Modulation of Food Consumption in Healthy Adults by Exposure to Coloured Lighting

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Abstract

The circadian rhythm (body clock) describes an endogenous (self-sustained) cycle that, amongst other cyclic functions, signals to the body when it is time to eat via the secretion of appetite stimulating and satiety hormones. Those suffering a misalignment of the circadian rhythm, such as dementia patients, may experience interruptions to their eating behavior, often resulting in malnutrition. The circadian rhythm is adjusted (entrained) to the local environment by external cues, or zeitgebers, which include natural daylight. There is some evidence that artificial white lighting can be used to mimic natural daylight in order to entrain the circadian rhythm to modulate normal sleeping patterns in those suffering from misalignment and in those who are not. However, little is known about any effects that coloured lighting might have on the circadian rhythm, or any potential to entrain the circadian rhythm to modulate food consumption. The present study investigated the effects of exposure to blue and yellow coloured lighting whilst eating on food consumption. Thirty non-obese participants (Age 26.8 (12.5)) years completed a repeated measures trial on three separate occasions, one day per week, over a period of three weeks. For each trial, participants consumed an *ad libitum* homogenous pasta meal until 'comfortably full and satisfied' for the duration of 30 minutes. Visual analogue scales were used to record appetite throughout. After checking for normality, one way ANOVA with repeated measures and Bonferroni post-hoc analysis revealed a significant increase in food consumption for the sample under yellow lighting compared to the white lighting control (P = 0.009), and very significant differences in food consumption for the sample between yellow and blue lighting (P = 0.002). However, 3*2 ANOVA identified a colour*sex interaction, with males consuming significantly more food under yellow compared to white (P = 0.002), but no significant increase or decrease under any coloured lighting condition in females. There was no effect of colour on appetite, hunger, or mood. There was no effect of sequence or restraint on food consumption. These novel findings suggest that exposure to yellow coloured lighting whilst eating can increase food consumption, most specifically in males. Further research is required to establish how coloured light-induced changes in food consumption occur, and to identify if there is an optimum shade of yellow and duration of pre-load exposure. These findings could be of particular interest in the context of patients suffering from malnutrition due to circadian misalignment, and the potential to develop new non-invasive treatments through lighting design and medical device development.

Acknowledgements

I would like to thank the staff and students of Sheffield Hallam University for their significant contributions to this study, without which it would not have been possible. Particular thanks are extended to my research assistants, who ably assisted me in the laboratory, and to each of the thirty wonderful participants who generously volunteered of their time in order to complete the study, without a single one dropping out. To Karen and Koko for their collective patience whilst navigating me through the dark art of statistics. Lastly to David, for his unceasing support, enthusiasm, knowledge, expertise and generosity as he supported me through this journey.

Dedications

To my family x

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APPENDICES

i. THE DOCTORATE IN PROFESSIONAL STUDIES AT SHEFFIELD HALLAM UNIVERSITY – an Overview of the Programme and the Assessment Process

Sheffield Hallam University (SHU) began offering a Doctorate in Professional studies (DProf) within the faculty of Health and Well-being in September 2004. Professional doctorates are described on the SHU website as being '*equivalent to PhDs but focus on the development of professional practice and suit the needs of experienced professionals*' (SHU, 2012). Part of 'suiting the needs' of health and social care professionals is the contact time with the University. Unlike the PhD, which usually involves a large commitment to attending an academic institution, the DProf is delivered via a seminar scheme, with meetings taking place on a regular, usually monthly basis. As the course moves into the research phase, contact with the University is largely at mutually convenient times and with the supervisory team. In the latter period of the programme, the largest amount of time is therefore spent conducting research either within a professional context at the place of work, or dependent upon the study design, within the University.

The DProf route of study can appeal to prospective doctoral students more than embarking on a traditional PhD route as studying the via a Doctorate route means that professionals can combine full time work, whilst exploring an area of expertise or professional interest (Scott et al., 2004). The depth of inquiry the DProf allows is for many professional doctoral students unsurpassed as it opens new levels of academic exploration. The DProf programme promotes this level of inquiry through the three main educational aims of the programme contained within the DProf handbook (SHU, 2014) –

- Promote the development of knowledge and skills required to create and interpret new knowledge, through the ability to conceptualise and design a project that could contribute to the advancement of an area of professional practice.
- Facilitate the development of independent learners who possess advanced professional knowledge and understanding with the skills to proactively deal with complex issues and problems and lead professional and organisational developments.
- Support the development of critically reflective professionals who can, through professional leadership, influence practice in the UK and internationally.

For students requiring funding, the cost of the DProf can be monetarily less to support than a traditional PhD and there are also potential organisational benefits to the programme with the research based around a professional theme. A DProf programme is an academic equivalent to a traditional PhD and it simply differs in being delivered through an applied professional context (Scott et al., 2004). The DProf is more likely to include research into aspects of professional practice and the assessment criteria also varies from its more traditionally academic PhD counterpart. The following section describes the assessment process which culminates in the submission of a doctoral project report.

The DProf programme is delivered over a 4 year period with each doctoral student having up to a maximum of 7 years to fully complete their studies. The first year of the DProf is a taught programme and is broken down into two modules - 'Review of Learning and Professional Experience' and 'Research for the Working World'. The first module allows students the opportunity to critically reflect on their professional history, scholarship, achievements and consider their readiness for this level of advanced study. Research for the working world then enables students to develop a critical understanding of research approaches and processes that will serve as a theoretical basis for research activity to be undertaken at academic level 8. The module also looks to prepare students for the complexities associated with research activity that crosses organisational boundaries and that take place within challenging and changing environments. These modules are each assessed by a 6000 word essay which includes appropriate levels of criticality and is underpinned by epistemological, ethical and philosophical discussion.

The second year of the DProf focuses on project planning with the aim to enable candidates to develop, justify and submit to the Faculty Research Ethics Committee (FREC) a systematic plan for work-based inquiry to be undertaken at doctoral level. In addition to the written element, candidates are required to give an oral presentation in support of their proposed project. Evidence of the candidate's performance in the oral assessment is taken into account when the FREC considers the candidates application. To successfully complete this module candidates are required to –

- Identify problems/issues that are critical, significant, timely and clearly drawn from a complex knowledge base.
- Identify relevant key concepts that underpin the proposed inquiry, with links made between concepts that are logical, relevant and significant and show how the synthesis of concepts are based on critical features drawn from a wide range of information.

- Demonstrate the need for inquiry by giving reasons that are valid and logical and are based on relevant, appropriate and evaluated evidence.
- Propose plans that are specific, achievable, realistic and innovative. Clearly explicate the predicted outcomes and benefits of the inquiry and proposes methodologies and strategies that are relevant and philosophically congruent to the issues/problems identified (SHU, 2012).

Upon successful completion of this module, the programme gravitates into the research phase of the investigation. In the case of the present study final SHU ethics approval was achieved in late March 2015 with recruitment to the study commencing in April 2015.

Running throughout the 4 years of study there is a requirement to maintain an electronic portfolio of Critical Professional Practice and Development. This chronological record of the doctoral journey provides evidence of how the undertaking of the DProf programme has enhanced professional practice, and is accompanied by a critical commentary.

The final stage in the DProf programme has three components in its assessment, a doctoral project report (of approximately 50,000 words) and an oral viva voce examination. The main aim of the final module is to enable candidates to generate project outcomes that impact on, and contribute to, the creation of professional knowledge (SHU, 2012). The final stage of the assessment process is a ‘persuasion’ of the research compromising a presentation and viva voce discussion (SHU, 2012). These assessments focus on the impact the work undertaken may have in terms of contribution of knew knowledge together with any potential to drive innovation within a professional and wider context.

Table 1. DProf Programme Structure.

<table>
<tr><th>Part</th><th>Study period</th><th colspan="2">Modules</th></tr>
<tr><td rowspan="4">Part One</td><td>Year 1
Semester 1</td><td>Module 1: Review of Professional Learning and Development
6000 words</td><td rowspan="4">Module 5: Critical Professional Practice and Development

Summative assessment in year 4 of the programme.

15,000 words equivalent, including 3,000 word critical commentary.</td></tr>
<tr><td>Year 1
Semester 2</td><td>Module 2: Research in the Working World
6000 words</td></tr>
<tr><td>Year 2
Semester 1</td><td>Module 3: Project Planning 1: Literature Review
6000 words</td></tr>
<tr><td>Year 2
Semester 2</td><td>Module 4: Project Planning 2: Epistemology, Methodology and Method
6000 words</td></tr>
<tr><td colspan="3">Submission of DPS1 to Research Degrees Sub Committee and appropriate Ethics approval</td><td rowspan="2"></td></tr>
<tr><td>Part Two</td><td>Year 3
onwards</td><td>Module 6: Doctoral Project
50,000 words (or equivalent) + oral examination</td></tr>
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ii PROFESSIONAL CONTEXT OF THE PRINCIPLE INVESTIGATOR

The principle investigator is a Director within a large Acute NHS Hospital Trust in South Yorkshire. An overarching strategic objective of the organisation is to deliver quality acute healthcare services to the local population. The provision of healthcare services involves a range of professionals from a number of disciplines, from specialist heart surgeons to chartered accountants and those which span the divide. As would be expected, the objectives of these disciplines also differ, with clinical services measuring performance against the delivery of quality and patient outcomes, and non-clinical services against quality and financial performance. Together these disciplines aim to provide safe healthcare services for patients in an environment that is conducive to aiding recovery. The specific professional context of the principle investigator is that of Strategy, Improvement and Infrastructure, which concerns itself with the strategic management of the physical asset and operational delivery of a number of support services including patient catering.

In 2014/15 the NHS served over 139 million meals at a cost of £534m (HSCIC, 2015). NHS catering has received significant attention over the last 25 years due to the high profile and costly campaigns to improve food quality in an attempt to reduce the incidence of patient malnutrition (Better Hospital Food, 2001., British Nutrition Foundation (BNF), 2004, Warner, 2004., Savage and Scott, 2005., British Dietetics Association (BDA), 2006., Age Concern 2006., Age UK, 2010., Edmondson-Jones, 2010). Age Concern (2006) claimed that patient malnutrition was costing the NHS £7.2bn each year. With such high levels of public expenditure, and no improvement in the nutritional status of hospital patients (BNF 2004, Age Concern, 2006), it is to be expected the subject receives significant attention from politicians and policy makers. In 2013 the Campaign for Better Hospital Food (CFBHF) claimed that between 1992 and 2013 there were 21 failed voluntary initiatives to improve hospital food, costing more than £54m. Journalist and broadcaster Lloyd Grossman and five different celebrity chefs Albert Roux, John Benson-Smith, Mark Hix, Anton Edelmann and Heston Blumenthal had all been drafted in to help improve standards (CFBHF, 2013)

The issue of patient malnutrition is a specialist area of professional and academic interest of the principle investigator due to the responsibility to provide catering services to hospital patients. Following the completion of a literature review for the fulfilment of a Master's Degree which focused on sustainable food procurement to the NHS in order to improve food quality (Edmondson-Jones, 2010), the intention in undertaking a DProf was to identify a novel approach to reducing patient malnutrition. Support was gained from the principle investigators organisation to provide funding for the DProf programme.

CHAPTER 1- INTRODUCTION TO THE RESEARCH STUDY

1.1 INTRODUCTION

The purpose of this first chapter is to introduce the research topic, identify the problem the research aims to address, state the research question and aim, and to provide the reader with the knowledge to understand the structure of the research. This first section includes the presentation of a research time line for the reader to review what and when activities occurred as part of the research study. The chapter will then provide a brief overview of the problem in order to support a better understanding of the context of the research, before presenting an account of the emergence of the original idea and the novel nature of the research question that has been investigated. A review of literature in chapter 2 supports the determination of research methods within chapter 3. The chapter concludes by summarising the problem, question, aim and approach taken.

The present study was undertaken in order to investigate the potential to develop a new treatment or therapy aimed at reducing malnutrition amongst hospital patients, which are especially prevalent amongst older patients (Age Concern, 2006; Age UK, 2010). Whilst consensus existed of the issue of malnutrition amongst hospital patients, it was felt that little improvement had been made despite significant investment in initiatives aimed at reducing patient malnutrition (Better Hospital Food, 2001., BNF, 2004, Warner, 2004., Savage and Scott, 2005., BDA, 2006., Age Concern 2006., Age UK, 2010., Edmondson-Jones, 2010). In 2013, the following research question, ‘Can coloured lighting modulate food consumption?’ was developed. A review of literature, at that time highlighted a paucity of data. However, within the literature there was some evidence to support the hypothesis that there may be physiological links between lighting, the circadian rhythm, the secretion of the appetite stimulating hormone ghrelin, and food consumption (Demarco and Clarke, 2001., Kuller et al., 2006., Broom, 2008., Rot et al., 2008., Munich and Bromundt, 2012., Ellis et al., 2013).

The circadian rhythm, or 'body clock', controls much of the body's cyclic functions such as sleep/wake and eating patterns (McEachron, 2012., Ellis et al., 2013., Kent, 2014). Therefore, the circadian rhythm is fundamental to maintaining normal eating behaviours, and as part of its function signals the production and secretion of the appetite stimulating hormone ghrelin (Gibbons et al., 2014., Kent, 2014). Ghrelin acts in the pituitary and hypothalamus to stimulate growth hormone secretion, energy homeostasis, appetite, and weight gain (Kojima et al., 1999; Wren et al., 2000; Tschöp et al., 2000; Kojima and Kangawa, 2005; Szentirmai et al., 2006; Chen et al., 2009; Castañeda et al., 2010). Ghrelin stimulates food intake (Nakazato et al., 2001; Toshinai et al., 2006), and circulating levels rise prior to mealtimes (Cummings et al., 2001; Frecka and Mattes, 2008). In addition to regulating appetite, there is evidence that ghrelin also plays a role in the circadian system by directly entraining circadian clocks that drive behavior or indirectly by stimulating appetite and activity (Cowley et al., 2003; Yi et al., 2006).

The circadian rhythm is controlled by the hypothalamus, a region of the brain that is sensitive to the external stimulus of lighting levels received through the retina via the retinohypothalamic tract (Kuller et al., 2006., Demarco and Clarke, 2001). Light therefore is defined as a 'zeitgeber' of the circadian rhythm, a zeitgeber being defined as an exogenous, that is external, cue or time-giver that helps entrain the circadian rhythm (Siffre, 1975., Boivin et al., 1996). Patients suffering from a misalignment of their circadian rhythm can experience disruption to their sleep/wake cycles (Siffre, 1975., Boivin et al., 1996., Ellis et al., 2013). It has been demonstrated that it is possible to manipulate an environment with specific levels of white lighting to positively realign circadian rhythms, inducing a more natural sleeping pattern (Ellis et al., 2013).

From this emerging field of bioengineering (Ellis et al., 2013), the awareness that ghrelin secretion stimulates food consumption (Nakazato et al., 2001; Toshinai et al., 2006) and that light is a zeitgeber of the circadian rhythm (Siffre, 1975., Boivin et al., 1996) potential links were made by the principle investigator between the use of white lighting to manipulate the circadian rhythm to modulate sleep (Ellis et al., 2013), and the novel idea that it might be possible to manipulate food consumption by exposure to different coloured lighting conditions. The literature also supported the development of a hypothesis for how this might be possible.

Following completion of the study design, a small scale simulation to test engineering methods and to identify the colours of light to be used, and the submission of ethical approval in late 2014, a study was published in February 2015 which found that blue lighting decreased food consumption in men, but not in women (Cho et al., 2015). The study investigated whether exposure to coloured lighting whilst eating breakfast affected the amount of food consumed, in addition to psychological hedonic sensory perceptions of food and willingness to eat. The study used the same two coloured lighting conditions that had been identified for use in the present study, blue and yellow, and a white control. Results highlighted blue lighting decreased the hedonic impression of the food's appearance, but not the willingness to eat, compared to yellow and white lighting conditions. Blue lighting significantly decreased the amount consumed in men, but not in women, compared to yellow and the white control. Overall flavour intensity and overall impression of the food were not significantly different among the three lighting colours.

To the author's knowledge the findings of Cho et al. (2015) were the first available empirical evidence that exposure to coloured lighting could modulate food consumption, and the first evidence that the novel idea that a colour of light might stimulate consumption was valid for further investigation, as were the colours selected to be tested. Therefore, investigating any modulating properties of coloured lighting on food consumption as part of the present study, the primary focus became finding a colour of lighting that might increase food consumption in the context of the issues of malnourished patients (Better Hospital Food, 2001., BNF, 2004, Warner, 2004., Savage and Scott, 2005., BDA, 2006., Age Concern 2006., Age UK, 2010., Edmondson-Jones, 2010). Figure 2. provides the timeline for the present study. It was important for the present study to build on the strengths of the research undertaken by Cho et al. (2015) by ensuring that the study design was robust. For this reason a repeated measures design was selected, using a lunch meal which allowed for fasting and a controlled breakfast meal. Recommendations from the study by Cho et al. (2015) were incorporated, which resulted in mood being measured in addition to hedonic impression and appetite. The present study also used an 18 question Three Factor Eating Questionnaire (TFEQ-R18) (Karlsson et al., 2000) in order to understand if restrained eating traits of participants were impacting upon the results.

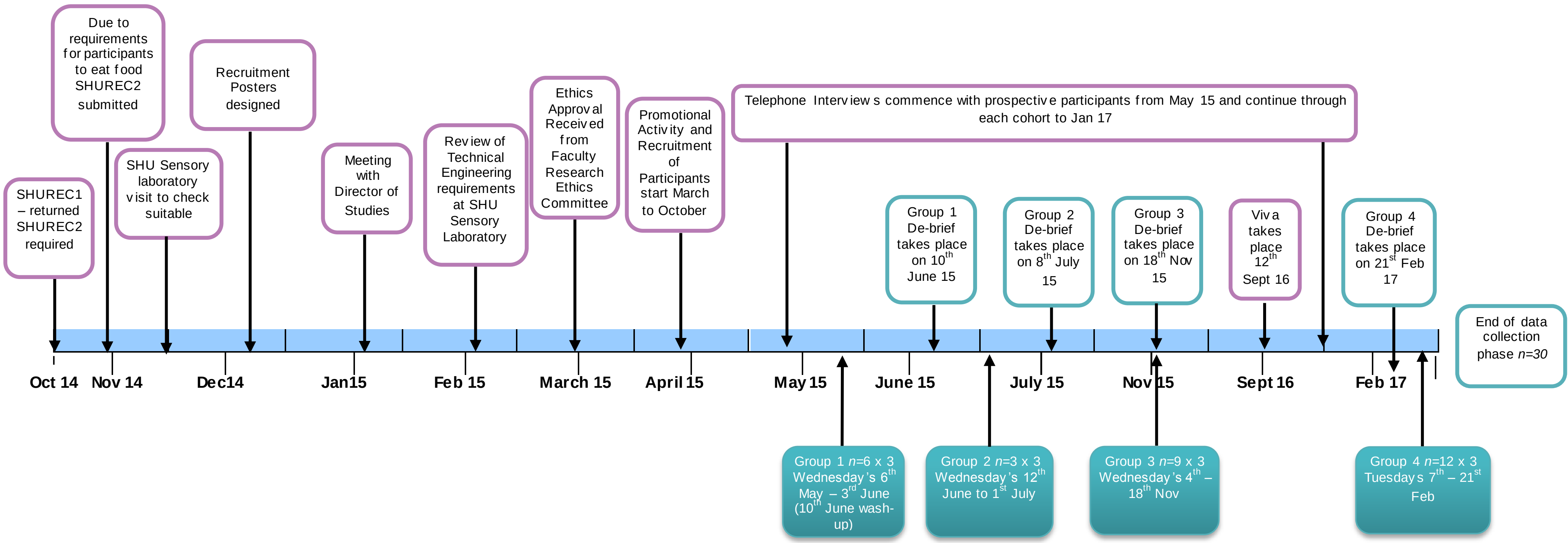

Figure 2: Research Time Line 2014 - 2017

1.2 THE ISSUE – AN OVERVIEW OF PATIENT MALNUTRITION IN HOSPITALS

Malnutrition is a condition that results from eating a diet in which nutrients are not adequate enough leading to health problems (Young, 2012). According to the United Nations Children's Fund (UNCF) (2010) malnutrition may involve too few calories or deficiencies in protein, carbohydrates, vitamins or minerals. Not enough nutrients is called undernutrition or undernourishment, malnutrition is often used specifically to refer to undernutrition where there is not sufficient nutrient intake (Young, 2012). Extreme undernourishment, known as starvation, may have symptoms that include: a short height, thin body due to low body mass, very poor energy levels, swollen legs and abdomen (UNCF, 2010). People often get infections and are frequently cold (Young, 2012). Malnutrition increases the risk of infection and infectious disease, and moderate malnutrition weakens every part of the immune system (Stillwaggon, 2008). For example, malnutrition is a major risk factor in the onset of active tuberculosis (Schaible, Kaufmann, 2007). Protein and energy malnutrition and deficiencies of specific micronutrients (including iron, zinc, and vitamins) increase susceptibility to infection (Stillwaggon, 2008). The effects of malnutrition include, Hypoglycemia (low glucose concentration) which can result from not eating for 4 to 6 hours, causing lethargy, limpness, convulsion, or loss of consciousness (Stillwaggon, 2008).

Malnutrition and being underweight are more common in the elderly than in adults of other ages (Kvamme, 2011). If older adults are healthy and active, the aging process alone does not usually cause malnutrition (Wellman et al., 1997). However, changes in body composition, organ functions, adequate energy intake and ability to eat or access food are associated with aging, and may contribute to malnutrition (Saka et al., 2010). Rates of malnutrition tend to increase with age with less than 10 percent of the "young" elderly (up to age 75) malnourished, while 30 to 65 percent of the elderly in home care, long-term care facilities, or acute hospitals are malnourished (Volkert, 2002).

The incidence of malnutrition amongst hospital patients is a recognised problem (Better Hospital Food, 2001., BNF, 2004, Warner, 2004., Savage and Scott, 2005., BDA, 2006., Age Concern 2006., Age UK, 2010., Edmondson-Jones, 2010). Up to 40% of hospital in-patients were malnourished and 1 in 10 would have a shorter stay in hospital if nutrition and patient food services were improved (NHS Plan, 2000). The need to improve hospital nutrition was of great concern, with malnutrition felt to be a major issue increasing complexity of disease and lengthening recovery times as it is felt that patients who do not eat enough food do not recover as quickly (British Nutrition Foundation, 2004). A view supported by Ginner et al. (1996) who undertook a prospective study of 129 patients, 43% of whom where malnourished, to determine whether malnutrition affected recovery. Patients admitted to an intensive care unit (ICU) were divided into well-nourished and malnourished groups. Length of hospital stay ($p > 0.05$), incidence of complications ($p < 0.01$), and number of patients not discharged from hospital ($p < 0.05$) were greater in the malnourished patients than in the well-nourished. Elia et al (2005) supported this further, stating that malnutrition not only predisposes to disease, but adversely affect outcome. Stratton et al. (2006) undertook a study of 150 consecutively admitted elderly patients (age 85 (sd 5.5) years), of which 58 % were at malnutrition risk. These individuals had greater mortality (in-hospital and post-discharge, $P<0.01$), longer hospital stays ($P=0.02$) and those at greater risk of malnutrition had a poorer clinical outcome ($P<0.002$). Food was accepted to be a vital part of the patient experience that supported recovery (British Dietetic Association, 2006). Six out of ten older people were at risk of becoming malnourished or their nutritional status diminishing during hospitalisation, and malnutrition was costing the NHS £7.3bn each year (Age Concern, 2006).

Despite the consensus regarding the importance of good nutrition in hospital, views on the factors contributing to poor nutritional status of hospital patients varied widely. This led to a range of approaches in attempting to reduce the incidence of patient malnutrition, with attempts to improve the situation involving the food itself, the screening of patients, assistance to eat and even the requirement to procure local sustainable produce in an attempt to tackle the growing problem (CFBHF, 2013). Within this section information will be presented relating to a number of national initiatives that were aimed at reducing patient malnutrition, together with evidence of the problem from the perspective of the organisations tasked with protecting the nutritional status of patients.

