis Symposium, June 2005. New York*, New York, New York Indoor Environmental Quality Centre, pp.1-29.

Vrijkotte, T.G.M., van Doornen, L.J.P. & de Geus, E.J.C. (1999) Work stress and metabolic and hemostatic risk factors. *Psychosomatic Medicine,* 61, pp.796-805.

Wallach, C. (1986) *IBEF bulletin vol. 6(2) - The effects of air quality on the serotonin irritation syndrome.* United States of America, International Bio-Environmental Foundation.

Williams, F. L., Haldeman, V. & Cramer, S. (1996) Financial concerns and productivity - financial counseling and planning. *Financial Counseling and Planning*, 7, pp.147-155.

Wing, R.R., Epstein, L.H., Blair, E. & Nowalk, M.P. (1985) Psychologic stress and blood glucose levels in nondiabetic subjects. *Psychosomatic Medicine*, 47 (6), pp.558-564.

Internet:

ABSA (2006) *FAQ > Personal > Loans > Home loans > Qualifying criteria and applications* [Internet], South Africa, ABSA Bank Limited. Available from: <http://www.absa.co.za/absacoza/content.jsp?VGN_C_ID=cb5dab4dc3eab010VgnVC

M1000003511060aRCRD&VGN_CI_ID=bd21ab4dc3eab010VgnVCM1000003511060aRCRD> [Accessed December 2006].

Aeris Technologies (n.d.) *FAQ* [Internet], Rosebery NSW 2018, Australia, Aeris Technologies. Available from: <http://www.aeris.com.au/faqs_cons.html#c01> [Accessed 15 August 2005].

Cause of (n.d.) *Cause of Serotonin irritation syndrome* [Internet]. Available from: <http://www.causeof.org/sis.htm> [Accessed 15 December 2006].

Christie, C. (n.d.) *Nutrition and well-being A-Z - Mood-food relationships* [Internet], United States of America, Thomson Gale (part of the Thomson Corporation). Available from: <http://www.faqs.org/nutrition/Met-Obe/Mood-Food-Relationships.html> [Accessed June 2006].

ChangingMinds.org (2002) Stress [Internet], Syque. Available from: <http://changingminds.org/explanations/stress/stress.htm>

Dean, W., South, J. & English, J. (1997) *5-HTP (5-Hydroxytryptophan) vs. Prozac (SSRIs)* [Internet], Delaware, Intelegen. Available from: <http://intelegen.com/nutrients/5htp_5hydroxytryptophan_vs.htm> [Accessed December 2006].

FUSE. (n.d.) *Exploring our universe: from the classroom to outer space I - Spectroscopy - Spectroscopy fact sheet: how astronomers study light* [Internet], FUSE Public Outreach and Education. Available from: <http://fuse.pha.jhu.edu/~bianchi/kit1/factsheet.html> [Accessed 25 September 2006].

Lewis, S. (2005) Air ions: new evidence supports their protection against infections and importance for health. *Institute for Complementary Medicine Journal* [Internet], May 2005. Available from:

<http://www.i-c-m.org.uk/journal/2005/may/a01.htm> [Accessed December 2006].

Lohr, V.I. & Pearson-Mims, C.H. (2000) *Physical discomfort may be reduced in the presence of interior plants* [Internet], Washington, Washington State University. Available from: <http://www.wsu.edu/%7Elohr/hih/pain> [Accessed December 2006].

SAPREF HSE/BE Department (2005) *SAPREF Business management system: Supplied breathing air quality* [Intranet], Durban, SAPREF HSE/BE Department. Available from: <http://corp.sapref.com/asc_bms/library/documents/approved/hsse/pr/hsse.pr.0015.doc> [Accessed 22 August 2005].

The Back Shop International (2003) *Price list* [Internet], Benmore, Sandton, The Back Shop International. Available from: <http://www.backshop.co.za/PRICELIST%20VAT%20retail%2028-03-03.doc> [Accessed March 2006].

UC Pancreatic Disease Centre (2004) *Medical glossary* [Internet], Cincinatti, Ohio, United States of America, University of Cincinnati. Available from: http://www.ucpancreas.org/glossary.htm [Accessed 11 November 2006].

Wikipedia the Free Encyclopedia (2006) *Cognitive Dissonance* [Internet], Wikimedia Foundation Inc. Available from: < http://en.wikipedia.org/wiki/Cognitive_dissonance> [Accessed December 2006].

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