1.2.1 Better Hospital Food Initiative

In 2000 the NHS committed £10 million (British Medical Journal (BMJ), 2000) to achieving targets aimed at providing 24 hour catering, dieticians to advise on the nutritional values of hospital patient menus, and improved quality which was all to be evidenced by increased patient satisfaction surveys audited through unannounced inspections. Shortly after this the Department of Health (DH) launched a £40 million initiative in May 2001 accompanied by the policy document, Better Hospital Food: a new menu for the NHS (DH, 2001) aimed at improving the quality of hospital food. The initiative that followed was designed by a team led by celebrity chef Lloyd Grossman. Each NHS Trust received a ‘national cookery book’ with the aim of having at least one national dish on their menu by August of 2001 and a full selection of dishes by the end of that year. Better Hospital Food (BHF) was designed to be the initial step of a longer term programme to continually improve catering services in hospitals. The three objectives were to ensure all hospitals met the required standards, to bring all hospitals to existing levels of excellence, and to develop new catering systems which provided modern services that were both efficient and responsive to the needs of patients (British Nutrition Foundation, 2004).

The British Nutrition Foundation (BNF) described how the new BHF national menu offered more choice by introducing more fresh ingredients and increasing the options for vegetarians and other specialised diets. BHF also took into consideration changing social patterns in food consumption and evolving tastes for a wider variety of foods to reflect cultural diversity. However, this point appears flawed since the approach being proposed by the BHF initiative was to centralise control of hospital menus by developing a national menu, thus by definition removing the ability to reflect local tastes.

In practice the implementation of the BHF national menu served to reverse any devolution that was in place which could have responded to local eating preferences and behaviours and replaced it with a one size fits all menu. Further, attempts by the national menu to reflect the increased diversity of the population led to dishes that were better suited to culturally diverse inner city conurbations being deployed into rural community hospital settings which in practice lacked any of the cultural diversity the menu was designed for. No evidence was provided by the BHF initiative to demonstrate how demographic evidence of food preferences had been established, and NHS Caterers felt that those designing the menus did not take account of the age demographic within NHS hospitals (BNF, 2004).

The intention of BHF initiative was for patients to be provided with a quality hospital meal service that encouraged them to eat enough food to satisfy their nutritional requirements by offering them foods which they would want to eat at times they wanted to eat them. However, five years after the launch of the initiative a report (Age Concern, 2006) criticised the BHF initiative for the unilateral introduction of unrecognisable dishes such as Navarin of Lamb, when they felt that what was required was good quality familiar fresh meals appropriate to the aging population of an acute hospital. Whilst the value of the BHF initiative had been recognised by the BNF in terms of its strategic aims for improving the quality and standards of hospital food and encouraging patients to increase their food intake, even whilst BHF was still active the initiative was viewed as having limited success and received criticism from catering professionals throughout the NHS (BNF, 2004). Additional concerns raised were that dishes had not been accurately costed, serving to halt implementation as budgets at a local level were insufficient to meet the requirements to facilitate full implementation.

Although BHF has never officially been withdrawn, the lack of any current information, websites or guidance, could be seen to be indicative of its limited success with just a small section on the Hospital Caterers Association (HCA) website which hosts a page giving advice on nutrition and best practice (HCA, 2009). Whilst BHF highlighted the need for hospital caterers to improve the standards and quality of patient food, according to BNF (2004) it had failed to provide the solution. At best BHF had served to raise expectations unrealistically, and at worst BHF had introduced exotic and unfamiliar dishes to hospital patient menus potentially exasperating the very problem it intended to address, that of patient malnutrition, and collectively wasting £54m of public money in the process (CFBHF, 2013).

A BNF report (2004) reviewed the BHF initiative whilst it was still active and was critical of the lack of impact of the initiative and an increasing pressing need to reduce malnutrition of hospital patients. Malnutrition was identified as a major issue increasing complexity of disease and lengthening recovery times (BNF, 2004). A charity, the BNF was established with the aim of providing authoritative, evidence-based advice of food and nutrition in the context of health and lifestyle to government, healthcare, schools industry and journalists (BNF, 2004). Their recommendation was to treat hospital food as part of a patient's treatment and to promote greater emphasis on provision and quality to reduce the incidence of malnutrition. They identified that meals had to be both appetising and meet nutritional standards and for patients to be offered assistance to eat were necessary, and linked quality food to improved patient nutrition and recovery with the added benefit of reducing length of stay (BNF, 2004). In support of this theory, Lord Warner, Parliamentary Under-Secretary of State in his speech on 'The Changing Face of Hospital Food' 29th April (Warner, 2004) recognised of the Better Hospital Food initiative that there was still much to be done and there was no quick fix. Warner (2004) also acknowledged links between poor nutrition status delaying recovery and increasing periods of illness. What was therefore emerging around 2004 were links between poor nutritional status of patients and delayed recovery and increasing length of stay in hospital.

1.2.2 Nutritional Care in Hospital

In their research paper 'Patients' nutritional care in hospital: An ethnographic study of nurses' role and patients' experience' (Savage, Scott, 2005) described and analysed nurses' involvement in the nutritional care of patients. Their choice of research method, specifically focused ethnography, aimed to provide a contextual understanding of the subject by collecting data within the naturally occurring setting of a hospital (Savage, Scott, 2005). The research suggested that there were a number of factors influencing the nutritional status of patients, the low status of nutritional care on the part of nurses, certain medical conditions such as cancer and chronic gastro-intestinal diseases and lack of robust nutritional assessment of patients all contribute to patients becoming malnourished whilst in hospital (Savage, Scott, 2005). Twenty recommendations emerged from the study aimed at policy makers which focused on raising the stature and importance of good nutrition, and ensuring that from nurses to senior clinicians and ward domestics there was sufficient understanding of food and its ability to aid recovery.

1.2.3 Hungry to be Heard

Age Concern's report 'Hungry to be Heard – The scandal of malnourished older people in hospital' (Age Concern, 2006) led to a step change in attitudes towards the prevalence of malnutrition amongst older hospital patients. Age Concern is a charity formed during the Second World War, independent of government that strives for the equality of people in later life (Age Concern, 2006). In the report Age Concern called for action from the NHS, the Healthcare Commission and the Department of Health to end the national scandal of malnourished older people in hospital (Age Concern, 2006). Malnutrition is defined by Age Concern (2006) as a condition that results when a person does not eat enough nutritious food. The causes of malnutrition were thought to be varied and include insufficient calorie intake, an unbalanced diet, or complications of illness (Age Concern, 2006). The report found that six out of ten older people were at risk of becoming malnourished or their nutritional status was diminished during hospitalisation, this malnourishment aspect meant older people were likely to experience increased complications following surgery, increased use of medication, increased length of stay, morbidity and higher mortality rates than well-fed patients (Age Concern, 2006). Age Concern (2006) identified that good nutrition not only leads to shorter hospital stays, but fewer post-operative complications and less need for drugs and other interventions (Age Concern, 2006), view also supported by (Kvamme, 2011., Wellman et al., 1997., Saka et al., 2010., Volkert, 2002). This view supports (BNF, 2004., Warner, 2004) in identifying these links between adequate nutrition and reduced mortality rates. Age Concern called for the introduction of their own 'seven steps to ending malnutrition in hospitals' (Age Concern, 2006) and for the NHS to appoint Older People's Champions to play an effective role in ensuring that older people received appropriate nutritional food and were offered assistance to eat. However, in 2010 the charity, now renamed Age UK, published a follow up report entitled 'Still Hungry to be Heard' suggesting that there had been little to no improvement since the first publication four years earlier, and that older people were still at a very high risk of becoming malnourished whilst in hospital (Age UK, 2010).

1.2.4 The Prevalence of Malnutrition in Hospitals Can Be Reduced

However, it is possible to make improvements to the prevalence of malnutrition in hospitals using the tools available. Research undertaken by O'Flynn et al. (2005), which consisted of three cross sectional studies of 2283 inpatients at Hammersmith Hospital, found that malnutrition was reduced over a period of 5 years following the implementation of several initiatives. The research found that following the introduction of an improved catering service at the hospital in 2000, the introduction of the BHF initiative and a nutritional screening tool in 2003, there was a reduction in the prevalence of malnutrition from 23.5% in 1998 to 19.1% in 2003 for patients over the age of 16.

Whilst an improvement of 4.4% over a five year period was deemed to be statistically significant, the prevalence of malnutrition by the end of the study remained at nearly 20%, with two out of every ten patients suffering from malnutrition.

1.2.5 Delivering Nutritional Care through Food and Beverage Services

In 2006 the BDA published a guidance document entitled, Delivering Nutritional Care through Food and Beverage Services, (BDA, 2006). Produced by their Food Counts Specialist Group, the document was a toolkit for dieticians in hospitals and the care sector. Although aimed primarily at dieticians the document was developed in partnership with the Hospital Caterers Association and provided a comprehensive toolkit for the provision of food within the healthcare environment taking account of the content of the NHS Plan (NHS, 2000). Mealtimes were recognised to be a vital part of the hospital patient experience, and adequate nutrition supported recovery and promoted health. They stated that meals should meet the nutritional needs of patients, and called for dieticians to work closely with catering professionals as there was a relatively small window of opportunity to act swiftly to prevent malnutrition as a complication of illness (BDA, 2006). The BDA toolkit is a seminal document still used by dieticians and caterers throughout the NHS and forms the basis by which all NHS menus should be planned and detailing the standards by which these should be delivered.

From the information presented in this section it is possible to identify the significance of the problem of patient malnutrition, particularly in older patients in hospital and care settings (Age Concern, 2006; Age UK, 2010). The apparent failure of the BHF initiative demonstrated the difficulty facing policy makers in their attempts to reduce patient malnutrition by increasing the quality of hospital meals (BNF, 2004., Age Concern, 2006., Age UK, 2010, CFBHF, 2013). The BDA toolkit (2006) provided the standards by which hospital dieticians and caterers should operate and gave evidence and context to these standards. The BNF (2004), Age Concern (2006) and Age UK (2010) recognised the seriousness of the poor nutritional status of patients in increasing complication, reliance on drugs, length of stay, morbidity and mortality rates. What is common within all of the evidence presented is the responsibility placed on those professionals within hospitals who are responsible for delivering catering services to entice and encourage ill patients to take in adequate food to prevent malnutrition. However, other than improving food quality, solutions as to how to do this were limited. The issue of patient malnutrition (Wellman et al., 1997., Volkert, 2002., BNF, 2004., Age Concern, 2006., Age UK 2010., Saka et al., 2010, Kvamme, 2011., Edmondson-Jones, 2010., CFBHF, 2013) led to the principle investigator selecting this area for further investigation, and to the emergence of an original idea and a potentially novel approach to investigate further..

1.3 EMERGENCE OF THE RESEARCH QUESTION

Late in 2013, a potential research question emerged from an informal verbal dieting tip to replace refrigerator lamps with blue coloured lamps as it was alleged that blue lighting deterred snacking. The suggestion was that blue coloured lighting had the ability to reduce a person's desire to snack on the fridge contents. This tip, if correct, caused the principle investigator to consider the possibility that another colour of lighting might have to opposite effect, increasing a person's desire to consume the fridge contents. Through the process of logical abductive reasoning (Magnani, 2001) a view was formed of the premise that coloured lighting might possess modulating properties on food consumption, and if so there could be the potential to increase food consumption in a non-invasive way simply by manipulating the environment with coloured lighting.

In the context of patient malnutrition (Wellman et al., 1997., Volkert, 2002., BNF, 2004., Age Concern, 2006., Age UK 2010., Saka et al., 2010, Kvamme, 2011., Edmondson-Jones, 2010., CFBHF, 2013) there could be a potential for coloured lighting to be designed into healthcare buildings, or for the development of new medical devices for portable use or retrofit within hospital, care and domestic settings. Following an initial brief review of literature undertaken in 2013, it was apparent that the potential for exposure to coloured lighting in order to modulate food consumption had not previously been investigated and appeared to be original with a potential to contribute new knowledge to the field. Therefore, the following research question was selected for further enquiry; Can coloured lighting modulate food consumption? It was necessary to conduct a review of literature presented at chapter

2 in order to identify suitable methodology and methods with which to investigate the research question.

1.4 RESEARCH QUESTION AND AIM

Whilst consensus existed regarding the importance of tackling the problem of levels of malnutrition amongst hospital patients (Better Hospital Food, 2001., BNF, 2004, Warner, 2004., Savage and Scott, 2005., BDA, 2006., Age Concern 2006., Age UK, 2010., Edmondson-Jones, 2010., CFBHF, 2013) which is more prevalent amongst older patients(Wellman et al, 1997., Volkert, 2002., BNF, 2004., Age Concern, 2006., Age UK 2010., Saka et al., 2010, Kvamme, 2011., Edmondson-Jones, 2010., CFBHF, 2013), views on the causes and how to address them were varied and included the role of nurses, use of screening tools and the quality of the food itself (BNF, 2004., Age Concern, 2006; 2010, CFBHF, 2013). By 2013 campaigners claimed that over £54m had been spent between 1992 and 2013 on 21 failed voluntary initiatives to improve hospital food (CFBHF, 2013), and that patient malnutrition was costing the NHS £7.3bn each year (Age Concern, 2006).

The novel nature of the research question: Can coloured lighting modulate food consumption? together with the aim of the present study, to identify a novel approach to reducing patient malnutrition, have been presented. The review of literature in chapter 2, concluded that experimental methodology using quantitative methods of measurement were appropriate and are presented in chapter 3. Within the next chapter the review of literature relating to coloured lighting research is presented and critically discussed in order to confirm the appropriateness of the research question for further enquiry; to identify a hypothesis, to present the gaps in existing knowledge;

and to confirm suitable research methods.

CHAPTER 2 - REVIEW OF LITERATURE

2.1 INTRODUCTION

This chapter presents a comprehensive systematised review of the theoretical and conceptual domains and discourses within which the research is situated. Consideration has been given to existing knowledge, practice and evidence bases relating to the present study. The proceeding sections present the literature search methods, followed by critical discussion of the search results. The epistemological context of the research evidence is reflected upon in relation to the search results. A summary of findings and recommendations for study design is contained within the chapter summary.

The method used in this formal review of literature adopted beneficial elements of two methods defined by Grant and Booth (2009) as critical and systematised. Grant and Booth (2009) describe a critical review as a method that demonstrates the writer has extensively researched a wide body of literature and critically evaluated its quality, going beyond mere description to include analysis and conceptual innovation. The output may constitute a synthesis of existing models or schools of thought, and could be a new interpretation of existing evidence, a benefit of the critical method is the opportunity to evaluate the value of a wide body of work and provide the opportunity to resolve any competing schools of thought (Grant and Booth, 2009). Cottrell (2005) suggests the many benefits of critical argument in considering a body of literature in order to add meaning to the process of review. Critical review may assist in the identification of a new phase of conceptual development and novel research in order to test a theory. However, weaknesses of critical review are felt by

Grant and Booth (2009) to be the lack of systematicity due to the absence of a requirement to present explicit details of the literature search strategy, results analysis and quality assessment. It is felt this lack of transparency may lead to interpretation and subjectivity which could negatively impact upon the robustness of the output.

A systematised review method is not to be confused with systematic review, as the method adheres to only one or two elements to be found in the systematic review process, and the resulting output lacks their comprehensiveness (Grant and Booth, 2009). Hart (2001) refers to elements of systemisation, describing the process as search management, and suggests that the importance of strict management of the search process cannot be overemphasized. According to Grant and Booth (2009) the strengths of this method are the systematic approach to the search process and cataloguing of literature. However, a weakness is felt to be the lack of criticality which may result in the exercise simply listing findings without consideration or critique. In addition, systematised reviews may be more open to bias than a full systematic review which adheres strictly to guidelines provided by the Cochrane Collaboration (Higgins and Green 2008) and the NHS Centre for Reviews and Dissemination (CRD) (CRD, 2009).

This combination of the positive elements of both critical and systematised review aims to balance the requirement to critically explore the literature whilst providing transparency of the search and analysis process. The beneficial systematic elements of systematised review were adopted as they applied rigour to the findings of critical review without the requirement for additional resources associated with systematic reviews, such as additional reviewers. The approach also enables others to duplicate the search. Reviewing the literature critically aimed to guard against the review being superficial, allowed for existing schools of thought to be challenged, and identified common research methodologies. Adopting the beneficial elements of these two methodologies served to increase confidence in the completeness of the review.

2.2 SEARCH STRATEGY

The initial informal scoping search of literature confirmed that the research question was suitable for further enquiry, and enabled the extraction of the following four concepts and accompanying search terms:

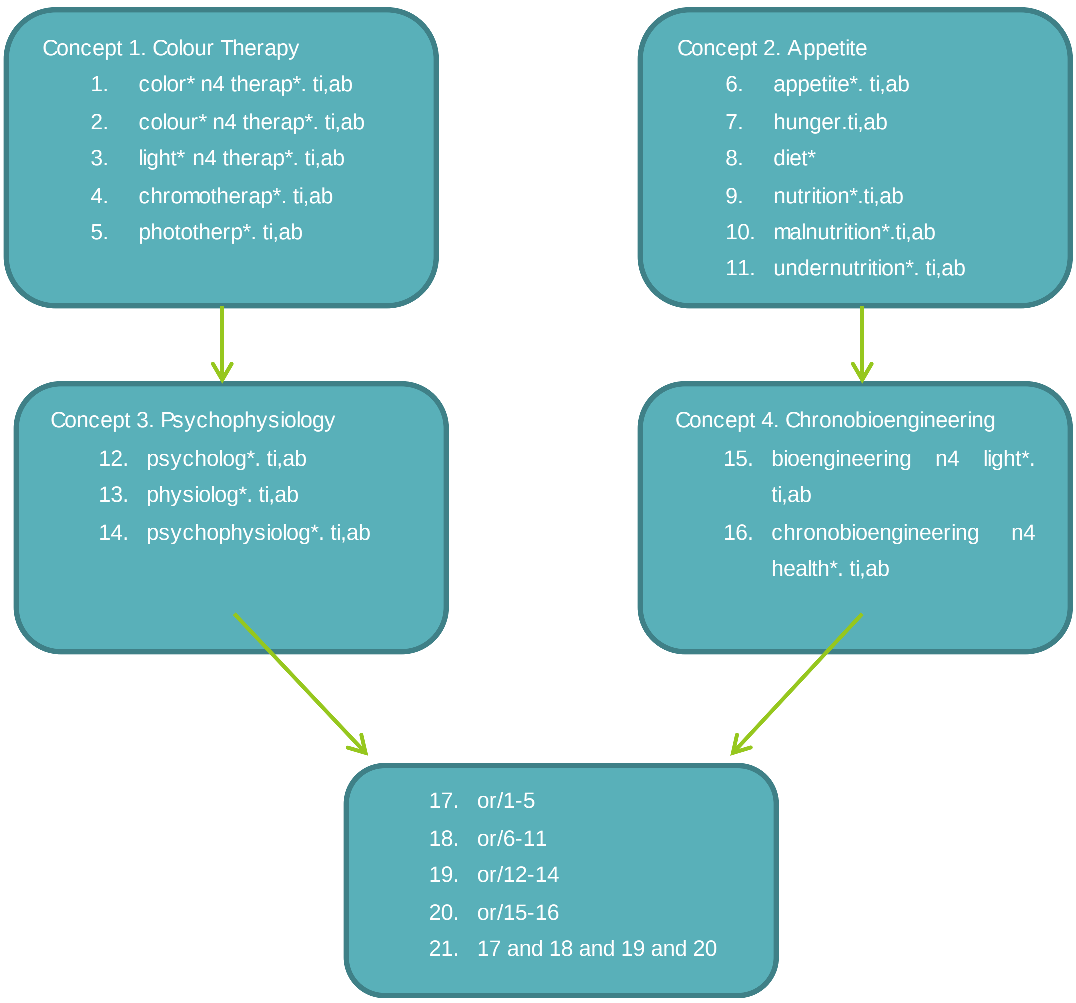

Figure 3. Search terms used to identify relevant literature

Databases searched were: MEDLINE, CINHAL, SCOPUS, PsycINFO, FSTA (Food Science & Technology Abstracts), Health Management Online, PEDro (Physiotherapy Evidence Database), HMIC, Health Business Elite, EMBASE, AMED, Pubmed, NICE Evidence Search, NICE Pathways, Cochrane Library, and UpToDate. Following the initial informal scoping search, it was apparent that specific literature on the subject was absent. In order to identify as much literature as possible no exclusion criteria were applied to any of the database searches with the exception of the term 'Humans'. This resulted in the search exercise looking as far back as 1806 through PsycINFO, and the inclusion of literature from other countries. The search terms were inputted to the databases in numerical order, as detailed in figure 3, index headings contained in the databases and Boolean logic were applied, together with some terms being restricted to within four words of each other. In order to refine results further, search terms were combined to identify the most relevant pieces of literature to the field of study. Each of the searches was saved and the literature was exported directly from the databases into RefWorks, title and abstract were then read and any further literature was identified from bibliographies. In total 61 pieces of literature were found and categorised into the four concept subjects as follows;

- Colour Therapy - 26
- Appetite – 14
- Psychophysiology – 10
- Chronobioengineering – 11

Following the search of databases, and in recognition of the lack of empirical evidence that coloured lighting might modulate food consumption, it was also necessary to search Google and Google Scholar in order to identify any further information which could illuminate the subject. Grey literature, such as technical reports, Government White Papers and Department of Health guidance documents were also included. This search identified a further 50 pieces of evidence which were categorised into the four concept subjects as follows;

- Colour Therapy – 39 (total of 65)
- Appetite – 5 (total of 19)
- Psychophysiology – 6 (total of 16)
- Chronobioengineering – 1 (total of 12)

In total 112 pieces of literature were identified, read and further categorised by relevance to the research question. These categorisation matrixes, adapted from Crookes and Davies (2004), can be found in appendix A - D

It was in these literature search and categorisation stages that elements of Grant and Booth's (2009) systematized methodology were adopted. Within the following sections the literature identified is critically discussed in order to identify any contradiction, ambiguity and uncertainty and to evaluate the implications of theory, discourse and evidence within the wider context of the present study. The review of literature also served to inform the selection of research methods for use in investigating the research question.

2.3 COLOUR

Colour surrounds us on a daily basis, is part of everyday life and influences many of the choices we make, from purchasing clothes and redecorating our homes, to preferences for eye and hair colour in our partners. The commercial industry has long since recognised the influence of colour; from product branding and advertising to television and film making. Significant investment is no doubt made each year in market research to identify optimum colours to influence the daily choices we make. The influence of colour is a wide field and in the absence of any research investigating the modulating effects of coloured lighting on food consumption until February 2015, the search criteria aimed to focus on the use of colour research identifying physical, psychological, physiological and psychophysiological reactions to it. The following critical discussion explores the evidence relevant to the research question, evaluating theory and discourse in order to form a research hypothesis.

2.3.1 COLOUR RESEARCH

2.3.1.1 Colour, Performance and Productivity

A large proportion of existing colour research has been undertaken in order to study singular applied concerns aimed at discovering which colours, if any, boost performance and productivity, these studies did not use colour in lighting form. Research focusing on the performance of athletes, workers and students has been undertaken as far back as 1917 when a founding father of colour research, Sidney Pressey (1917), produced his Doctoral thesis for Harvard University. His study on the influence of colour on mental and motor efficiency was published in 1921 by the American Journal of Psychology examining the effect of brightness and hue of colour upon mental and physical output of workers. More recent examples of colour research with similar singular concerns regarding performance are Hatta et al., (2002), Isaacs (1980) and Rosenstein (1985).

Goldstein (1942) asserted a theory of conceptualisation of colour and psychological functioning, that the body has inherent physiological reactions to colour that are reflected in psychological experience and functioning. Based on theory by Goethe of ‘active’ and ‘passive’ colours (Goldstein, 1942), he proposed that the colours red and (to a lesser degree) yellow are experienced as stimulating and disagreeable and focus individuals on the outward environment, whereas the colours green and (to a lesser degree) blue are experienced as quieting and agreeable and focus individuals in-ward (Goldstein, 1942). Accordingly, red (and yellow) relative to green (and blue) were posited to impair performance on activities in which exactness was required (Goldstein, 1942, p. 151).

Goldstein’s conceptualisation of colour has since been empirically applied by researchers through the use of the Yerkes-Dodson law (1908) which determines the relationship between levels of arousal and performance. This theorized that longer wavelength colours (red, orange) are arousing, and shorter wavelength colours (green, blue) are viewed as calming, and it is thought that longer wavelength colours, relative to shorter wavelength colours, impair performance on complex tasks (Elliot et al., 2007). However, research asserting these theories is contradictory, Soldat et al. (1997) hypothesized that red is associated with happiness and heuristic processing which can undermine cognitive performance, and blue is associated with sadness and can evoke systematic processing that increases cognitive performance. Hill and Barton (2005) hypothesized that red triggers dominance and wearing red in contests enhances performance relative to wearing blue. According to Elliot et al. (2007) context is significant and simply asserting that the colour red enhances the performance of a competitor ignores the interaction of that colour on the second competitor. It is perhaps not the wearing of the colour red that enhances performance, but the influence of the colour red on the co-competitor whose performance is then undermined. The results are the same, the red wearing competitor will dominate and win, but this is not as a result of any increased performance on their part, in fact their performance may stay the same, their success is as a result of the inhibiting effect of red on their competition (Elliot et al., 2007).

Within the literature focusing on colour research, many contradictions exist, for example, whilst Wilson (1966), Hill and Barton (2005) and Stark et al.(1982) assert the psychophysiological arousal properties of red, their findings are contradicted by Soldat et al. (1997) and Elliot et al. (2007) who found that red reduced performance, encouraged avoidance motivation and reduced achievement. Spenwyn et al. (2010) supported this by concluding that red was not a significant factor in increasing risk taking in gambling behaviour, and Valdez and Mehrabian (1994) found that darker colours elicited negative psychological and emotional responses. It is possible that contradictions exist as a result of methodological weaknesses of the studies, according to Valdez and Mehrabian (1994) this is certainly a criticism that could reasonably be directed at the majority of colour research.

2.3.1.2 Technical Considerations of Using Colour in Light Form

In addition to concerns of methodological weaknesses in the use of colour in paint and fabric form (Valdez and Mehrabian, 1994), the use of colour delivered through lighting within empirical research could prove challenging for a researcher (Van Hoof et al., 2012). An issue recognised by Van Hoof et al. (2012) who stated that in order to reduce variables and increase the rigour of findings, researchers must observe strict adherence to guidance in the design of methods of lighting research from an engineering perspective. Coloured lighting is measured by a number of aspects which must be consistently designed within research studies, Valdez and Mehrabian (1994) support Van Hoof et al. (2012) in the use of standardised hue or standardised colour notation (e.g. Munsell Colour Scale, (Munsell, 1961)) together with the saturation value and brightness of colour in addition to the luminescence of lighting, suggesting that many research studies do not observe these disciplines.

Valdez and Mehrabian (1994 investigated emotional reactions to colour hue, saturation, and brightness (Munsell color system and color chips) using the Pleasure-Arousal-Dominance emotion model. Saturation (S) and brightness (B) evidenced strong and consistent effects on emotions. Regression equations for standardized variables were; Pleasure = .69B + .22S, Arousal = -.31B + .60S, Dominance = -.76B + .32S. Brightness effects were nearly the same for chromatic and achromatic colours (Valdez and Mehrabian, 1994). Their research asserted other serious methodological problems relating to the measurement of response to colour, illustrated by the use of adjective checklists with dubious reliability and validity, and vague single-emotion terms which offer too much subjectivity for the participants. However, to suggest that contradictory findings within colour research are as a result of methodological weaknesses alone would perhaps be an overly simplistic conclusion to make. These are not the only variables demonstrated within the research and whilst each study aims to identify participants' reactions to the intervention of specific colours, the measurement of reactions to the stimulus are captured in a number of different ways. For example, Wilson (1966) exposed 20 undergraduate students to 5 red and 5 green slides in an alternating order for 60 seconds to measure the physiologically arousing properties of red using electrodermal measures of conductance level and galvanic skin resistance (GSR), whilst Valdez and Mehrabians' (1994) contradictory findings measured reactions with participant evaluation using the Pleasure-Arousal-Dominance (PAD) emotion model.

Elliot et al. (2007) undertook six experiments on a total of 282 participants (85 male, 197 female) and aimed to capture the psychological impact of colour, but not coloured light, on performance using the results of IQ tests and participant self-evaluation, The research focused on the relation between colour and psychological functioning, specifically, that between red and performance attainment. The findings suggested that care must be taken in how red is used in achievement contexts and illustrate how colour can act as a subtle environmental cue that has important influences on behaviour. The effect was documented in two different countries (the United States and Germany), with two different age groups (high school and undergraduate), in two different experimental settings (laboratory and classroom), using two different types of color presentation (participant number and test cover), using four different variants of red and green hues, using all three achromatic colors (black, white, and gray), and using both language-based and number-based achievement tasks (Elliot et al., 2007).

However, Stark et al. (1982) used coloured lighting to identify psychoanalytical theory and psychophysiological effect by observing gambling behaviour. Gambling at a modified version of three-card brag was observed for 28 volunteers, subjected to red or blue light conditions. It is concluded that subjects within a red light environment gambled more money more often and selected riskier odds than did subjects gambling under blue light. Furthermore, riskier bets were generally associated with later trials and red light again enhanced such an effect as compared with blue light (Stark et al., 1982).

The results of these studies are contradictory, with Stark et al (1982) finding red light stimulated participants to increase bets and take more risks whereas Elliot et al (2007) demonstrated the colour red, (not delivered in light form), impeded performance and induced avoidance motivation. It would appear that whilst these studies share commonality in identifying participants' reactions to the colour red, the variables that existed within the context of what is being measured i.e. delivery of the colour itself and the method of capture had a direct and significant impact upon the results, rendering them incomparable.

According to the literature it would appear that humans react to colour, and the way in which it is delivered, in a number of ways and on a number of levels; psychologically, physiologically, psychophysiologically and emotionally. This might explain the contradictory results to the colour red of (Wilson, 1966., Hill and Barton, 2005., Stark et al., 1982) and (Valdez and Mehrabian,1994., Soldat et al., 1997., Elliot et al., 2007). To increase the complexity of the study of coloured light further, Elliot et al. (2007) accept that whilst in the context of examinations and performance the colour red induced a negative reaction, in other contexts red can invoke positive reactions, for example valentines love hearts and red lipstick which aim to increase feelings of pleasure and sexual arousal. Interestingly this was also the view asserted by Goldstein (1942) finding that whilst red was often felt to be a disturbing colour and green calming, this was not found to be the case in all circumstances. Valdez and Mehrabian (1994) found evidence to suggest that the impact of colour is subjective and contextual. In addition, Valdez and Mehrabian (1994) found that whilst a colour can provoke a positive reaction in certain conditions, where a colour is perceived by the participant to be used out of context, i.e. blue hair or blue food, positive reactions can turn to negative ones.

According to Elliot et al. (2007), colour influences performance and psychological functioning via learned associations which may be embedded in deeply ingrained predispositions. Asserting that from infancy onward, people encounter both explicit and subtle pairings between colours and particular messages, concepts, and experiences in particular situations. Their contention is that colour does influence performance and psychological functioning, and although much of the research identified has variable and contradictory findings, the evidence supports the intention to explore the research question, that coloured lighting may modulate food consumption. Most specifically, Valdez and Mehrabian's (1994) findings relating to the context of colour was extremely significant, and provided at least some empirical evidence in support of the anecdotal dieting tip that blue coloured lighting may supress the desire to consume the food in a refrigerator..

2.3.2 CHROMOTHERAPY

2.3.2.1 Coloured Light Therapy - A Brief History

The therapeutic use of colour and light, or chromotherapy, has been practiced for thousands of years with the ancient Egyptians using sunlight and colour for healing purposes (Yousuf et al., 2005). Also popular in Greece, China and India, people have used colour as medicine since 2000 BC with all major civilizations recognizing the healing power of light (Demarco and Clarke, 2001). The Assyrians, Babylonians and Egyptians used sunlight as therapy, and the Greek city of Heliopolis, translated as ‘City of the Sun’, had specially designed temples with light rooms where windows were covered with dyed cloth of specific colours in order to treat a variety of conditions (Demarco and Clarke, 2001). In 1876 Pleasanton used blue lighting to stimulate secretory glands and the nervous system, and in 1878 Babbitt published ‘The Principles of Light and Colour’ after developing a method for irradiating water with sunlight through coloured filters (Demarco and Clarke, 2001; Yousef et al., 2005). During the 1890’s it was discovered that ultraviolet light had anti-bacterial properties, and in 1903 Finsen was awarded the Nobel Prize for his work using ultraviolet light to treat skin tuberculosis (Demarco and Clarke, 2001; Yousef et al., 2005). After 23 years of evaluation, in 1920 Ghadiali developed the Spectro-Chrome system of healing, based on the relationship between colours and specific areas of the body (Demarco and Clarke, 2001). During the 1920’s and 1930’s the ‘father’ of coloured light phototherapy, Riley Spitler, developed the principles of syntonics, in which light was used to balance the sympathetic and parasympathetic nervous systems (Demarco, Clarke, 2001). Then, in the 1930’s and 40’s Rollier and Knott (Demarco, Clarke, 2001) established the use of sun therapy and light irradiation of blood for the treatment of TB, puerperal sepsis, peritonitis, encephalitis, polio and herpes simplex. However, according to Demarco and Clarke (2001) with the advent of the era of antibiotics following World War 2, chromotherapy was side-lined to make way for drug therapy and the monopolization of healthcare provision by the pharmaceutical companies, an interesting and perhaps controversial assertion.

2.3.2.2 Chromotherapy - How does it work?

Both Demarco and Clarke (2001) and Yousuf et al. (2005) provide definitions of colour and light in the metaphysical sense, light being electromagnetic energy which is part of a continuous spectrum of wave energy ranging from cosmic waves to infra-red, microwaves, radar, television and radio waves. All are forms of radiation but with differing wavelengths, colour being a spectrum of energy waves each with its own frequency. However, whilst Yousuf et al. (2005) critical analysis of chromotherapy and its scientific evolution concurs with statements made by Demarco and Clarke (2001), they differ on what the effects of coloured light energy vibration have on the body.

Yousuf et al. (2005) suggest that coloured light interacts with water at a cellular and molecular level, whilst Demarco and Clarke (2001) suggest that coloured light is received optically through the visual cortex, affecting the pineal gland and the hypothalamus which regulate the autonomic nervous system that regulate fluid balance, heat, circulation, breathing, growth, maturation and pituitary secretions, and the endocrine (hormonal) system. This assertion is supported by Kuller et al. (2006) who state that light is received by the retina, and is transmitted to the hypothalamus, an endocrine gland that controls the circadian rhythms influencing physiological variables such as melatonin secretion, cortical activity and alertness. Additionally, the circadian rhythm affects the limbic system which regulates feelings of happiness, sadness, anger and other emotions. According to Rot et al. (2008) exposure to bright light over a short time period is associated with positive social interaction and good mood. These assertions that coloured lighting is received by the hypothalamus via the retina, influencing the circadian rhythm and the secretion of hormones (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008) became fundamental elements in the formation of a research hypothesis for the present study.

2.3.3 PHOTOTHERAPY (Heliotherapy)

2.3.3.1 White Light or Daylight Therapy

Light therapy or phototherapy (classically referred to as heliotherapy) appears interchangeable with chromotherapy but consists of exposure to daylight or specific wavelengths of light using polychromatic polarized light, lasers, light-emitting diodes (LED's), fluorescent lamps, dichroic lamps or very bright full-spectrum light (Thompson, 1990., Benedetti et al, 2003., Terman, 2007., Prasko, 2008., Sanissi, 2014., Lam et al, 2016). The light is administered for a prescribed amount of time and, in some cases, at a specific time of day (Lam et al, 2016). One common use of the term is associated with the treatment of skin disorders, chiefly psoriasis, acne vulgaris, eczema and neonatal jaundice (Diffey, 1980., Hamilton et al., 2009., Titus and Hodge, 2012., Pei et al., 2015). It is thought that light therapy is received by the retina and is also used to treat circadian rhythm disorders such as delayed sleep phase disorder (DSPD) and can be used to treat seasonal affective disorder (SAD) with some support for its use also with non-seasonal psychiatric disorders (Lam et al, 2016). In relation to alleviating the symptoms of SAD, bright light therapy (BLT) can have benefits (Krzysztof et al., 2012., Lam et al., 2016) although even for such an established treatment for SAD there is some evidence to the contrary (Cugini, 2001., Berg and Siever, 2009).

Whilst it appeared that some contradiction also existed for the use of white or natural light as a therapy, as with coloured light therapy, importantly Munich and Bromundt (2012) concurred with Demarco and Clarke (2001) suggesting that light synchronizes the primary mammalian biological clock in the suprachiasmatic nuclei, stating that light is strongest synchronizing agent (zeitgeber) for the circadian rhythm. The evidence presented on the efficacy of white or daylight as a therapy in treating certain conditions, further supported the emerging hypothesis that coloured lighting could potentially manipulate the circadian rhythm to modulate food consumption.

2.3.4 WHITE LIGHT AS THE ZEITGEBER OF THE CIRCADIAN RHYTHM

2.3.4.1 White Light and Sleep - The Emergence of Chronobioengineering

White light is described as a zeitgeber of the circadian rhythm (Siffre, 1975). Exogenous zeitgebers, such as light, are external cues or time-givers that help to keep circadian rhythms in tune with the changing external environment (Siffre, 1975., Biovin et al., 1996). If organisms are lacking these zeitgebers the biological rhythms such as the sleep wake cycle would be distorted (Boivin et al., 1996). Therefore exogenous zeitgebers are crucial in keeping the biological rhythms in time with that of the changing external environment. The importance of external cues and the significance of artificial light have been shown by Boivin et al. (1996) who also found that zeitgebers have the ability to over-ride endogenous factors that is those factors controlled internally by the body (Russel et al., 1980). The research (Boivin et al., 1996) helped disprove the assumption that the sleep-wake cycle was only affected by natural light, supporting the notion that artificial lighting could also act as a zeitgeber to the circadian rhythm.

Ellis et al. (2013) present the benefits of manipulating white lighting levels within healthcare and nursing home environments, suggesting that designing the correct levels of white lighting can alleviate symptoms for patients with misalignment of their circadian rhythm such as those suffering from Alzheimer's and dementia. The basis for this suggestion is supported by numerous researchers (Siffre, 1975., Russel et al., 1980., Biovin et al., 1996) with regard to artificial white lighting and the nature of light as a zeitgeber, and the research of others (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008., Munich and Bromundt, 2012). By taking into account the evolution of circadian rhythm systems, normally aligned to the geophysical cycles of night and day, and recognising the debilitating effects of 24/7 artificial illumination within indoor environment, Ellis et al. (2013) claim the beneficial effects of white light in normalising the circadian rhythms and a positive effect on reducing sleep disturbance and misalignment. For aging circadian systems, or those with dementia, it is possible to realign them with the geophysical cycles with the use of artificial night and day light differentiation (Ellis et al., 2013). Chronobioengineering is an emergent field of study combining chronobiology, the study of periodic (cyclic) phenomena in living organisms with photobiology, the study of the effect of light on living organisms (Ellis et al., 2013). Chronobioengineering aims to translate scientific results from these fields for practical application, a theory supported by (McEachron, 2012., Ellis et al., 2013., Kent, 2014).

The evidence identified supporting the potentially modulating properties of white lighting on sleep cycles (Siffre, 1975., , Russel et al., 1980., Biovin et al., 1996., Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008., Munich and Bromundt, 2012., Ellis et al., 2013., Kent 2014) further supported the emergence of the hypothesis.

2.3.5 WHITE LIGHT AND APPETITE

2.3.5.1 The Hypothalamus and Appetite Stimulating Hormones

The relatively recent assertion regarding the beneficial effects of white lighting as a zeitgeber in realigning the circadian rhythms and sleeping patterns of Alzheimer's and dementia patients is becoming better understood (McEachron, 2012., Ellis et al., 2013., Kent, 2014). Most significantly in the context of the present study, Kent (2014) raised the possibility that light may also possess the ability to stimulate other biological activities controlled by the hypothalamus, such as appetite. The systems by which the body is physiologically signalled to eat or to feel full are described by Schwartz et al. (2000), Halford and Blundell (2000) and Blundell et al. (2012). According to Gibbons et al (2014), the complex homeostatic system comprises a network of gastrointestinal peptides and brain neurotransmitters, and also peripheral neural signalling and adipokines such as leptin. Kent (2014) states that ghrelin is an orexigenic hormone synthesized by oxyntic cells in the stomach and by neurons in the medial and lateral hypothalamic nuclei (Kojima et al., 1999; Cowley et al., 2003) and is a peripheral and central hormone directly implicated in appetite. Ghrelin acts in the pituitary and hypothalamus to stimulate growth hormone secretion, energy homeostasis, appetite, and weight gain (Kojima et al., 1999; Wren et al., 2000; Tschöp et al., 2000; Kojima and Kangawa, 2005; Szentirmai et al., 2006; Chen et al., 2009; Castañeda et al., 2010). Ghrelin stimulates feeding (Nakazato et al., 2001; Toshinai et al., 2006), and circulating levels rise prior to mealtimes (Cummings et al., 2001; Frecka and Mattes, 2008).

In addition to regulating appetite, there is evidence that ghrelin also plays a role in the circadian system by directly entraining circadian clocks that drive behavior or indirectly by stimulating appetite and activity (Cowley et al., 2003; Yi et al., 2006). Under restricted feeding conditions, the circadian system is sensitive to ghrelin and other feeding-related neuropeptides (Yannielli et al., 2007). Wright (2004) found links between hormone secretion by the hypothalamus and hunger, finding that Leptin, the hormone that influences perceptions of fullness, influenced food consumption and nutritional intake. Rolls (2006) concurred with Wright (2004), but also suggested that whilst food intake and satiety were controlled by brain mechanisms, a number of sensory and environmental factors contribute to the regulation of food intake. In further support of the effectiveness of ghrelin in the stimulation of appetite, Hotta et al. (2009) found that treating anorexia nervosa patients with ghrelin injections increased hunger and food consumption. However, some of the research undertaken to assess the beneficial effects of bright light therapy (BLT) on patients with anorexia nervosa is contradictory. BLT had a positive effect on some patients (Yamamotova et al., 2008) with Goel et al. (2009) calling for further trials after finding that patients with Night Eating Syndrome (NES) had their symptoms relieved by BLT. However, in later research BLT was shown to have either no effect or a very temporary effect (Daansen, Haffman, 2010., Suarez-Pinilla et al., 2015).

Conversely BLT has also been used to treat patients suffering from conditions which cause periods of binge eating, such as bulimia nervosa (Blouin et al., 1996), winter binging by bulimia nervosa sufferers (Braun et al., 1999), and night eating syndrome (McCune, 2014). The effects of light therapy on food intake and affective symptoms of bulimia nervosa (BN) were examined in a double-blind study by Blouin et al. (1996). Eighteen women who met *DSM-III-R* criteria for BN were randomly assigned to receive either 2500 lux of bright light (experimental condition) or < 500 lux of dim light (placebo condition) daily in the early evening for a 1-week period. Whilst subjects in the bright light condition showed a significant improvement in depressed mood during light exposure, no effect of light therapy was found on the frequency, size, or content of binge-eating episodes. However, in a double blind study of 34 bulimic patients Braun et al. (1999) treated 16 with a 10,000 lux bright white light and 18 with a 50 lux dim red light (placebo control) during the winter months. The mean binge frequency decreased significantly more from baseline to the end of treatment for the bright light group ($F(1,29) = 6.41$, $P = .017$) than for the placebo group. McCune (2014) found significant improvement in night eating measures following application of BLT. Results showed statistically significant reductions in mean scores on measures assessing night eating symptoms (NESS) with scores decreasing on average by 9.47 points and participants reported a 47% reduction of weekly nocturnal ingestions ($t = 2.68$, $p = .02$) from pre- to post-treatment, decreasing from an average from 3.47 times per week before treatment to 1.83 times per week after treatment McCune (2014) This study was one of the first to advance the chronobiological treatment literature by testing the efficacy of bright light therapy to improve symptoms of night eating syndrome. By 2016, De Young et al. stated further research was required to investigate the possible mechanisms through which BLT may influence binge eating in BN.

In terms of lighting affecting the appetites of those not suffering from a specific condition, Wansick (2012) found that replacing bright lights with dimmed lighting and soft music in fast food restaurants reduced food consumption, and Reid et al. (2014) suggested that light had more of an impact on weight regulation than sleep. Wyse et al. (2014) undertook a review to determine the relationships between artificial lighting and interruptions to the circadian rhythm, finding evidence that imbalance in lighting found in the modern city environment, with brightly lit nights and artificially lit daytime environments, impacted upon appetite and may even be connected to global obesity.

2.3.6 COLOURED LIGHT - A ZEITGEBER OF FOOD CONSUMPTION?

2.3.6.1 A Novel Field of Investigation

Despite a body of evidence in fields closely related to the present study question, such as chromotherapy, phototherapy and chronobioengineering, up to February 2015 no empirical evidence existed in support of the assertion that coloured light may modulate food consumption. However, there was some research evidence that coloured lighting had some effect of the hedonic impression of foods, although this was scant. Suk et al. (2012) provided participants with various food stimuli (green salads, mixed sweets, blueberry cake) under coloured light-emitting diode (LED) lighting, but participants were not required to eat the food. The study investigated an interaction effect on 60 participants (28 male, 32 female) between lighting colour and food colour that stimulates or reduces appetite. Two empirical studies were undertaken supposing that there would be an interaction effect between food colour and lighting colour, and that appetite should increase or decrease caused by this interaction effect (Suk et al., 2012). For the preliminary test, the observers were able to add only a certain lighting hue to the given context that was already lit with daylight. In the main experiment, the lighting facility was improved, so that observers might control not only hue aspect but also colour chroma and illumination. Food stimuli were composed of two aspects, type (natural or processed) and complexity (low or high), and consequently they were grouped into four categories analysing the best and worst combination (Suk et al., 2012). The results of the study found three major findings: First, among chromatic lighting, yellow stimulates while red and blue discourages. Second, when colour categories of lighting and food are similar to each other, it stimulates the appetite whereas complementary, it discourages it. Third, the type of food does not act as an influencing factor (Suk et al., 2012). This provided the final piece of convincing evidence in support of the original research question and in the formation of the novel study hypotheses. Suk et al. (2012) also provided the first evidence that yellow lighting might be the colour that increases food consumption.

However, what is unclear from the study by Suk et al. (2012) is the duration of exposure to the coloured light, and the implications of shorter or longer periods of exposure. In considering exposure duration in the design of the present study, exposure will be limited to the food consumption period, with very limited pre-exposure as participants enter the laboratory area.

2.4 SMALL SCALE SIMULATION – initial observations

Following the review of literature and identification of a possible hypothesis that coloured lighting could potentially manipulate the circadian rhythm in order to modulate food consumption, in July 2014 a small scale simulation of the study by Suk et al. (2012) was performed in order to test methods and inform the design of the present study. An LED lighting bar was used to illuminate three plates of food with red, green, yellow, blue and white light in the controlled conditions of a blacked out room. The meals used were fish, chips and mushy peas, chicken curry with white rice, and cheese and onion quiche with mixed leaf salad. The simulation was undertaken to identify the hedonic visual palatability of the plates of food under each of the coloured lighting conditions in order to narrow down the number of test colours for the present study, no food was consumed. The simulation included two participants, one being the principle investigator, and each plate of food was subjected to each of the 5 lighting conditions for the duration of 5 minutes. Hedonic impression of the visual palatability of the food was recorded in a laboratory note book, and determined that blue coloured lighting appeared to have the most negative effect on the hedonic impression of the food, and yellow coloured lighting appeared to have the most positive effect on the hedonic impression of the food. The results of this small-scale simulation, in addition to Suk et al. (2012), were then used to progress the design of the present study.

2.5 COLOURED LIGHT AND APPETITE

Following the small scale simulation, Hasenbeck et al. (2014) published a study to determine the colour and illuminance level of lighting to modulate willingness to eat photographs of coloured bell peppers. Participants were shown photographs of red, green and yellow bell peppers taken under white, red, green, blue and yellow LED lighting. The study recruited 57 participants (49 women and 8 men) with an age range of 19 and 76 years. Participants were shown photographs of three different coloured bell papers that had been taken under the four coloured lighting conditions. The participants themselves were not exposed to these coloured lighting conditions, they were seated in booths illuminated with standard fluorescent white light whilst observing the photographs on a computer screen and rating them using a 9 point Likert scale. The study found statistically significant results for the hedonic impression and willingness to eat bell peppers under the blue and yellow lighting, a negative and positive effect respectively. Their suggestion was that blue coloured lighting has a distorting effect on the appearance of the food and thus had a negative effect on hedonic impression, whereas yellow light increased visual clarity of the surface of the food thus increasing the hedonic impression and willingness to eat. There was acceptance that further research was required using real foods in replacement of photographs in order to support these initial findings, although the absence of the manipulation of the participants' direct environment with coloured lighting was not discussed. In addition, Hasenbeck et al. (2014) used photographs of illuminated food, whereas the small-scale simulation and (Suk et al., 2012) illuminated real food under coloured LEDs. However, despite these limitations both studies (Suk et al., 2012, Hasenbeck et al., 2014), and the small-scale simulation conducted in July 2014, found that blue coloured lighting appeared to have a negative impact on the hedonic appearance of the photograph or plate of food, and yellow coloured lighting had the most positive effect on the hedonic appearance of the photograph or plate of food.

However, whilst (Suk et al., 2012, Hasenbeck et al., 2014) were significant in this little researched field the basis of their research hypotheses was grounded in the use of coloured light as a psychological stimulus, rather than any physiological effect coloured light may have on the circadian rhythm. The premise of both studies was to identify what visual psychological stimulus was significant in the hedonic selection of food in order to inform commercial retail and food industry. The hypotheses of the Suk et al. (2012) and Hasenbeck et al. (2014) studies was that colour has a psychological impact on hedonic impression, and no links were made between the potential for coloured lighting to modulate food consumption via a manipulation of the circadian rhythm. Whilst both studies (Suk et al., 2012, Hasenbeck et al., 2014) findings concurred with the results of the small scale simulation in relation to the effects of blue and yellow coloured lighting, the reasons for how this might work differed greatly from the present study's novel hypothesis. Despite this, the two studies provided a sound evidence base upon which to view the results of the small-scale simulation study, and importantly supported the decision to use blue and yellow coloured lighting in the present study.

However, during the planning stages for this research study, and following submission of ethics approval, in February 2015 a publication entitled: 'Blue lighting decreases the amount of food consumed in men, but not women', was published by Cho et al. (2015). The study was designed to investigate whether the colours of lighting affected the amount of food consumed, in addition to psychological hedonic sensory perceptions of the food and willingness to eat. The influence of lighting colour was also compared between men and women of the one-hundred and twelve participants (62 men and 50 women) who consumed an *ad libitum* breakfast meal of omelettes and mini-pancakes under one of three different lighting colours: white, yellow, and blue. During the test, hedonic impression of the food's appearance, willingness to eat, overall flavour intensity and overall impression of the food, and meal size (i.e., the amount of food consumed) were measured. The results demonstrated that blue lighting decreased the hedonic impression of the food's appearance, but not the willingness to eat, compared to yellow and white lighting conditions. The blue lighting significantly decreased the amount consumed in men, but not in women, compared to yellow and white lighting conditions. Overall flavour intensity and overall impression of the food were not significantly different among the three lighting colours.

Cho et al. (2015) mirrored many of the methods already designed for the present study, in that it was conducted within a controlled sensory laboratory environment and the focus was on the use of blue and yellow coloured lighting. However, there were weaknesses in their methods; each participant was only exposed to one of the lighting conditions, just once, whereas the study by Hasenbeck et al. (2014) conducted a repeated measures design and within group analysis. Additionally, the meal consisted of multiple components with differing nutritional values and protein density, thus rendering the measurement of food consumed by weight flawed; in addition the participants were not blinded to the conditions of the study and any restrained eating habits of the participants were not tested.

Despite these flaws in selection of methods, the study found the effect of lighting colour on the amount of food consumed was different between men and women. A two-way ANCOVA found a significant two-way interaction of lighting colour and gender in the meal size (i.e., the amount of food consumed) ($P = 0.02$). The meal size significantly differed across lighting colours in men ($P = 0.002$), but not in women ($P = 0.90$). Men consumed significantly less of the meal served under blue than under yellow coloured lighting ($P < 0.001$) and white coloured lighting ($P = 0.03$). The study also found that the meal size was not significantly different between yellow and white lighting conditions ($P = 0.22$) (Cho et al., 2015).

However, there were no significant differences among the three colours of lighting in women. Cho et al. (2015) suggest a plausible explanation for the sex difference in the lighting colour-induced meal size may be related to women's superiority in detecting, discriminating, identifying, and remembering odour cues (Doty et al., 1984; Larsson, Lövdén, & Nilsson, 2003., Hummel et al., 2007). Before beginning to consume the breakfast meal, nasally perceived odours could lead the participants to evaluate if the foods are safe to eat. Based on previous findings that women outperform men in identifying and discriminating odours (Hummel et al., 2007) and women are more attentive and dependent on olfactory cues for their daily decisions (Croy et al., 2010; Seo et al., 2011; Seo, Lee, & Cho, 2013), women are expected to more easily identify whether or not a meal is safe to eat, regardless of the lighting colour under which is presented. By contrast, men's sense of smell is relatively less sensitive leaving the men more dependent on visual cues, potentially rendering them more vulnerable to distorted visual cues such as blue lighting.

Cho et al. (2015) accepted their findings should be interpreted with caution due to limitations of their study. Firstly, it could not be ruled out that lighting colour induced mood or emotional state modifications might influence their results. However, they felt that this assertion was not enough to explain the gender difference in the effect of lighting colour on the amount of food consumed. It was also noted that flavour intensity was recorded as not significantly different among the three lighting colours, and between men and women.

Cho et al. (2015) findings support and extend the notion that the colour of lighting can affect the hedonic impression of the overall appearance of foods. Further, the study claimed to provide new empirical evidence that the colour of lighting influenced the volume of food consumed, albeit the modulatory effect was more pronounced in men than women. That is, men, but not women, consumed significantly less of the meal under blue lighting compared to under the yellow and white lighting conditions. Overall impression of the meal was not different among the three lighting colour conditions. However, the claim that less food was consumed under blue lighting compared to yellow lighting ($P < 0.001$) is flawed as a significant difference between meal sizes between the two test colours does not indicate more or less. Only an increase or decrease in consumption against the white control can be identified as either an increase or decrease, therefor this claim that less food was consumed by males under blue lighting compared to yellow is incorrect, as equally it could be said that more food was eaten under yellow lighting than blue lighting when compared to each other and not a control.

In contrast to the two previous studies (Suk et al., 2012, Hasenbeck et al., 2014) who examined hedonistic reaction to coloured lighting in order to inform the commercial retail and food industry, Cho et al. (2015) asserted that based on their results, blue coloured lighting could be applied to reducing overconsumption in obese men. Their findings suggested a potential way of addressing the global obesity problem (Must et al., 1999) and associated economic burdens (Finkelstein et al., 2009). However, recognition was given that the research offered only a first step in understanding the effect of lighting colour on food consumption, and further studies would need to be conducted to confirm and support their findings. A recommendation was made to conduct further studies, by measuring positive or negative mood or emotional state, to determine whether or not the effect of lighting colour on the amount of food consumed results from the lighting colour-changed mood or emotional state.

In conclusion, Cho et al. (2015) have provided the first empirical evidence that the colour of lighting can modulate food consumption. More specifically, the claim that blue coloured lighting decreased the amount of food consumed in males without reducing their acceptability of the food provided the first empirical evidence of the initial verbal dieting tip that has led to the abductive formation of a research question for the present study. However, the results found no significant difference in food consumption under yellow lighting compared to white lighting conditions, although there were significant differences in consumption in males between blue and yellow lighting conditions. Due to the limitations of Cho et al. (2015) further investigation using within subject methods was deemed necessary.

2.6 CHAPTER SUMMARY AND IMPLICATIONS FOR STUDY DESIGN AND METHODS

The aim of the review of literature was to develop a comprehensive and critical review of the theoretical and conceptual domains and discourses. Consideration was given to existing knowledge, practice and the evidence base relating to the present study. Existing literature has identified through the development of a search strategy a systematic approach. Theory, discourse and evidence have been evaluated with reference to the field of investigation, which highlights a degree of contradiction. Empirical research evidence to support the hypothesis has been identified and critically discussed.

Within the research that tested performance under coloured lighting conditions using specific colours (red and green), empirical evidence demonstrates colour appears to have a stimulating psychophysiological effect in certain contexts Wilson (1966), Soldat et al. (1997), Hill and Barton (2005), Stark et al. (1982) and Elliot et al. (2007). There are also assertions that coloured lighting is received by the hypothalamus via the retina, influencing the circadian rhythm and the secretion of hormones (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008) which became fundamental elements in the formation of a research hypothesis for the present study. Whilst it appears that some contradiction exists for the use of white or natural light as a therapy, as with coloured light therapy, importantly Munich and Bromundt (2012) concurred with Demarco and Clarke (2001) suggesting that light synchronizes the primary mammalian biological clock in the suprachiasmatic nuclei, stating that light is strongest synchronizing agent (zeitgeber) for the circadian rhythm. The evidence presented on the efficacy of white or daylight as a therapy in treating certain conditions further supported the emerging hypothesis that coloured lighting could potentially manipulate the circadian rhythm to modulate food consumption.

Ellis et al. (2013) presented the benefits of manipulating white lighting levels within healthcare and nursing home environments and suggesting that by designing the correct levels of white lighting, symptoms could be relieved for patients suffering misalignment of their circadian rhythm and sleep disturbance such as those with Alzheimer's and dementia. The basis for the suggestion is supported by (Siffre, 1975., Russel et al., 1980., Biovin et al., 1996,) with regard to artificial white lighting and the nature of light as a zeitgeber, together with the research of (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008., Munich and Bromundt, 2012). This suggestion in the context of the problem the present study aims to address, that of high levels of patient malnutrition which have been found to be more prevalent amongst older patients (Age Concern, 2006., Age UK, 2010., Edmondson-Jones, 2010) is of particular interest. The suggestion that white lighting is a zeitgeber of the circadian rhythm and can help those suffering from a misalignment of their circadian rhythm and indicated there might be the potential that coloured lighting might also be a zeitgeber of the circadian rhythm. In further support of this, evidence of a potential link between white lighting, a zeitgeber, and food consumption was provided by Kent (2014) who suggested the possibility that light may also possess the ability to stimulate other biological activities controlled by the hypothalamus, such as appetite. Kent (2014) states that white light can stimulate the secretion of the hormone ghrelin, which is directly implicated in appetite acting in the hypothalamus to stimulate appetite and weight gain.

However, despite this evidence it has been established that the concept that coloured lighting could be a zeitgeber of food consumption is a novel concept and has the potential to contribute new knowledge to the field of enquiry. Additionally, whilst the first published study, Cho et al. (2015), sought to identify any modulation in food consumption as a result of coloured lighting as a variable, their hypothesis is focused entirely on psychological assumptions, rather than any physiological effects.

Whilst the present study is a progression of the study by Cho et al. (2015), the hypothesis that coloured lighting could potentially manipulate the circadian rhythm in order to modulate food consumption is novel. Additionally, if the present study were to find that yellow coloured lighting increased food consumption, this contribution of empirical evidence to the field of investigation could have significant implications for the prevention of malnutrition amongst hospitals patients, particularly those suffering from misalignment of the circadian rhythm such as Alzheimer's and dementia patients. Whilst the ability to manipulate the psychology associated with food and hedonic impression is of interest, the potential to modulate food consumption physiologically through a manipulation of the circadian rhythm could be significant.

2.6.1 Implications for Study Design and Methods

Much of the research evidence identifying the effects of colour and coloured light uses quantitative research methods, such as randomised control trials and questionnaires (Wilson, 1966., Soldat et al., 1997., Hill and Barton, 2005., Stark et al., 1982., Elliot et al, 2007). The use of such methods indicates a positivist scientific philosophical epistemology, described by Crotty (1998) as being borne out of a philosophy with an objective epistemological stance and a positivist theoretical perspective. Polgar and Thomas (2000) describe the scientific method and the positivist view as having three basic elements, 1. Scepticism. The notion that any proposition or statement, even those by great authorities, is open to doubt and analysis. 2. Determinism. The notion that events in the world occur according to regular laws and causes, not as a result of the caprices of demons or witches. 3. Empiricism. The notion that enquiry ought to be conducted through observation and verified through experience (2000). This philosophical stance lends itself readily to quantitative research methods such as experimentation, randomisd control trials and longitudinal studies. However, although a positivist scientific approach has been taken within many of the studies, through critical discussion it has been identified that contradiction exists between the results. It has been established that humans react to colour in a variety of ways, physically, physiologically, psychologically and psychophysiologically and that context is a significant factor. As a result, in designing a quantitative research study to test the hypothesis, strict contextual and methodological considerations need to be observed to provide rigour to any findings. The weaknesses identified in the study by Cho et al. (2015) such as the lack of blinding of participants, the meal being made up of components with varied protein and carbohydrate density, the exposure of participants to only one lighting condition rather than a repeated measures within group comparison (Hanna and Dempster, 2012), have all been taken into account in the design of the present study and will be presented in detail within chapter 3.

Following the review of literature, the null hypotheses that have emerged are:

- Coloured light does not modulate food consumption
- Coloured light does not modulate appetite
- Coloured light does not modulate visual palatability
- Coloured light does not modulate mood
- Coloured light is not a zeitgeber of food consumption

2.6.2 Definitions in Context

It is helpful to provide some definitions of the nouns ‘appetite’ and ‘palatability’, which are used throughout the remainder of the project report. It can be observed that both of these terms can be defined subjectively, and are commonly used together and interchangeably. Within the Oxford English Dictionary (OED), appetite is defined as ‘a natural desire to satisfy a bodily need, especially for food or sexual activity’ (OED, 1990, p51). Immediately there is an issue presented within the dictionary definition for appetite, as it could reasonably be expected that an appetite for food would differ somewhat from an appetite for sexual activity. As will be presented in Chapter 3, appetite was measured using a combined score of four questions rated 1 – 100 on VAS with participants rating their levels of hunger, fullness, desire to eat and capacity to eat. The scores for hunger, desire to eat and capacity to eat were combined, together with the reverse score for fullness with a range of 1 - 400. The use of VAS to determine appetite is supported (Stubbs et al., 2000). Therefore, within the context of the present study, the term ‘appetite’ is used to mean the self-rated appetite scores obtained from participants during the experiment which rated their overall ‘desire to eat’. The OED define palatability as ‘pleasant to taste’ (OED, 1990, p857), however Yeomans et al. (2004) question whether ‘palatability’ is a response to nutritional need or a need-free stimulation of appetite. In the present study the term is used in conjunction with the word ‘visual’ in order to assess if something ‘looks pleasant to taste’. As will be presented within Chapter 3, Methods, data gathered was derived from Visual Palatability VAS in order to assess participants’ self-rated hedonic impression of the meal before tasting it. Therefore, within the context of the present study the term ‘palatability’ is used alongside ‘visual’ to determine the self-rated scores obtained from participants prior to eating the meal in order to rate hedonic impression.

CHAPTER 3 - STUDY DESIGN AND METHODS

3.1 INTRODUCTION

The previous chapter hypotheses that coloured lighting could potentially manipulate the circadian rhythm in order to modulate food consumption grounded in the theories of chromotherapy (Demarco and Clarke, 2001., Yousuf et al., 2005), phototherapy (Thompson, 1990., Benedetti et al, 2003., Terman, 2007., Prasko, 2008., Sanissi, 2014., Lam et al, 2016) and the emergent field of chronobioengineering (McEachron, 2012., Ellis et al., 2013., Kent, 2014). Following the initial dieting tip and the completion of a small scale simulation, the colours yellow and blue were identified for use in the present study. The selection of these colours was further supported by Hasenbeck et al. (2014) and Cho et al. (2015) who found that blue coloured lighting had the most negative impact on the hedonic impression of food, whilst yellow coloured lighting had the most positive impact. Therefore, within the context of the problem of patient malnutrition, and based on the evidence presented within the literature, the present study aimed to identify specifically if yellow coloured lighting increased food consumption. Additionally, the weakness in study design and choice of methods identified in Cho et al. (2015) were taken into account in order to strengthen the present study design and methods, with the aim of increasing the quality of data produced in order to withstand a greater degree of rigour.

This chapter will present a critical and justified account of the epistemological underpinning, the research design, and the rationale for selecting the specific methods of data collection and statistical analysis required to identify any modulating effects of coloured light on food consumption. Suggested methods of research are explored from a practical perspective and results critically discussed in order to demonstrate the suitability of methods for inclusion within the present study. Firstly, any ethical considerations posed by the present study are presented.

3.2 RESEARCH PARTICIPANTS

3.2.1 Ethical Considerations

Having identified an area for further investigation in the context of the problem of patient malnutrition, it is perhaps helpful to understand some founding principles of research ethics. In 1943 the Moscow Declaration of The Four Nations on General Security was agreed and signed by President Roosevelt, Premier Stalin and Prime Minister Churchill (Salman et al., 2014). The declaration had four parts, one of which focused on preventing a reoccurrence of the atrocities performed in Nazi Germany. In 1947 this work was developed further with the publication of the Nuremberg Code, consisting of ten founding research principles aimed at protecting participants (Salman et al., 2014). Then in 1964 the World Medical Association General Assembly adopted the Declaration of Helsinki, further amended on six occasions up to 2008 (Salman et al., 2014) The declaration is a statement of ethical principles to provide guidance to physicians and other participants in medical research involving human subjects, considerations relating to their well-being should take precedence over the interests of science and society (Salman et al., 2014). In support of this the Royal College of Nursing (RCN) (2007) argues that all research can be potentially harmful to participants, controlled trials that test new drugs through invasive procedures could unintentionally cause harm, likewise naturalistic enquiries that seek evidence about sensitive topics could cause inadvertent emotional stress and potential damage to individuals. Researchers therefore are required to uphold specific ethical principles, reducing the risk to participants whilst also addressing any potential moral issues (RCN, 2007). The Department of Health (DH) Research Governance Framework for Health & Social Care (DH, 2005), states that the dignity, rights, safety and well-being of participants must be the primary consideration in any research study. Informed consent is at the heart of ethical research and the law gives special protection to people who are unable to give consent on their own behalf. Researchers must respect a person's previous wishes, and consult someone, such as a carer, who is able to take an independent view of an incapacitated person's interests, wishes and feelings (DH, 2005). The Economic & Social Research Council (ESRC) (2005) provided six principles of research ethics which aimed to ensure the appropriate design and delivery of research, and the safeguarding of research participants.

Health research, by its very nature, may involve the use of patients as research participants, therefore when considering research ethics the status of participants must be considered. Within the context of hospital patients, these are classified into two groups, in-patients who stay overnight and out-patients who attend appointments. To generalise, it is likely that the acuity of illness of an in-patient might be more severe than that of an out-patient, although there are some obvious exceptions such as oncology patients seen on an out-patient basis for chemotherapy or renal patients undergoing dialysis. As part of the selection of appropriate research methods, consideration was given to the potential to undertake the present study by recruiting participants who were the intended beneficiaries of the research, that is, hospital patients. In order to consider this, the status of hospital patients was considered, and according to the definition provided by The Social Research Association (SRA) Ethical Guidelines (2003) was found to be classified as vulnerable. SRA (2003) view that those participants in a dependent relationship to the researcher or commissioning body are classified as vulnerable, in the context of the present study a hospital patient and an NHS Hospital Trust.

The RCN Research Ethics – Guidance for Nurses (2007) define vulnerable to encompass a multitude of different patient populations including children, people with mental illness or learning difficulties, prisoners or young offenders. Wray (2008) expands this to include people with mental health problems, learning disabilities, minority groups including refugees and asylum seeker communities, unemployed people, disabled people, older people, pregnant teenagers, homeless people and single parents. It appears therefore, that many people receiving health care potentially fall into these groups and could be classified as vulnerable. As service users this puts them into a dependent relationship with the researcher or commissioning body, to say nothing of their clinical state (SRA, 2003). As a result of defining of patients as vulnerable, this poses a dilemma for the hospital based researcher in that the necessity of undertaking research within the workplace will always result in the research participants being in a position of vulnerability. Therefore, in selecting an appropriate research design and methods for use in answering the research question, the potentially vulnerable status of participants was taken into account. From the results of Suk et al. (2012), Hasenbeck et al. (2014); and Cho et al. (2015), it was likely that blue coloured lighting might decrease food consumption and thus it would be inappropriate to expose patients classed as vulnerable (SRA, 2003., RCN, 2007., Wray, 2008) to a blue lighting which might decrease their nutritional intake. This resulted in a decision to recruit volunteer participants for the present study from groups of 'healthy' university students and staff. The use of vulnerable patient participants is discussed further in chapter 5.

3.2.2 Ethical Approval

Following the decision to recruit volunteer participants from university student and staff groups, any ethical considerations arising from the decision were reviewed with reference to the SHU Research Ethics Policy and Procedure, 6th Edition (SHU, 2015). The first stage of ethical approval process was the completion of an ethics checklist known as the SHUREC1, (see appendix E) such as the ability of participants to give consent, the use of vulnerable participants, and ability for participants to withdraw from the study were considered. In completing the SHUREC1 it was identified that because the present study intended to administer food, completion of a SHUREC2b form was required for referral to the Faculty Research Ethics Committee (FREC) (see appendix F). Confirmation of approval for the study by the FREC was received in March 2015 (see appendix G), and was subsequently amended in May 2015, (see appendix H).

3.3 EPISTEMOLOGICAL, METHODOLOGICAL AND METHODS CONSIDERATIONS

Following the conception of the original idea that coloured light may modulate food consumption, a critical review of the literature was undertaken in order to confirm the suitability of the hypotheses for the purposes of further research. The application of logical reasoning to knowledge gained from authoritative and empirical sources confirmed the validity of the hypothesis, and although very limited previous research had been undertaken, there was some empirical evidence to suggest that colour may have a modulating effect on food consumption in certain contexts. Much of the research evidence identifying the effects of colour and coloured light used quantitative research methods, such as experimentation, randomised control trials and questionnaires. In order to design the methods for this study a number of logical assumptions were made using the existing knowledge gained from the review of literature. These assumptions were then tested by undertaking an initial small-scale simulation of the study methods to enable critical reflection and the identification of any learning points.

3.4 SMALL-SCALE SIMULATION - JULY 2014

In order to consider the engineering and technical implications as recommended by Van Hoof et al. (2012) and to confirm the colours to be used taking account of (Suk et al., 2012), in July 2014 some methodological assumptions were made and then tested by undertaking a small-scale simulation..

The simulation was undertaken within a non-clinical area of an NHS Hospital. A small room, approximately 1.5m x 2.5m was used and a high level window was blacked out using thick cardboard. Three meals were selected from the daily menu of the staff restaurant; quiche and salad, fish and chips with mushy peas and chicken curry and white rice, and these were placed on a table in the room. A bar shaped light fitting containing 5 LED colour changing lamps with a single electronic controller was used to illuminate the room and meals. There were four primary colours, in addition to white as Suk et al. (2012) had shown statistically significant results for the hedonic selection of lighting relative to food colour. In total five monochromatic colours were used to illuminate the meals in the following sequence and colour intensity:

1. Blue 100%
2. Green 100%
3. Red 100%
4. Yellow (Red and Green 100%)
5. White (Red, Green and Blue 100%)

Results were taken in the form of notes in order to keep a record of the effects of each of the coloured lighting conditions on the meals. No participants other than the principal investigator and a lighting engineer were involved in the simulation, and the meals were not consumed under the coloured lighting conditions.

3.4.1 Simulation Discussion

The simulation suggested that small rooms or cubicles (1m x 1m) would be most effective for use in the final study, indicating the use of a purpose built sensory laboratory containing individual feeding booths. In support of this, empirical evidence identified through the review of colour research undertaken (Wilson, 1966., Isaacs, 1980., Stark et al, 1982., Rosenstein, 1985., Valdez and Mehrabian, 1994., Hatta et al., 2002., Soldat et al, 1997., Hill and Barton, 2005., Elliot et al, 2007., Spenwyn et al., 2010) provided useful descriptions of the methods applied and the practical implications for the research of colour and light. For example; study participants are exposed to different colour conditions on an individual basis or in groups dependent upon the activity being tested. Natural light is eliminated from the study area so as not to dilute the colour, and the colour saturates a large area such as an entire wall or room, and in the case of coloured light research coloured lighting is the only method of illumination. In previous research studies participants have been required to undertake certain tasks whilst exposed to the colours, such as the completion of academic tasks, gambling or a sporting activity. As SHU has a purpose built sensory laboratory consisting of 12 International Standards Organisation (ISO) standard sensory feeding booths the decision was made to use this facility.

As well as determining the use of a sensory laboratory, it was observed during the small-scale simulation that the different lighting colours had a dramatic effect on the appearance of the meals, in support of findings by Suk et al. (2012). These initial observations suggested that both blue and red coloured lighting made each of the meals look particularly unappetising. However, yellow lighting appeared to have a positive effect upon the appearance of the meals by enhancing the intensity of the colours. Even benign colours in foods such as white rice and deep fried yellow batter of fried fish appeared more vibrant, golden and appetising. From these results, and the review of literature identifying results of research (Suk et al., 2012) the colours blue and yellow were selected for use, rather than using all four colours (red, green, blue, yellow) as had previously been assumed.

The small-scale simulation proved invaluable in determining some of the methods used in the final study design, such as an appropriate environment and the colours to be used. In addition, within a month of the completion of the small-scale simulation, in August 2014 results of the bell pepper study by Hasenbeck et al were published, closely followed in February Cho et al. (2015). As well as both studies supporting the choice of the colours of blue and yellow, the studies also supported the use of a controlled laboratory environment.

3.5 METHODS

Following identification in the literature of contradictory evidence arising from colour research, and a recommendation to follow engineering methods for the research of lighting (Ellis et al., 2013), the present study aimed to achieve a Gold Standard in its design of methods for the research of coloured light and appetite (Gibbons et al., 2014). Critical reviews of research methodology undertaken by Ellis et al. (2013) for the use of light, and Sorensen et al. (2003) and Gibbons et al. (2014) for the study of eating behaviour, food consumption and appetite, were drawn upon and applied in the context of the present study and in order to critique the methods used by Cho et al. (2015).

Gibbons et al. (2014) suggest the researcher needs to make an initial distinction between the type of research to be undertaken, either within a controlled laboratory condition or a free-living environment. This fundamental decision must be made based on a trade-off between the rigorous control that can be applied within a laboratory, and that of a more naturalistic eating environment. Ultimately the study hypothesis and theoretical background will determine the decision. In the context of the present study the requirement to isolate a specific factor for investigation, coloured light, and to reduce any other influences or variables demanded a laboratory environment. This decision was supported by the methods applied by Cho et al. (2015) who undertook their research within a sensory laboratory environment within the University of Arkansas. Additionally, the type of data being collected in order to demonstrate any effect of the intervention requires the rigour of a strictly controlled environment. Gibbons et al. (2014) assert that when procedures and methodologies to measure appetite, food consumption and eating behaviour are conducted with the appropriate degree of scientific control, data produced is of a high quality. Good laboratory practice (GLP) (Gibbons et al., 2014) was observed and version controlled Standard Operating Procedures (SOPs) (Gibbons et al., 2014) were developed and followed rigidly, for example; directions on food preparation, and the management and administration of raw data.

Having identified weaknesses in the methods used by Cho et al. (2015) which measured differences between 112 subjects, the present study used a repeated measures within group comparison design in order to measure differences both within and between subjects (Sorensen et al., 2003). A repeated measures design is preferred as each participant is exposed to each of the colours of lighting, and becomes their own control (Hanna and Dempster, 2012). There are also benefits of increased power with a smaller sample size, although according to Minke (1997) the benefits of repeated measures designs can be great, there are internal validity issues that must be addressed. "Carryover" effects are effects from one treatment that may extend into and affect the next treatment, these include tracking memory over time or investigating practice or fatigue on a targeted behaviour (Minke, 1997). However, this internal validity threat can be controlled through counterbalancing, that is by varying the presentation order of treatments, either randomly or systematically, and interaction between treatment order and main effect can be investigated through data analysis (Huck and Cormier, 1996). Additional weaknesses identified in the study by Cho et al. (2015) were considered, such as the decision to use a composite breakfast meal made up of separate components of a pre-made ham and cheese omelette and mini pancakes. The reasons given for selecting these food items were that they were recognisable breakfast foods in North America (Cho et al., 2015). However, as the measure of consumption was made by weight of food consumed, the use of multiple components in the meal containing varied protein and carbohydrate density and calorific values was not robust, and therefore reduces the validity of their results. Additionally, the decision to test a breakfast meal, whilst enabling a fast from the evening meal the previous night, did not allow for the delivery of a controlled pre-load meal to control any variables further. In addition, in the study of eating behaviour and food consumption the delivery of a controlled pre-load meal, followed by a homogenous meal are felt to be more robust methods (Sorensen et al., 2003., Gibbons et al., 2014). Study participants were also blinded in order to protect against bias (Schulz and Grimes, 2002), and a number of other controls were put in place such as inclusion/exclusion criteria which included a requirement to complete a questionnaire identifying eating behaviour. As in the study by Cho et al. (2015), data would be collected for a number of factors such as visual palatability, appetite, weight of food consumed, and following a recommendation by Cho et al. (2015) for mood. With the basis of study design in place, consideration was given to identifying a sufficient sample size.

3.6 SAMPLE SIZE

In addition to the evidence from the small-scale simulation and the determining of the main components of study design, some other constraints of the present study were already known which would affect sample size, such as constraints on time and on funding. Following the decision to undertake the study within a laboratory environment rather than a naturalistic one (Gibbons et al., 2014), consideration was given to constraints such as the availability of the laboratory facilities and the number of sensory booths, twelve, contained within that facility. As the colours to be tested had been determined to be (white (control), blue and yellow), the colours to be used were known to be three in number, therefore to undertake a repeated measures within group comparison using three lighting colours, participants would be required to visit one of the twelve sensory booths on three separate occasions to consume a meal under each lighting colour. Studies with repeated measures within group comparison need to avoid treatment fatigue by ensuring a sufficient time interval between treatments, a wash-out period (Hanna and Dempster, 2012). Therefore the decision was taken to design the study with a six day wash out period interval. The day selected for each of the four groups was either a Tuesday or Wednesday, as it was felt that by being in the middle of the week it was more likely that participants would adhere to pre-trial controls such as fasting. The study would be repeated on the two following corresponding weekdays, over a period of three weeks in total, in order to expose each participant to the white (control), blue and yellow lights, with a wash-up week for any participants that may have missed a week due to illness or any other reason. An additional de-briefing session was also required due to the decision to blind participants; therefore, it took a minimum of four weeks to run the study for a maximum of twelve participants due to only having 12 sensory booths.

In order to determine if twelve participants is sufficient, the conducting of power analysis can be advantageous whilst designing a study, not least in order to determine the necessary number of subjects required. However, according to Cohen (1988) trying to find the absolute, bare minimum number of participants needed in a study is often not a good idea. However, power analysis can be used to determine power given an effect size and the number of subjects available, and can be used if the maximum number of subjects is already predetermined where the identification of power justifies undertaking the study, as there would no reason to undertake an underpowered study. In addition, according to Cohen (1988) conducting power analysis reduces the chances of Type I and Type II errors occurring. A Type I error occurs when the null hypothesis is true (in other words, there really is no effect), but you reject the null hypothesis. A Type II error occurs when the alternative hypothesis is correct, but you fail to reject the null hypothesis (in other words, there really is an effect, but you failed to detect it) (Cohen, 1988). However, according to Hoenig and Heisay (2001) there are some limitations to power analysis, one of which is that power analyses do not typically generalize well. If the methodology changes in how data is collected or the statistical procedure used to analyse the data is changed, the power analysis will need to be redone. In some cases, a power analysis might suggest a number of subjects that is inadequate for the statistical procedure. For example, a power analysis might suggest that 30 subjects are required for a logistic regression, but logistic regression, like all maximum likelihood procedures, require much larger sample sizes (Hoenig and Heisay, 2001). Perhaps the most important limitation is that a standard power analysis is only able to provide a best case scenario, simply an estimate of the necessary number of subjects needed to detect the effect. In most cases, this best case scenario is based on assumptions and educated guesses (Hoenig and Heisay, 2001).

According to Shadish, Cook and Campbell (2002), power analysis is just part of doing good research. A power analysis is a good way of making sure that every aspect of a study and the statistical analysis has been considered before collecting data. Acknowledging the limitations, and taking consideration of all the reasons for undertaking a power analysis, one of the major benefits is to ensure that every detail of a research project has been considered in order to design a robust study.

3.6.1 Obtaining the Necessary Numbers to do a Power Analysis

According to Cohen (1988) there are at least three ways to guestimate the values that are needed to do a power analysis: a literature review, a pilot study and using Cohen's own recommendations. However it is the effect size that is often the most difficult to obtain and has the strongest impact on power. It was established within the review of literature that only one other study by Cho et al. (2015) existed that was similar to this study, however this was not published when power analysis was undertaken for this study. Additionally, even then when it was published it did not report the effect size or power; therefore a value could not have been identified from previous literature for effect size. Due to the constraints of time, money and resource is was not feasible to conduct a pilot study using participants in order to provide a rough estimate of the effect size, in addition the limitations associated with the use of small numbers in a pilot study may have rendered the effect size flawed and could have led to an increased error risk (Hoenig and Heisay, 2001). In such circumstances an expert clinician could also provide a view of the value of a difference of an independent variable from the control mean, and in the context of the present study an NHS Dietician provided a view that in the context of a nutritionally compromised patient, any increase in (g) consumption is helpful as this improves the current position in terms of calorific intake. However, this opinion is difficult to translate into an effect size.

Sedlmeier and Gigerenzer (1989) found that the average effect size for articles in The Journal of Abnormal Psychology was a medium effect, or 0.5. Lipsey and Wilson (1993) undertook a meta-analysis of 302 meta analyses of over 10,000 studies and found that the average effect size was 0.5, which supports a view by Cohen that, as a last resort, guess that the effect size is 0.5 (Bausell and Li, 2002). According to Keppel and Wickens (2004), when you really have no idea what the effect size is, go with the smallest effect size of practical value. Although effect size is often the largest contributor to power, according to Cohen (1988) there are at least a dozen other factors that influence the power of a study. Many of these factors should be considered not only from the perspective of doing a power analysis, but also as part of doing good research. Other factors affecting power are significance (alpha) applying 0.01 rather than 0.05, increasing sample size and other methodological issues such as the type of method of collecting data, such as repeated measures within group design, and collecting data at multiple time points, and collecting more than one measure of response.

3.6.2 Power Calculation

A power calculation was undertaken using the following assumptions:

- Medium Effect Size $d = 0.5$
- Significance level (alpha) $P < 0.05$
- Individual Sensory booths
- Repeated Measures within Group design - each participant to be exposed to every colour

- 3 lighting colours: Blue, Yellow and White (control)
- Randomised exposure to each colour

This initial identification of some of the study methods enabled power calculations to be undertaken providing both a sample size and a proposed duration of the study. Table 2 shows that (g) have been used for illustration. If the average meal consumed in the study were to have a mean of 800g and standard deviation of 100g, so that most meals consumed are between 500-1100g ie. ±3 SD of the mean, the effect size and sample size calculation can be based on being able to detect differences (between light colours) of certain proportions of this standard deviation. For instance, for a study of 15 subjects, it could be said that it would have 0.85 power to detect a difference of half a standard deviation (50g) between the mean (g) consumed under different light colours. Some suggested values were:

Table 2. Shows the number of participants required to achieve varying power and effect sizes, * denotes 15 participants can achieve a power of 0.85, and effect size of 0.50.

Participants	Power	Effect Size (No. of SDs)
5	0.8	0.93
5	0.85	1
5	0.9	1.07
5	0.95	1.2
10	0.8	0.59
10	0.85	0.63
10	0.9	0.67
10	0.95	0.74
15	0.8	0.47

15*	**0.85***	**0.50***
15	0.9	0.53
15	0.95	0.59

The smaller the difference the study aims to detect, the more difficult it is and the more participants are required. It was determined that a difference of half a standard deviation 0.50 is considered to be a suitable effect size to apply (Sedlmeier and Gigerenzer, 1989., Bausell and Li, 2002), therefor as indicated by * a sample size of 15 participants would be a good number to consider in order to achieve sufficient power and a medium effect size to provide rigour to the results. However, in order to reduce the potential for order effect as a consequence of the sequence of exposure to each lighting colour and the control, results are presented for 30 participants. This number was selected as it increased the power of the study, and whilst counterbalancing was not fully achieved due to design restrictions within the sensory laboratory with only 5 out of the possible 6 sequences being tested, Table 3. the potential for any undetected effect of order was reduced and will be analysed as part of the data analysis.

Table 3. Latin square design showing the 6 possible sequences.

	Sequence	Sequence
	1 W Y B	4 W B Y
Participant	2 Y B W	5 B Y W
	3 B W Y	6 Y W B

3.7 PARTICIPANT RECRUITMENT

In total four groups were recruited to and recruitment was conducted under the blinded study title of: The Effects of Coloured Light on Mood whilst Eating. Promotion of the study was undertaken via the Sheffield Hallam Staff electronic newsletter, group emails to staff and PhD students, promotion by the supervisory team in lectures, and the wide and repeated distribution of recruitment posters throughout both the City and Collegiate Campuses. An example of a recruitment poster is provided (see appendix I).

A review conducted by Sorensen et al. (2003) of 14 studies researching appetite and food intake focused on reducing variables of the study participants to strengthen the power of a study. Sorensen et al. (2003) suggest that participants recruited should be healthy subjects, ideally with a ‘normal’ body mass index of 18.5-25.0 kg/m^2, aged between 18-50 years. However, it can be seen that the study by Cho et al. (2015) provides a mean BMI for each group randomly assigned to white, blue or yellow light with the mean BMI’s being 27.1 kg/m^2, 27.9 kg/m^2 and 26.6 kg/m^2 so the average participant is defined as ‘overweight’. The decision was taken not to exclude participants from this study if their BMI exceeded 25 kg/m^2, unless their BMI was a significant outlier to the rest of the group in order to avoid the sample becoming too heterogeneous. Prospective participants were initially interviewed by telephone to ensure they met the inclusion criteria using a telephone interview sheet (see appendix J).

The inclusion criteria for participants were:

- Participants aged 18 – 70 years

- Ideally a Normal Body Mass Index (BMI) score ($18.5 kg/m^2$ to $25 kg/m^2$)
- Males and females
- Participants not taking any medication known to stimulate or suppress appetite
- Stable weight (no loss or gained ≥ 2 kg in the preceding six month period)
- No metabolic health conditions, particularly those known to effect appetite
- Participants have a normal eating behaviour, confirmed by the completion of the revised Three Factor Eating Questionnaire (TFEQ-R18)

Note: The prevalence of male colour blindness was considered but since red and green were not used this was deemed not to be a significant control factor.

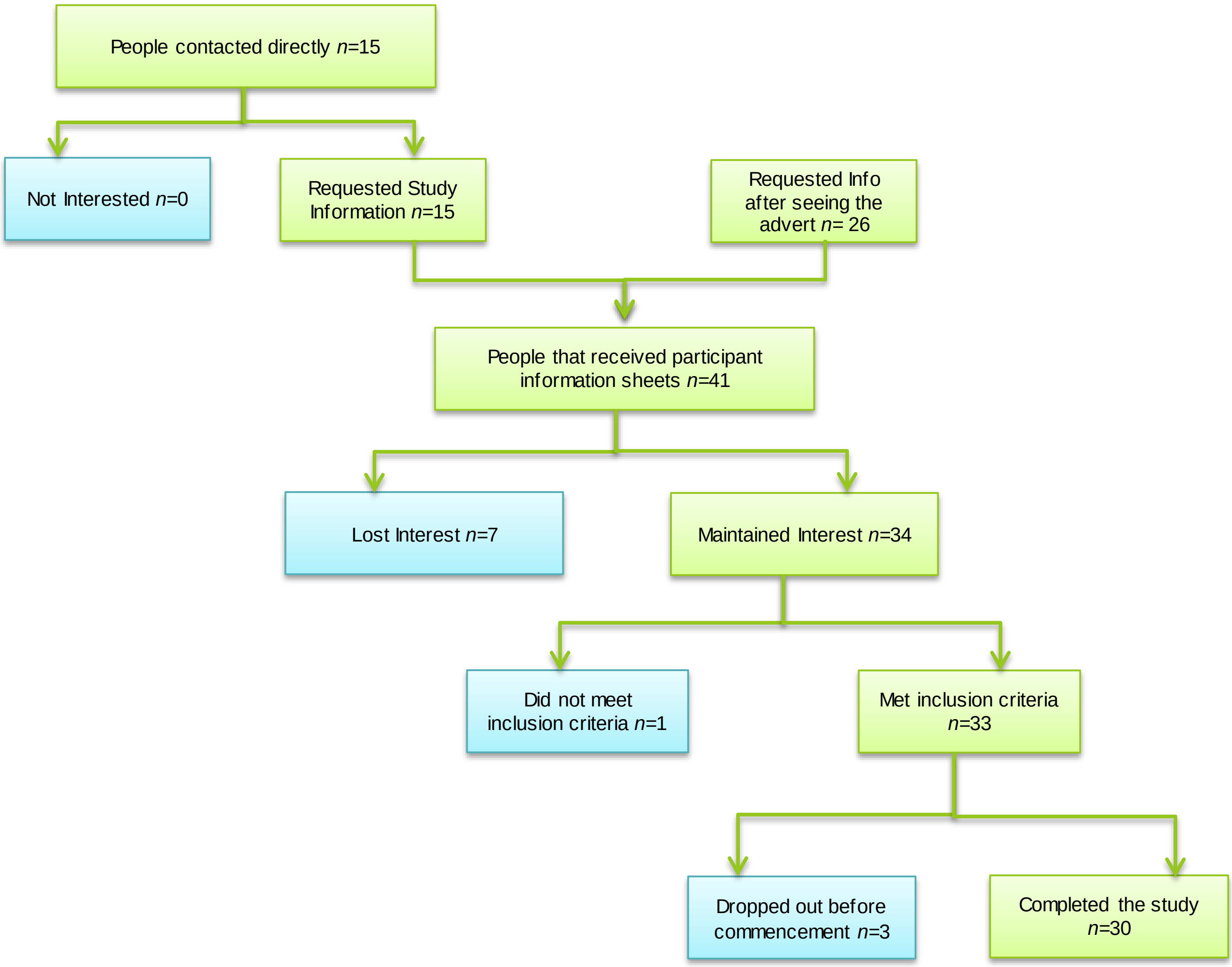

Figure 4. Recruitment Activity.

In total 34 people were assessed for inclusion into the study, only 1 was excluded on health grounds due to taking medication for diabetes, and 3 withdrew before commencement of the study. In total, thirty non-obese participants (Age 26.8 (12.5) y; BMI 23.6 (3.16) kg/m^2), males n=16 (Age 26 (11.6) y; BMI 23.6 (3.7) kg/m^2) and females n=14 (Age 27.6 (13.9) y; BMI 23.6 (2.5) kg/m^2) completed the present study.

Participants were randomly assigned into four groups based on the date they volunteered, and exposure to the colours was randomised between groups as detailed in figure 5 in order to avoid any learning or sequence effects. Participants were assigned a numbered sensory booth alphabetically by surname, and were assigned a code deduced from their booth number and a gender initial as identification. In addition, two participants were unable to attend the planned second week where they would have been exposed to blue light and therefore received blue in a wash-up session on an additional week. The wash-up sessions improved the robustness of results by allowing more participants to be exposed to all three colours.

Participant Code Group/Booth Number/Gender	Week 1	Week 2	Week 3
G1 B1 M	White	Blue	Yellow
G1 B2 M	White	Blue	Yellow
G1 B3 M	White	Yellow	Blue(Wash-Up)
G1 B4 M	White	Yellow	Blue(Wash-Up)
G1 B5 M	White	Blue	Yellow
G1 B6 M	White	Blue	Yellow
G2 B1 F	White	Blue	Yellow
G2 B2 F	White	Blue	Yellow
G2 B3 F	White	Blue	Yellow
G3 B1 F	Blue	Yellow	White
G3 B2 F	Blue	Yellow	White
G3 B3 M	Blue	Yellow	White
G3 B4 F	Blue	Yellow	White

G3 B5 M	Blue	Yellow	White
G3 B6 F	Blue	Yellow	White
G3 B7 M	Blue	Yellow	White
G3 B8 F	Blue	Yellow	White
G3 B9 M	Blue	Yellow	White
G4 B1 M	Yellow	Blue	White
G4 B2 M	Yellow	Blue	White
G4 B3 F	Yellow	Blue	White
G4 B4 M	Yellow	Blue	White
G4 B5 F	Yellow	Blue	White
G4 B6 F	Yellow	Blue	White
G4 B7 F	Yellow	White	Blue
G4 B8 M	Yellow	White	Blue
G4 B9 F	Yellow	White	Blue
G4 B10 M	Yellow	White	Blue
G4 B11 M	Yellow	White	Blue
G4 B12 F	Yellow	White	Blue

Figure 5 Participant code and sequence of exposure to colour.

3.8 PRE-STUDY REQUIREMENTS AND ACTIVITY

Following the initial telephone interview a participant information and consent booklet (see appendix K), was provided to all participants in electronic format via email. It was explained to all participants that two paper copies of the booklet would be available for them to complete and sign, together with the Principle Investigator, on the morning of the first day of the study. One copy was retained by the participant, and one copy was retained by the principle investigator. The Participant Information Sheet, Participant Consent Form were administered before the study commenced as part of the recruitment process.

Participants were required to complete a 24 hour food and exercise diary for a day preceding the first study day and to repeat this prior to subsequent study days. Participants were instructed to use the diary to keep a record of their food consumption and were asked to refrain from vigorous exercise for the 24 hour period preceding each of their three study days. The 24 Hour Food and Exercise Diary is provided (see appendix L). Participants were also required to refrain from eating, with the exception of water, after their last meal the evening before the study in order to achieve metabolic homeostasis (Gibbons et al., 2014).

3.9 THREE FACTOR EATING QUESTIONNAIRE (TFEQ-R18)

When examining appetite, controlled recruitment of participants is a significant factor in reducing any natural variables which may arise from a participants ‘normal’ eating behaviour, or eating traits. Therefore a study requirement was the completion of the 18 question Three Factor Eating Questionnaire (TFEQ-R18) (Karlsson et al., 2000) during the preliminary visit. The TFEQ-R18 was developed on the basis of psychometric analyses of the original 51-item TFEQ in a sample of 4377 Swedish, middle-aged, obese men and women (Karlsson et al., 2000). Although it was constructed using data from obese adults, it has been shown to be valid in the general population in France (De Lauzon et al., 2004) and in the United States (Cappelleri et al., 2009) which showed that TFEQ-R21 needed refinement. Three items were removed from the CR domain, producing the revised version TFEQ-R18V2 (Comparative Fit Index (CFI)=0.91) used for the present study. Testing TFEQ-R18V2 in the web-based sample of 1275 obese, overweight and normal weight adults supported the revised structure (CFI=0.96; Cronbach's coefficient alpha of 0.78-0.94), two independent datasets, the TFEQ-R18V2 showed robust factor structure and good reliability (Cappelleri et al., 2009). The TFEQ-R18 was also shown to be valid in female adolescents and adults in Finland (Angle et al., 2009), structural validity of the TFEQ-R18 was good in this sample of young Finnish females with a varying range of body weights. Use of the instrument as a measure of eating behaviour was thus corroborated. The questionnaire is composed of 18 questions that measure 3 different aspects of eating behaviour: restrained eating (conscious restriction of food intake in order to control body mass; 6 items), uncontrolled eating (tendency to eat more than usual due to a loss of control over intake accompanied by subjective feelings of hunger; 9 items) and emotional eating (inability to resist emotional cues; 3 items). As recommended by Karlsson et al. (2000), responses to statements were completed on a 1-4 Likert scale (1= definitely false, 4 = definitely true) with the values being initially summated into scale scores for cognitive restraint, uncontrolled eating, and emotional eating, and later converted to a 0-100 scale using the following formula:

(Raw score – lowest possible score) / (possible raw score range) x 100.

The ranges for the items were 6–24 for cognitive restraint, 9–36 for uncontrolled eating, and 3–12 for emotional eating with higher scores in the respective scales being indicative of greater cognitive restraint, uncontrolled, or emotional eating. High levels of cognitive restraint have been associated with intent to diet and controlled eating (Lawson et al., 1995). However, it is important to consider that this scale was not designed to measure disordered eating behaviour, and does not designate a cut-off score that would indicate the threshold of clinical levels of restrained eating. Therefore, participants were deemed as highly restrained eaters when scoring more than 18 (raw score out of a total of 24) or 66 (percentage score).Of the sample recruited, one male and one female, scored above the highly restrained eater threshold with a scores of 72 and 88 respectively, (see appendix M)., however due to the requirement to maintain a sample size of 30 and in case of withdrawals these participants were included within the study.

In order to test if there were any associations or interactions for restraint within the results, restraint scores for all 30 participants were used as a covariate in the analysis of the data.

3.10 ENGINEERING METHODS

Reflecting upon the evidence provided by existing colour research (Sorensen et al., 2003., Van Hoof et al., 2012., Hasenbeck et al., 2014) and subsequently by Cho et al. (2015), taking into consideration that this study aimed to research both coloured lighting and appetite, it was also necessary to observe very strict methods for technical engineering

Following the identification that the lamp fittings within the sensory feeding booths at SHU would not support LED lamps, the following lamps were identified for use within this study, with two corresponding coloured lamps being fitted to each booth on the corresponding weeks:

- Blue Crompton Coloured Reflector ES-E27 240 Volt Lamps, 35 degree beam angle, 80mm Diameter/112mm Height
- Yellow Crompton Coloured Reflector ES-E27 240 Volt Lamps, 35 degree beam angle, 80mm Diameter/112mm Height

Table 4. Lamp Specifications

Lamp Product Code	**Colour Temperature/Hue in Kelvin (k)**	**Nominal Lumens (lm)**	**Colour Rendering**	**Munsell Scale Match**
Crompton R8060BES	3425.6	15	80.76	5B Blue
Crompton R8060YES	2229.6	485	92	6Y Yellow
B00CNKHXRS E27	6000	1080	N/A	10 White

The colour temperature, or hue, is described in Kelvin (Valdez and Mehrabian, 1994) and has been matched to the nearest colour notation on the Munsell scale (Munsell, 1961). Figure 6 provides some context with regard to the numerical Kelvin colour temperature of the lamps selected, giving parameters such as the midday sun, moonlight and sunrise and sunset. From this colour temperature chart it can be determined that the colour temperature of the blue coloured lamp at 3425.6k is situated just beneath the colour temperature of 3500k of the morning and evening sun. It can also be determined that the colour temperature of yellow coloured lamp at 2229.6k is just beneath the colour temperature of 2500k of sunrise and sunset. According to the chart, a white light bulb is 3000k and is situated equidistantly between 2500k of sunrise and sunset, and 3500k of morning and evening sun. Cho et al. (2015) did not provide details of the colour temperature used. The relevance of the colour temperature used in the present study will be presented in the concluding chapter.

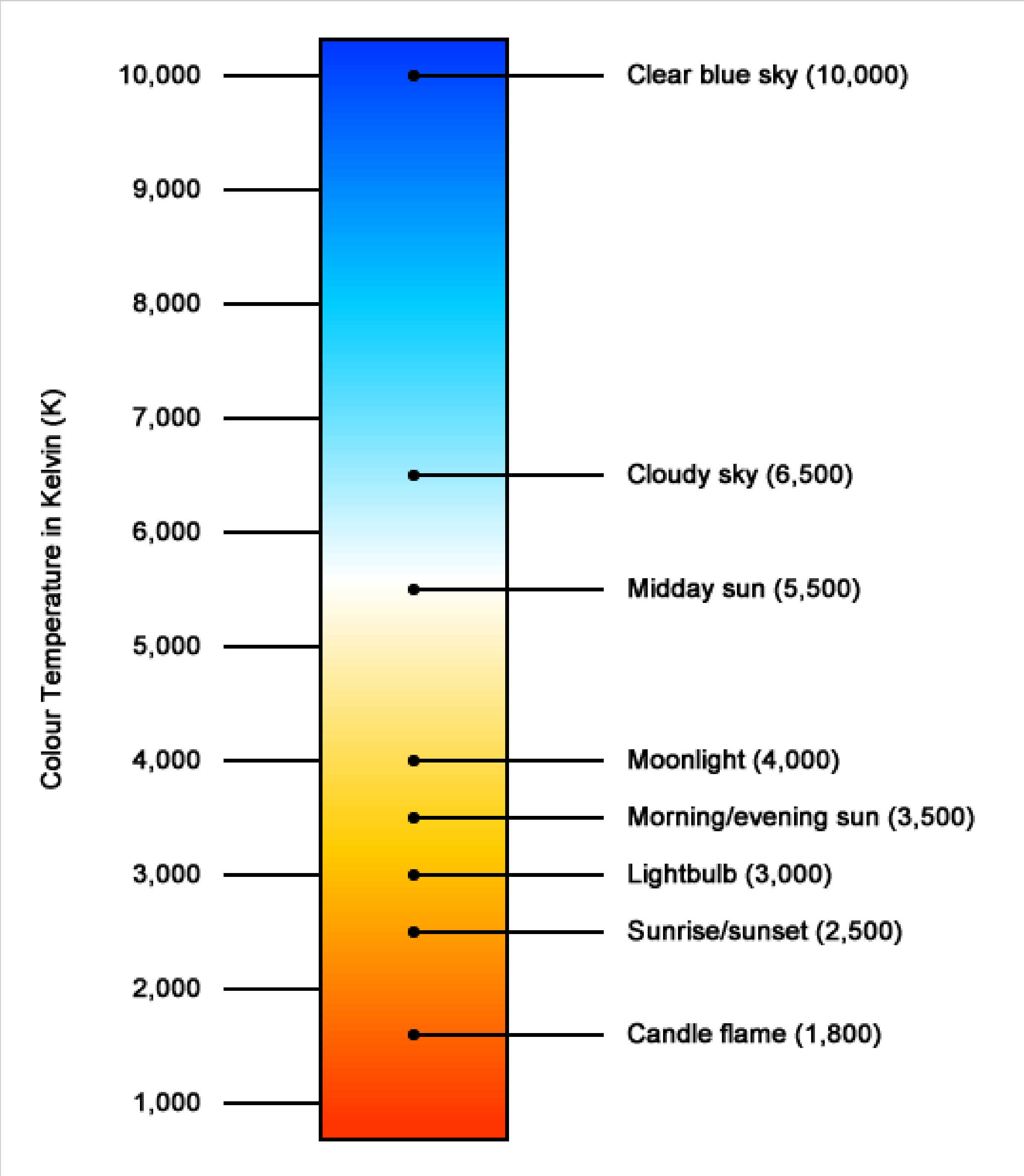

Figure 6. Colour Temperature (Hue) Chart taken from http://www.photographymad.com/pages/view/what-is-colour-temperature

3.11 STUDY MEAL SELECTION

In deciding on the composition and timing of the meal to be consumed, consideration was given to the existing research evidence. In developing the methods for the present study, methodological weaknesses identified in the study by Cho et al. (2015) were considered, such as the decision to use a composite breakfast meal made up of separate components of a pre-made ham and cheese omelette and mini pancakes. The reasons given by the researchers for selecting these food items were that they were recognisable breakfast foods in North America (Cho et al., 2015). However, as the measure of consumption was made by weight of food consumed, the use of multiple components in the meal containing varied protein and carbohydrate density and calorific values was not methodologically sound, and therefor reduces the robustness of their results. Therefore, the decision was taken to provide a homogenous meal (Hill et al., 1995., Blundell et al., 2010). Additionally, the decision to provide a breakfast meal, whilst enabling a fast from the evening meal the previous night, did not allow for the delivery of a controlled meal prior to the study to further control any variables (Gibbons et al., 2014). As a result of the methodological weaknesses identified within the study by Cho et al. (2015) decisions were made to provide the *ad libitum* lunch meal at 12.00pm midday, following a pre-study fast overnight and the consumption of a controlled breakfast meal at 9am on the morning of the study.

Following numerous trials of potential meals for the controlled breakfast and study lunch meal, the controlled breakfast meal chosen was a Kellogg’s Nutrigrain Elevensies Raisin Bake bar. Whilst the energy density of the control breakfast was the same for males and females, it was standardised so any varying effects on satiety prior to consuming the study meal was consistent for each lighting condition.

The controlled breakfast meal was consumed at 9am on the morning of the study day and consisted of: Kellogg's Nutri-Grain Elevenses Raisin Bake, portion size delivered at 0.75g per kilo of participant body weight, and two 330ml bottles (660ml in total) of Harrogate still water. The nutritional content of the Nutri-grain bake are provided in Table 5.

Table 5. Nutritional Content of Kellogs' Nutrigrain Elevensies Bar

Kellogg's Nutri-grain Elevensies Raisin Bake	**Per 100g**	**Recommended Daily Intake**
Energy	1569kJ 372 kcal	8400kJ 2000 kcal
Fat	9 g	70 g
of which saturates	0.8 g	20 g
Carbohydrate	67 g	-
of which are sugars	40 g	90 g
Fibre	2.5 g	-
Protein	4.5 g	-
Salt	0.45 g	6 g
Vitamins	% NRV	-
Thiamin (B1)	0.62 mg (56)	-
Riboflavin (B2)	0.78 mg (56)	-
Niacin	9.0 mg (56)	-
Vitamin B6	0.78 mg (56)	-
Folic Acid	112 ug (56)	-
Vitamin B12	1.4 ug (56)	-
Iron	5.3 mg	-

(38)

The homogenous lunch meal chosen for the study meal consisted of white penne pasta in Dolmio™ tomato and basil sauce. The decision to use a homogenous meal was taken to ensure that the protein density and calorific value of the entire study meal was consistent from the first spoon consumed through to the last (Hill et al., 1995., Blundell et al., 2010). Participants were required to eat the *ad libitum* homogenous lunch meal until they felt comfortably full and satisfied; the meal was served in portions of 500g. Participants were able to indicate they needed more food by depressing a switch within the sensory booth activating an external light only visible to the research team. A further 500g portion of the pasta lunch meal was then provided without the requirement for any interaction between the participant and the research team. A standard operating procedure (SOP) for the production of the study lunch meal was developed which details controls from the purchase and supply of the ingredients, to the method of cooking and maintaining the temperature of the study meal whilst serving. The dried white Penne Pasta was placed into a large saucepan 2/3 filled with already boiling water (heated to a rolling boil) for a minimum of 12 minutes and a maximum of 15 minutes, and then drained. The Dolmio™ Tomato and Basil sauce was heated in a separate medium sized saucepan to a minimum temperature of 63 degrees centigrade, and maximum temperature of 75 degrees centigrade (Food Standards Agency, 2007). The SOP for Food Production is provided (see appendix N). The calorific and nutritional values of the pre-load breakfast and study meal are provided in table 5.

The *ad libitum* study lunch meal was consumed between 12.00 and 12.30 pm and was made up of Penne White Pasta and Dolmio™ Tomato and Basil Sauce which was combined in volumes of 12kg of pasta (cooked weight) to 5kg of Dolmio™ sauce. The nutritional contents are provided in table 6 for a 500g portion of the cooked penne pasta and Dolmio™ sauce.

Table 6. Nutritional content of the study meal

Cooked White Penne Pasta in Dolmio™ Tomato and Basil Pasta Sauce	**Per 500g**	**Recommended Daily Intake**
Energy	3,540kJ 710 kcal	8400kJ 2000 kcal
Fat	3.9 g	70 g
of which saturates	0.67 g	20 g
Carbohydrate	141 g	-
of which are sugars	12.7 g	90 g
Fibre	4.5 g	-
Protein	24.2 g	-
Salt	1.1 g	6 g

The *ad libitum* study meals were served in on square white china plates, accompanied by a stainless steel knife, fork, spoon and paper napkin. The same style of plate and cutlery were used throughout the study. Pictures of the study meal under each lighting condition are shown in figures 7, 8 and 9.

Figure 7. Lunch meal under White light

Figure 8. Lunch meal under Blue light

Figure 9. Lunch meal under Yellow light

3.12 DATA COLLECTION

3.12.1 Appetite

Sorensen et al (2003) recommends that appetite should be measured by self-evaluation using Visual Analogue Scales (VAS). Flint et al. (2000) support the use of VAS asserting that they provide good reproducibility, and are a valid assessment of appetite sensations, a view supported by Stubbs et al. (2000) who highlights that VAS act as a useful adjunct to measures of food, energy and nutrient intake. VAS show sensitivity to experimental manipulations and good reproducibility (Flint et al., 2000). VAS are horizontal lines of varying length, with statements anchored at each end describing the extremes of a unipolar question, (for example for hunger: 'I have never been more hungry'/ 'I am not hungry at all') (Sorensen, 2003 p1153). Participants indicate their feelings by making a mark along a horizontal line measuring 100mm in length with quantification being made by measuring distance from the left end of the line to provide a score out of 100. Data from the present study were gathered using paper based VAS for appetite and visual palatability (hedonic impression). The principle investigator measured all VAS to ensure there were no differences in interpretation of the results.

In order to determine any differences in appetite ratings between the colours, VAS, (see appendix O), were completed at five set times points before, during and post consumption of the study meal at 11.00pm, 12.00pm, 12.15pm, 12.30pm, 12.50pm. In order to minimise interaction with participants, timing of completion were indicated by the sounding of a whistle. Levels of hunger, fullness, desire to eat, capacity to eat and thirst were all measured along their own separate scales. A single appetite score was derived using a combined score of four of the scales rated 1 – 100mm, hunger, fullness, desire to eat and capacity to eat. The scores for hunger, desire to eat and capacity to eat were combined, together with the reverse score for fullness with a range of 1 - 400mm. On order to test for any effect of colour on hunger specifically, hunger scores were analysed separately.

3.12.2 Visual Palatability (Hedonic Impression)

On each of the study days the participants completed one visual palatability VAS at 12.00pm in order to measure hedonic impression of the food prior to tasting it (see appendix P).

3.12.3 Mood

As per a recommendation from Cho et al. (2015), mood state was also measured during the study in order to identify any differences under, and between, each lighting condition, the absence of which is recognised as a weakness in their own study. The measuring of mood state also supported the blinding of participants as they believed the study to be: The Effects of Coloured Light on Mood Whilst Eating. The tool selected to measure mood was the Profile of Mood State (POMS) questionnaire (McNair, 1971) which is a standard validated psychological test. The questionnaire contains 65 words/statements that describe feelings people have. Validity of the tool is supported for use in an adult population (Terry et al., 2003) confirmatory factor analysis provided support for the factorial validity of a 24-item, six-factor model using both independent and multi-sample analyses. The test required participants to indicate for each word or statement how they were feeling and the results are represented by an aggregated Total Mood Disturbance (TMD) score. A TMD score is calculated by adding the raw scores from tension, depression, anger, fatigue and confusion and then subtracting a vigour score. This gives a value between –24 and 177, with lower scores indicative of people with more stable mood profiles. Therefor a numerically declining score indicates an improving mood, and transversely a numerically increasing score indicates a worsening of mood. Participants were required to complete a POMS questionnaire (see appendix M) at three points over the duration of the study at 11am, 12pm and 12.30pm.

3.12.4 Food Consumption

Food consumption was measured by weighing the food remaining on each participant's plate from the *ad libitum* meal described in section 3.11 at the end of 30 minutes allowed. The weight of the china plates used was excluded from the measurements by utilising the 'tear' option on the calibrated scientific scales located within the sensory laboratory metabolic kitchen. Each 500g portion of the lunch meal was precisely weighed using calibrated weighing scales. Car was taken to include any food stuff remaining on cutlery.

3.12.5 Data Collection Summary

Data were collected using the following tools:

- Appetite rated using Visual Analogue Scales (VAS)
- Visual Palatability - Hedonic Impression rated using VAS
- Mood state rated using Profile of Mood State (POMS) Total Mood Disturbance (TMD)
- Food consumption measured by weight in grams (g)

The gathering of the data using these tools was undertaken on five separate occasions during the study at the set times detailed. The paper copies of the data tool packs were placed in the sensory booths for completion during the meal session, together with a pen, to prevent any interaction taking place during the study meal.

Despite the present study hypothesis indicating that it may be possible for coloured lighting to manipulate the circadian rhythm to modulate food consumption via the secretion of the appetite stimulating hormone ghrelin (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008., Munich and Bromundt, 2012, Ellis et al., 2013),it was not possible to measure ghrelin levels as part of the present study. This was due to the processes involved in the measurement of ghrelin, which requires blood samples to be taken from participants in order to test blood chemistry (Broom et al., 2008). Due to restrictions of funding, it was not possible to recruit a suitably trained medical professional to undertake such tests or analyse ghrelin. The absence of ghrelin level measurement will be discussed in chapter 5 in study limitations.

3.13 STUDY DAY ACTIVITY

Participants were provided with their standardised breakfast and required to consume this at 09.00am either in the laboratory itself, or in their work/study area. A text reminder was sent to ensure compliance. As described each controlled breakfast, consisting of a Kellogg's Nutrigrain Elevensies Raisin Bake, was calculated for participants individually at 0.75g per kilogram of body weight. Participants were also provided with 660ml of Harrogate still water and were required not to eat or drink again until the study meal at 12.00pm.

At 11.00am the first of the data tool packs were completed consisting of a POMS questionnaire and appetite VAS. At 11.15 to 11.45am the homogenous study meal of white penne pasta in Dolmio™ tomato and basil sauce was prepared in the sensory laboratory metabolic kitchens. The meal was prepared fresh to be ready for 11.45am, and held to a temperature standardised temperatureas per Food Hygiene Regulations 2006 and EC Regulations 852/2004 (Food Standards Agency, 2007). Temperature was tested using a calibrated temperature food probe. It was possible to hold the meal at a minimum of 63 degrees centigrade for a maximum period of 2 hours (Food Standards Agency, 2007) which was more than sufficient for the consumption period of the study of 30 minutes. At 11.55am, participants were seated in their sensory booth, which were already illuminated with the coloured light, as designated by their unique participant code. At 12.00pm the study meal was served to each participant through the sensory booth access door hatch to minimise any interaction during the study. The study meal was served in 500g portions. The second of the data tool packs were completed which included as VAS for hedonic impression of visual palatability, VAS for appetite and POMS. Participants indicated they required more food via a switch inside the sensory booth which illuminated a light indicator on the outside of the feeding booth. Additional 500g portions of the pasta study meal were provided as many times as the participant indicated. At 12.15pm the third of the data tool packs were completed which contained a VAS for appetite. At 12.30pm a whistle was used to indicate that eating must stop and the fourth data tool pack was completed. This contained a VAS for appetite and a POMS and on completion participants were escorted from the sensory booths back to a seminar room within the laboratory.

Between 12.35 to 12.50pm individual participants plates were collected from their sensory booths and the food remaining was weighted and then subtracted from the total food that had been requested to give a weight of food consumed. At 12.50pm the fifth and final data tool pack was completed which contained a VAS for appetite, participants were then free to leave. Participants were devoid of external food cues but were not devoid of time cues. Figure 10 shows the study day activity.

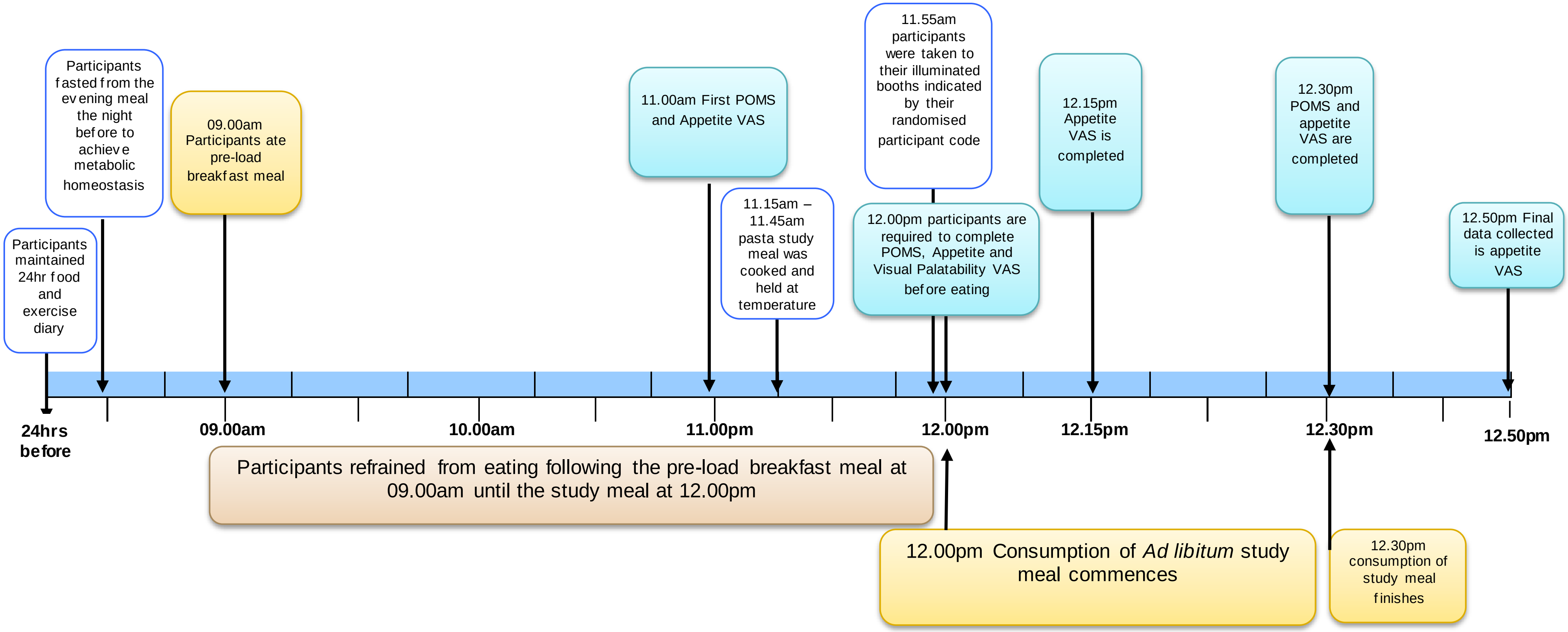

Figure 10: Study Day Activity

3.14 STUDY DAY CAPACITY

As a result of the design of the present study, and as a reflection of the multitude of tasks that were required to take place simultaneously on the study day itself including responding to sensory laboratory indicator lights with additional food, it was necessary to recruit additional capacity in the form of trained research assistants. The research assistants were university students from the University of Hull, Sheffield Hallam and Loughborough University, studying nutrition related modules. All three volunteered to work as research assistants on the study in order to gain experience and add to their research portfolios. All three research assistants were formally inducted into the sensory laboratory, and provided with a SHU Special Technical Facilities Safety Guidance Notes document and the two SOP's specific to this study for Food Production and Data Administration. The research assistants were supervised at all times by the Principle Researcher.

3.15 POST-STUDY DEBRIEF

As the participants had been blinded to the true nature of the studyit was necessary to undertake a post-study debrief session. At this session all participants were informed of their duty of confidentiality with regard to sensitive information and Intellectual Property, which was confirmed by the signing of a Non-Disclosure Agreement (NDA), (see appendix Q). A PowerPoint presentation highlighted the study aims and hypotheses and participants were given an opportunity to ask questions. A lunch accompanied with drinks was provided for volunteering their time.

3.16 STATISTICAL ANALYSIS OF THE DATA AND STORAGE

The present study used repeated measures within subject group design. A repeated measures design is described by Field (2011) as using the same participants for all of your experimental conditions. This is in contrast to an independent group design, in which different groups of participants for different experimental conditions are used so that each participant is exposed to just one condition (Howitt and Cramer, 2011). A benefit of using repeated measures is it allows the researcher to exclude the effects of individual differences that could occur if two different people were used instead (Howitt and Cramer, 2011). Another benefit of repeated measures is it requires fewer participants than independent groups. For example, whereas repeated measures may only need 20 participants, independent groups would need 20 participants for each condition (Howitt and Cramer, 2011). Repeated-measures are therefore quicker and easier to successfully recruit the necessary number of participants. The requirement for recruitment of less participants, whilst maintained the power of the results, was a major factor in the selection of repeated measures design for the present study due to the financial and time restrictions of the principle investigator.,

However, using the same participants for all conditions can lead to difficulties counteracting problems of order effects. Results could therefore be due to boredom effecting concentration and performance in reaction times or accuracy (Pan, Shell & Schleifer, 1994). Although, according to Field (2011) the risks of order effects can be reduced by counterbalancing, for example, the participants would be exposed to each condition in a different sequence. The results should then be less affected by factors such as boredom and practice. Additionally, researchers can also provide breaks during the experiment to counteract boredom and loss of concentration (Pan, Shell & Schleifer, 1994). As a result, a 6 day wash-out period was part of the present study design. Taking all of these factors into account, the benefits of a repeated measures design, together with methods to reduce any negative effects, were felt to be most appropriate for the present study.

During the study all data gathered was written onto a paper based master table, eg. weight of food consumed, or filed within lever arch files containing plastic pockets labelled by participant name and code, eg. VAS/POMS. All information relating to the study was stored securely within a secure cupboard with restricted access within the university building.

Data collected were continuous variables for weight of food consumed, mood, appetite and visual palatability. Data were analysed using the Statistical Package for the Social Sciences (SPSS) software ver. 20.0 for Windows (SPSS, Chicago, IL). Normal distribution was calculated using Shapiro-Wilks test of normality. One-way ANOVA with repeated measures and 3*2 ANOVA were used to assess differences between colours, and between colour*sex, colour*restraint, colour*sequence, colour*appetite. To assess the effect of colour on hunger, a linear repeated measures mixed model, with subjects as random effects, was fitted to hunger at times 1200, 1215, 1230 and 1250. This gave the advantage of being able to fit a baseline measure of hunger (at 1100) as one covariate, and volume of food consumed as another, while sex was treated as a fixed factor. An unstructured covariance matrix was assumed.

Sphericity is assumed where significance is above 0.05, where this is less than 0.05

the Greenhouse Geisser (GG) adjustment was used. Where significant differences were detected, post hoc comparisons between independent variables were conducted using Bonferroni post-hoc tests. P values used are for two tailed tests (Kock, 2015) as the analysis looked to identify either an increase of decrease against the white control. Statistical significance, alpha, was accepted at the 5% level. The power achieved in the present study was above 0.8, with most analysis being above 0.9.

3.17 CHAPTER SUMMARY AND IMPLICATIONS FOR RESULTS DISCUSSION

With regard to the context of the present study, knowledge was acquired through developing an original idea and identifying a novel research question, Can exposure to coloured lighting modulate food consumption?. Authoritative knowledge was then derived from the review of literature, and it was the logical reasoning of this knowledge that formed a hypothesis that coloured lighting may potentially manipulate the circadian rhythm to modulate food consumption. The hypothesis was confirmed as being suitable for further investigation and that there was potential to contribute new knowledge to the field of investigation. A research paradigm of quantitative methodology and methods was justified from the critical review of the available literature. Assumptions made regarding epistemological and methodological issues were tested by undertaking a small-scale simulation of the methods. Detailed descriptions of the methods have been set out within this chapter, together with the accompanying documents used. Ethical issues arising from the study methods were considered in the context of participant recruitment, and an account of the approval process within SHU is provided. Within the next chapter the results of the study are presented.

CHAPTER 4 - RESULTS

4.1 CHARACTERISTICS OF SAMPLE

Thirty non-obese participants (Age 26.8 (12.5) y; BMI 23.6 (3.16) kg/m^2), males n=16 (Age 26 (11.6) y; BMI 23.6 (3.7) kg/m^2) and females n=14 (Age 27.6 (13.9) y; BMI 23.6 (2.5) kg/m^2) completed the present study.

The sequences in which participants were exposed to coloured light were as shown in Table 7.

Table 7. Number of Participants Exposed by Sequence

Sequence	No. of Males	No. of Females	Total
WBY	4	3	7
WYB	2	0	2
YWB	3	3	6
YBW	3	3	6
BYW	4	5	9

Mean results for TFEQ-R18 for the sample can be seen in Table 8, and in figures 11 and 12.

Table 8. Mean and SD of TFEQ-R18

	Male (n=16)		Female (n=14)		Overall (n=30)	
	Mean	SD	Mean	SD	Mean	SD
Restrained	25.69	21.73	38.50	21.96	31.67	22.42
Uncontrolled	44.44	20.68	44.64	18.89	44.53	19.52
Emotional	32.21	27.37	42.43	25.84	37.03	26.71

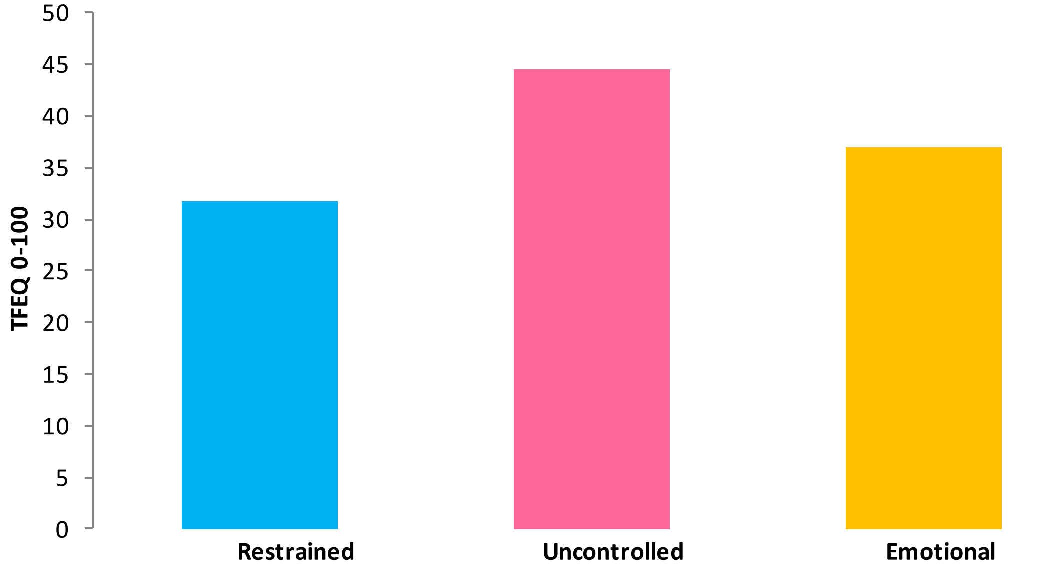

Figure 11. Mean results for TFEQ-R18 for the sample (*n*=30).

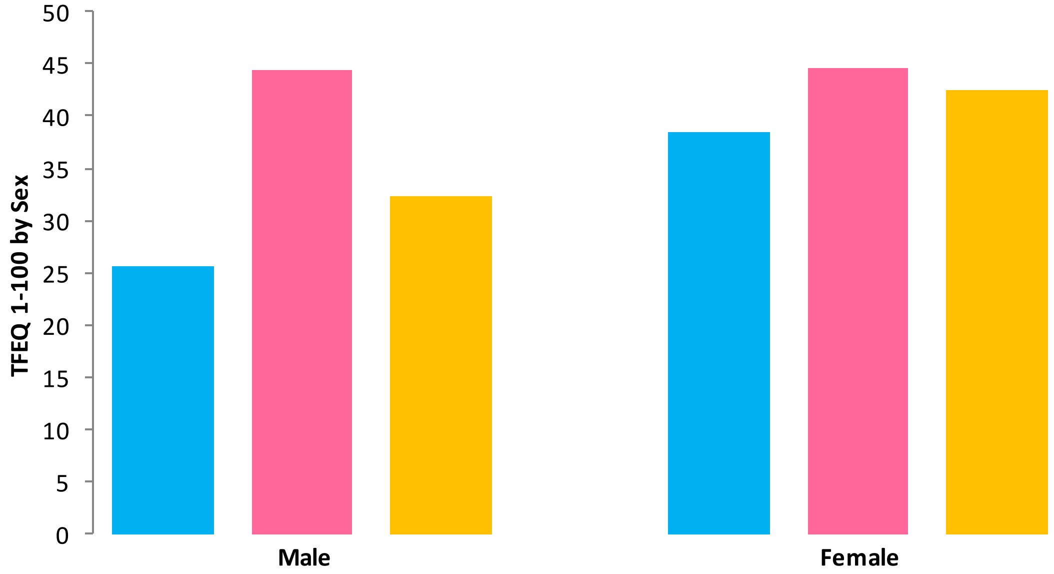

Figure 12. Mean results for TFEQ-R18 by sex.

4.2 VOLUME OF FOOD CONSUMED

4.2.1 Food Consumption by Light Colour

Table 9 Mean Food Consumption (g)

	Male (n=16)		Female (n=14)		Overall (n=30)	
	Mean (g)	SD	Mean (g)	SD	Mean (g)	SD
White	881.94	275.91	568.36	196.96	735.60	286.50
Blue	801.94	298.27	539.79	217.93	679.60	291.55
Yellow	1055.56	293.62	579.57	162.27	833.43	338.72
Overall	913.15		562.57		749.54	

As can be seen in table 9, there was a mean difference in food consumption for the group between white and yellow -97.83g (95% CI -174.15, -21.51), between blue and yellow -153.83g (95% CI -257.10, -50.56), and white and blue 56.00g (95% CI -7.20, 119.20). Female food consumption was on average 350.57g less than male consumption. Under white light female consumption was 313.58g less than males, under blue light female consumption was 262.15g less than males, and under yellow light female consumption was 475.99g less than males.

4.2.2 Unadjusted Impact of Colour on Food Consumption

A repeated measures ANOVA indicated a significant association overall between lighting colour and food consumption for the group (n = 30) [F (1.493, 43.293) = 11.464, $P \leq 0.001$]. As shown in figure 13, Bonferroni post-hoc analysis identified that food consumption significantly differed between white and yellow (P = 0.009), and blue and yellow (P = 0.002). Food consumption did not differ between white and blue (P = 0.096).

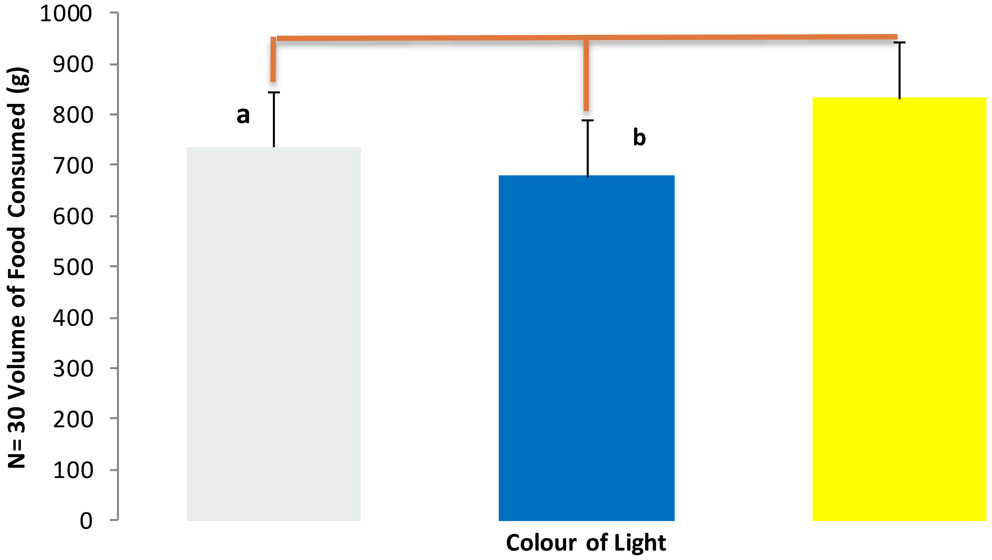

Figure 13. Mean of the sample (n=30) volume of food consumed by lighting colour. Consumption under white light was 735.6g, blue light 679.6g, and yellow light 833.4g [a]consumption different between yellow light and white light P = 0.009.[b] consumption different between blue lighting and yellow light P = 0.002. Error bars show confidence interval at 95%.

4.2.3 Impact of Sex on the Colour/ Food Consumption Relationship

A 3*2 ANOVA indicated a significant interaction between lighting colour and sex in their effect on volume of food consumed. Lighting colour remained significant [$F(1.606, 44.955) = 12.536$, $P \leq 0.001$], while lighting colour*sex [$F(1.606, 44.955) = 7.097$, $P = 0.004$] indicated a significance difference between the sexes in terms of the effect of lighting colour as is indicated by Table 6. There was also a significant main effect of sex [$F(1,28) = 17.132$, $P \leq 0.001$]. As shown in figure 14, there was a significant difference in food consumption between white and yellow in males (P = 0.002), but not in females (P = 1.000), a significant difference between blue and yellow in males (P = 0.002), but not in females (P = 0.884), and no difference between white and blue in males (P = 0.124) or females (P = 1.000).

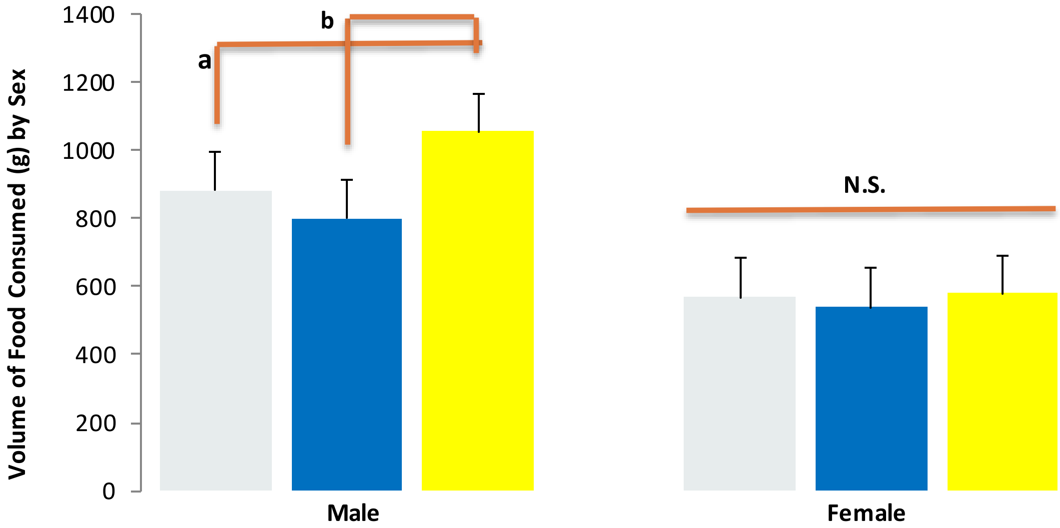

Figure 14. Mean of sample by sex (*n*=16 males, *n*=14 females) volume of food consumed by lighting colour. Males consumed 881.9g under white, 801.9g under blue, and 1055.6g under yellow. Females consumed 568.4g under white, 539.8g under blue and 579.6g under yellow. [a]consumption different in males between yellow lighting and white lighting *P*=0.002.[b]consumption different in males between yellow lighting and blue lighting *P*=0.002. The N.S. indicates no significant difference in females at $P > 0.05$. Error bars represent confidence interval at 95%.

4.2.4 Impact of Sequence on the Colour*Sex / Food Consumption Relationship

Table 10. shows mean food consumption by sequence. It is apparent that food consumption levels differed overall by sequence, but his is probably due to random differences between participants assigned different sequences. In every sequence, the least volume of food was consumed under blue light and the greatest under yellow light, i.e. there appears to be no interaction effect of sequence and light colour on volume of food consumed.

Table 10. Mean Food Consumption by Sequence (g)

		All.White.Vol		All.Blue.Vol		All.Yell.Vol	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Sequence	BYW 9	671.33	227.40	639.44	269.15	729.78	240.74
	WBY 7	853.14	458.76	802.00	411.20	961.43	553.64
	WYB 2	881.50	2.12	806.00	14.14	1000.00	.00
	YBW 6	697.00	291.89	734.50	303.79	813.00	281.67
	YWB 6	684.83	124.19	500.00	96.33	804.50	265.85

Sequence has been adjusted for in the ANOVA model by the addition of a main effect of sequence and a colour*sequence interaction term to the model of section 4.2.3. This does not indicate a significant effect on food consumption of sequence [$F(4,21) = 0.526$, $P = 0.718$] nor of a moderating effect of sequence on the colour/consumption relationship [$F(6.251, 32.820) = 1.134$, $P = 0.365$] given that sex has also been accounted for.

4.2.5 Impact of Restraint on the Colour*Sex / Food Consumption Relationship

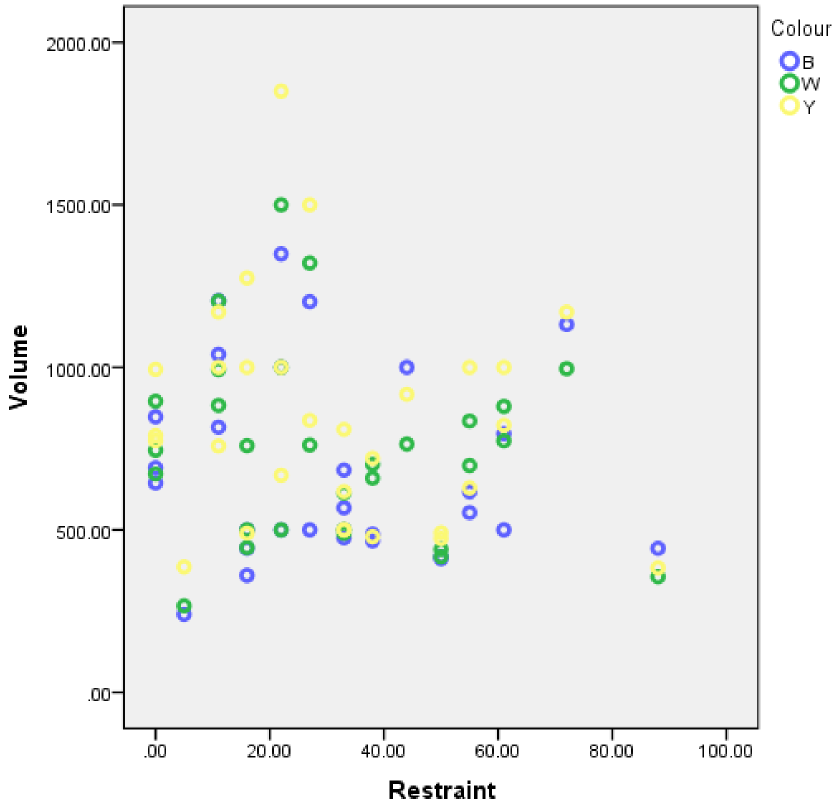

Figure 15. Results for volume of food consumed by restraint for the group.

Figure 15 shows volume of food consumed by restraint score. Although those with high restraint ate small volumes and those eating high volumes had low restraint, overall there is not a strong relationship, as many with low restraint also ate small volumes. There is no consistent relationship with colour.

The addition of restraint scores shown in Table 8 and a further 2-way interaction (colour*restraint) to the ANOVA model of section 4.2.3 does not indicate a significant effect on food consumption either within subjects (colour*restraint) [F(2,54) =0.22, *P*=0.979] or between subjects (restraint) [F(1,27)=0.015, *P*=0.903.

4.2.6 Impact of Visual Palatability on the Colour*Sex / Food Consumption Relationship

Despite there being a significant difference in visual palatability scores between white and blue lighting for the sample and by sex $P \leq 0.001$, and blue and yellow lighting for the sample and by sex $P \leq 0.001$, as shown in figures 16 and 17, the addition of a further 2-way interaction (colour*visual palatability) to the ANOVA model of section 4.2.3 does not indicate a significant effect on food consumption either within subjects for white [$F(1.600,40.001) = 0.776$, $P = 0.441$], blue [$F(1.600,40.001) = 0.941$, $P = 0.380$], or yellow [$F(1.600,40.001) = 0.093$, $P = 0.870$], or between subjects (visual palatability) for white [$F(1,25) = 0.003$, $P = 0.954$], blue [$F(1,25) = 0.002$, $P = 0.963$], or yellow [$F(1,25) = 0.016$, $P = 0.899$].

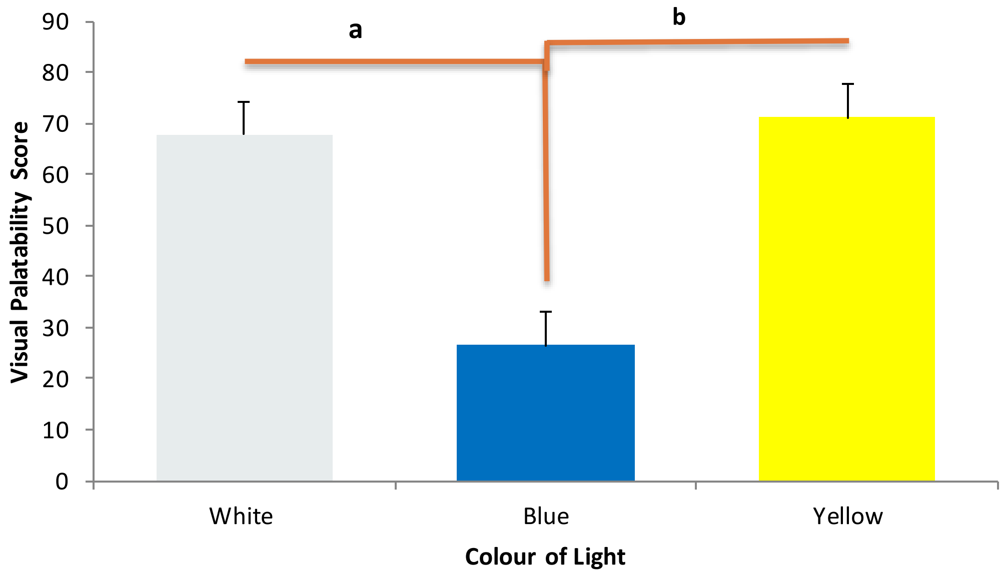

Figure 16. Mean visual palatability for the sample (n=30) by lighting colour. [a]visual palatability different between white and blue lighting $P \leq 0.001$; [b]visual palatability different between yellow and blue lighting $P \leq 0.001$. Error bars represent the confidence interval.

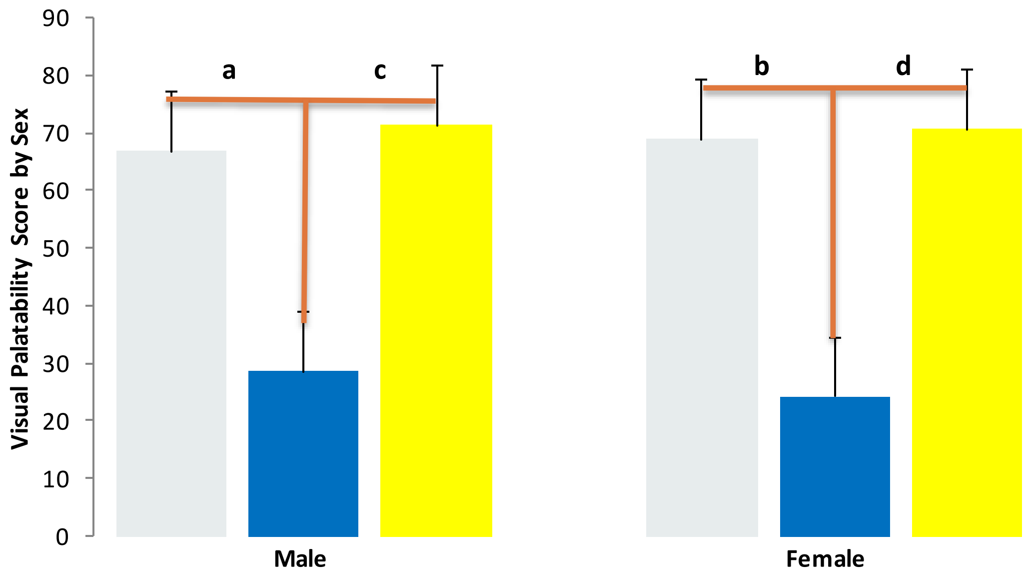

Figure 17. Mean results by sex for visual palatability by lighting colour. [a]visual palatability different between white and blue lighting in males $P \leq 0.001$; [b]visual palatability different between white and blue lighting in females $P \leq 0.001$; [c]visual palatability different between yellow and blue lighting in males $P \leq 0.001$; [d]visual palatability different between yellow and blue lighting in females $P \leq 0.001$. Error bars represent the confidence interval.

4.3 APPETITE

4.3.1 Impact of Colour on Appetite

Table 11 shows the results of the repeated measures mixed model, with subjects as random effects, which was fitted to appetite at times 1200, 1215, 1230 and 1250. A baseline measure of appetite (at 1100) was used as one covariate, and volume of food consumed as another, while sex was treated as a fixed factor. An unstructured covariance matrix was assumed. Once baseline appetite was accounted for there were significant differences in appetite at the different time points. There was no significant effect on appetite of colour, volume of food consumed or sex. Overall there is no significant main effect of colour. The means for the group, and by sex, are provided at figures 18 and 19.

Table 11. Results for Appetite scores.

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	82.924	92.286	.000
Time	3	29.000	112.093	.000
Colour	2	26.207	.117	.890
Sex	1	26.452	.182	.673
App11	1	67.967	48.394	.000
Time * Colour	6	29.000	1.883	.118

a. Dependent Variable: Appetite.

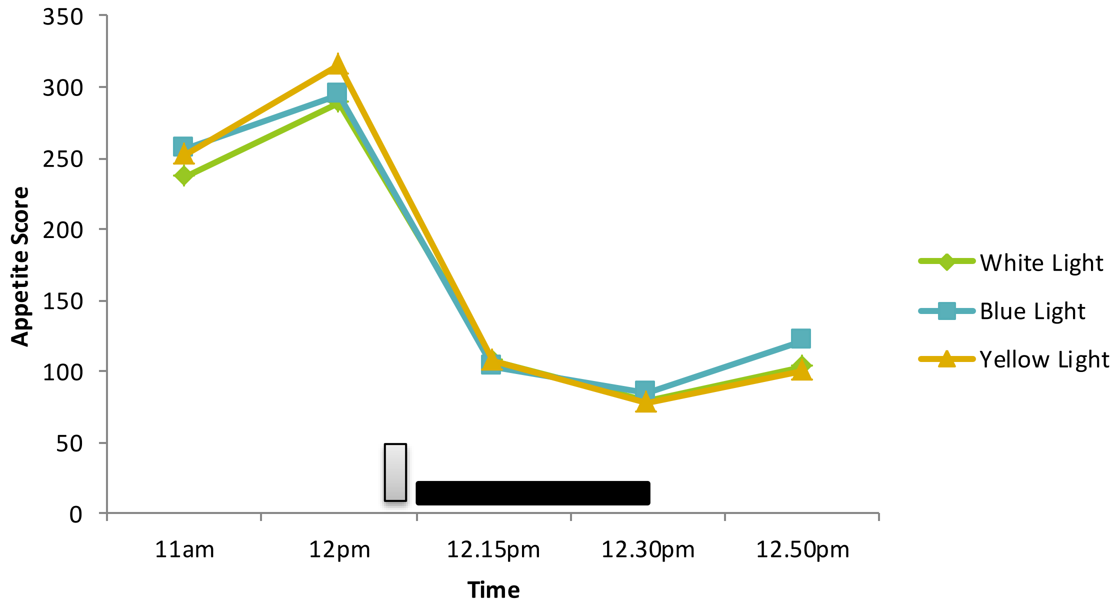

Figure 18. Mean of the sample (*n*-30) Appetite score over time at 5 points. Grey shaded rectangle indicates first exposure to coloured lighting condition on entering sensory booth at 11.55pm. Black shaded rectangle indicates meal consumption period from 12.00-12.30pm. There is no difference between the results under any of the lighting colours. Error bars have been removed to improve clarity.

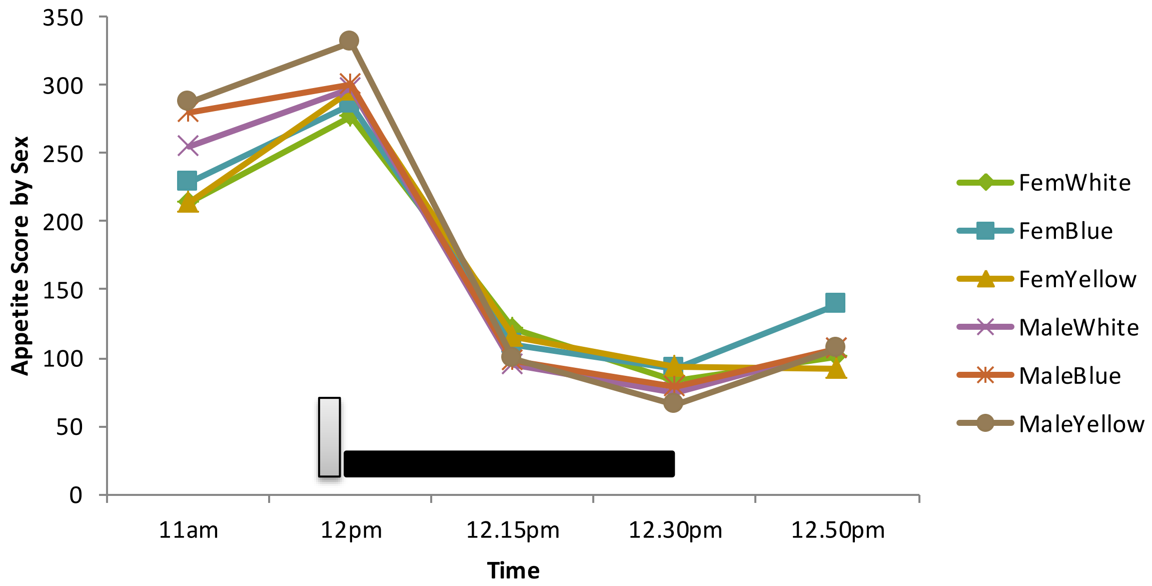

Figure 19. Mean of the sample by sex (males *n*=16, female *n*=14) for Appetite score over time at 5 points. Grey shaded rectangle indicates first exposure to coloured lighting condition on entering sensory booth at 11.55pm. Black shaded rectangle indicates meal consumption period from 12.00pm -12.30pm. There is no difference between the results under any of the lighting colours. Error bars have been removed to improve clarity.

4.4 HUNGER

4.4.1 Impact of Colour on Hunger

Table 12. Results for Hunger Scores

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	50.429	77.099	.000
Sex	1	23.463	.887	.356
Colour	2	28.372	1.711	.199
Time	3	29.000	208.006	.000
Volume	1	32.798	.282	.599
Hunger11	1	62.186	17.220	.000

a. Dependent Variable: Hunger.

Table 12 shows the results of the repeated measures mixed model, with subjects as random effects, which was fitted to hunger at times 1200, 1215, 1230 and 1250. A baseline measure of hunger (at 1100) was used as one covariate, and volume of food consumed as another, while sex was treated as a fixed factor. An unstructured covariance matrix was assumed. Once baseline hunger was accounted for there were still significant differences in hunger at the different time points. There was no significant effect on hunger of colour, volume of food consumed or sex.

4.5 MOOD

4.5.1 Impact of Colour on Mood

Table 13 shows the results of the repeated measures mixed model, with subjects as random effects, which was fitted to mood at times 1200 and 1230. A baseline measure of mood (at 1100) was used as one covariate, while sex was treated as a fixed factor. An unstructured covariance matrix was assumed. Once baseline mood was accounted for there was no consistent overall significant main effect of colour on mood. The means for the group, and by sex, are provided at figures 20 and 21.

Table 13. Results for Mood Scores

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	26.299	1.544	.225
Sex	1	23.088	.120	.732
Time	1	29.000	8.410	.007
Colour	2	28.243	.914	.412
Mood11	1	63.919	83.720	.000

a. Dependent Variable: Mood.

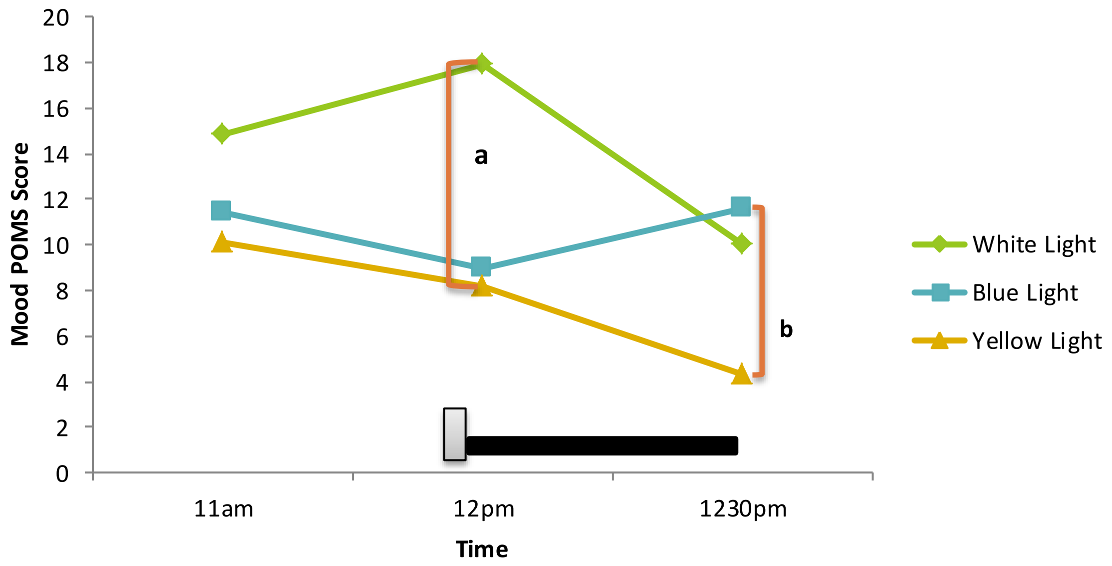

Figure 20. Mean of sample (n=30) for Mood POMS collected over 3 time points. Grey shaded rectangle indicates first exposure to coloured lighting condition on entering sensory booth at 11.55pm. Black shaded rectangle indicates meal consumption period from 12.00-12.30pm. [a]Mood POMS trend between colours is different at 12.00pm under yellow lighting than white lighting P = 0.015. [b] Mood POMS trend between colours is different at 12.30pm between yellow lighting and blue lighting P = 0.043.

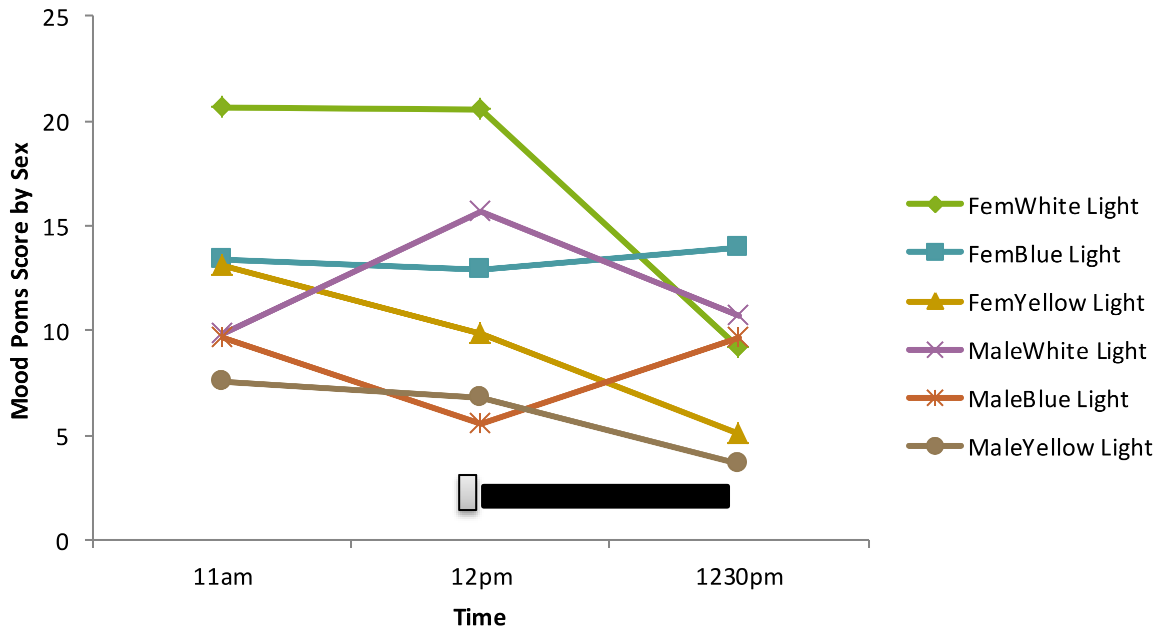

Figure 21. Mean of the sample by sex (male *n*=16, female mean *n*=14) for Mood POMS collected over 3 time points. Grey shaded rectangle indicates first exposure to coloured lighting condition on entering sensory booth at 11.55pm. Black shaded rectangle indicates meal consumption period from 12.00-12.30pm. No difference detected between the sexes at any time point either between or within any colour.

CHAPTER 5 - DISCUSSION

5.1 INTRODUCTION

In this chapter results presented in Chapter 4 are interpreted and critically discussed in the context of the research hypothesis, in order to formulate a deeper, more profound understanding of the subject. The underlying meaning of the study is presented, and any implications of the findings for other research examining the modulation of food consumption using coloured lighting are presented. The relative importance of the findings is assessed in the context of contributing new knowledge to the field, recommendations are made and the practical implications highlighted.

The key findings from this research are that there was a significant increase in food consumption under yellow lighting conditions compared to the white control for the sample, and a significant difference in food consumption between the yellow and blue lighting conditions. There was a significant interaction effect of sex and colour of lighting on food consumption, with males consuming significantly more food during exposure to yellow lighting conditions compared to the white control, and a significant difference in food consumption between yellow and blue lighting conditions. However, there was no significant increase or decrease in consumption in females under any of the coloured lighting conditions. This finding is supported by Cho et al. (2015) who found female food consumption was unaffected by lighting colour. The findings of this study in relation to no significant reduction in food consumption under blue lighting against a white control are in contrast to the findings of Cho et al. (2015) who found a significant decrease in consumption under blue lighting compared to a white control, and no significant difference in consumption in males between yellow and white lighting conditions. However, Cho et al. (2015) did detect a significant difference in consumption by males between yellow and blue lighting conditions, although they reported this as evidence of reduced consumption under blue lighting, whereas equally this could indicate increased consumption as a result of exposure to yellow lighting. The study by Cho et al. (2015) did not publish the results for the sample, only by sex.

There was no effect on food consumption of appetite, hunger, sequence, restraint, visual palatability, or mood. These findings are supported by the findings of Cho et al. (2015) who found no difference to any other factor measured. However, there was a significant difference in mood for the sample at 12.00pm with mood being better at first exposure to yellow lighting conditions compared to white lighting conditions; however, there was no difference between these colours at the end of the 30 minute eating episode at 12.30pm. The study by Cho et al. (2015) did not measure the effect of coloured lighting on mood, although the measurement of mood was a recommendation from their study.

Results for visual palatability (hedonic impression) were significant for both the sample as a whole and by sex. There was a significant difference in hedonic impression for the sample and in both sexes between yellow lighting and blue lighting, but not between yellow lighting and white lighting. Hedonic impression results showed that food was rated as looking the most pleasant to taste under yellow lighting, and the least pleasant to taste under blue lighting. These findings are supported by previous findings of hedonic impression of food, and photographs of food, under blue and yellow lighting conditions (Suk et al., 2012, Hasenbeck et al., 2014; Cho et al., 2015).There was no difference in appetite ratings (desire to eat), or hunger between any of the colours for either the sample or by sex. This finding is supported by previous findings by Cho et al. (2015).

Weaknesses in study design by Cho et al. (2015) were identified in order to strengthen the design of the present study. Unlike Cho et al. (2015) which undertook a comparative study of 112 participants by sex, the present study used repeated measures, within subject group design comparing both sample and sex within and between participants. Effect size and power were considered in order to identify a suitable sample size, in total 30 participants completed the present study. Variables were controlled such as; food intake prior to the study, inclusion/exclusion criteria, blinding, randomisation, wash-out period, and by conducting the study within a controlled laboratory environment. Data was gathered for volume of food consumed, visual palatability, appetite, restraint, and mood, therefor there can be increased confidence in the data.

In particular, the increases in food consumption for the sample, and in males, under yellow lighting conditions compared to white lighting conditions are novel findings. These novel findings could be relevant in the context of malnutrition amongst hospital patients (Better Hospital Food, 2001., BNF, 2004, Warner, 2004., Savage and Scott, 2005., BDA, 2006., Age Concern 2006., Age UK., 2010., Edmondson-Jones, 2010., CFBHF, 2013). The NHS Plan (2000) states that up to 40% of hospital in-patients are malnourished and 1 in 10 would have a shorter stay in hospital if nutrition and patient food services were improved. British Nutrition Foundation (BNF) (2004) recognised the need to improve hospital nutrition, identifying malnutrition as a major issue increasing complexity of disease and lengthening recovery times. Similarly; British

Dietetic Association (BDA) (2006) stated that food was a vital part of the in-patient experience that supports recovery and promotes health. Furthermore, Age Concern (2006) identified that six out of ten older people were at risk of becoming malnourished or their nutritional status was diminished during hospitalisation, and malnutrition was costing the NHS £7.3bn each year. Despite over a decade of attempts to improve the situation little had changed (Age UK, 2010).

5.2 RESULTS DISCUSSION

Previous research (Suk et al., 2012, Hasenbeck et al., 2014; Cho et al., 2015) demonstrated that visual palatability (hedonic impression) of food could be affected as a function of coloured lighting conditions. (Cho et al., 2015) also found coloured lighting conditions had the potential to modulate food consumption. However, due to the limited amount of evidence, little is known about how coloured lighting is able to modulate food consumption. Therefore, in addition to discussing the findings of the present study in respect to the modulation of food consumption, there is also discussion as to how this might occur.

The main findings of the present study are:

1. Food consumption significantly increased under yellow lighting compared to white lighting conditions for the sample, the difference was very significant for males.
2. Food consumption was significantly different between yellow lighting and blue lighting conditions for the sample, the difference was very significant for males.
3. Food consumption was not significantly different between blue lighting and white lighting conditions for the sample, or by sex.

4. Female food consumption did not differ significantly under any of the coloured lighting conditions.
5. Visual Palatability (hedonic impression) was significantly different as a function of coloured lighting conditions by sample, and by sex, between blue lighting and white lighting conditions, between blue lighting and yellow lighting conditions, but not between white lighting and yellow lighting conditions.
6. Appetite and hunger were not significantly different as a function of coloured lighting conditions for the sample, or by sex.
7. Mood was significantly better for the sample under yellow lighting conditions compared to white lighting conditions upon first exposure at 12.00pm, but was not significantly different between these colours by the end of the eating episode at 12.30pm.
8. Mood between colours was not significantly different as a function of coloured lighting conditions by sex.

5.2.1 Food Consumption

There was a significant difference in food consumption between yellow lighting conditions and white lighting conditions, and between yellow lighting conditions and blue lighting conditions. This resulted in a mean consumption 92.42g higher under yellow lighting than white lighting, and a mean difference in consumption of 146.71g under yellow lighting compared to blue lighting. However, there was no difference detected between blue lighting and white lighting. A sex comparison found a very significant mean increase of 173.62g in consumption for males under yellow lighting compared to white lighting, and a difference of 253.62g against the mean under yellow lighting compared to blue lighting. However, there was no difference in consumption for males or females between blue lighting and white lighting conditions, or for females under ant of the lighting colours.

The results of the present study do not concur with Cho et al. (2015) with respect their being a significant increase in food consumption under yellow lighting compared to white lighting for the sample, and in males. This could be explained by the different methods of the two studies. Whilst Cho et al. (2015) undertook a comparison between 112 participants randomly split into three groups, one for each of the colours, the present study used more robust repeated measures within subject group design. According to Hanna and Dempster (2012) as participants within the present study were acting as their own control, the results are regarded to be more robust than the results of Cho et al. (2015). There may also be an impact of selecting other methods, such as a different meal time and meal, which allowed for a controlled meal before the study meal. However, it is not the aim of the present study to disprove the results of Cho et al. (2015), or to find that yellow lighting increases food consumption at the expense of blue lighting decreasing food consumption. Both studies are able to reject the null hypotheses that coloured lighting does not modulate food consumption with their findings with Cho et al. (2015) finding blue lighting decreased consumption compared to white lighting in males, and findings of the present study that yellow lighting increases consumption compared to white lighting for the sample and in males. Furthermore, both studies have consistency between findings with regard to a difference in consumption between yellow and blue lighting; the only variance between the results is the statistical significance of the difference in consumptions. Whilst statistical significance is of course important, according to Benjamini and Hochberg (1995) the conservative nature of ANOVA and

Bonferroni must be acknowledged in increasing the risk of false negative results.

Furthermore, the results of the present study for the female sample support the results of Cho et al. (2015) in that both studies found that female consumption did not differ significantly between the colours. Whilst results of the present study show the sample consumed significantly more food under yellow lighting compared to blue lighting, and close to approaching significantly more compared to white lighting conditions, notably the results of the present study show the effect of lighting colour on the volume of food consumed was different between the sexes. Males consumed significantly more of the meal when it was served under yellow lighting conditions compared to under white lighting or blue lighting conditions, whilst female consumption did not differ significantly under any of the lighting conditions. Cho et al. (2015) suggest a plausible explanation for the difference between sexes in lighting colour-induced amount of food consumed may be related to superiority in detecting, discriminating, identifying and remembering odour clues in females (Doty et al., 1984, Larsson et al., 2003, Hummel et al., 2007). The suggestion being that, before beginning to consume food, ortho-nasally perceived odours could lead the participants to expect not only other sensory aspects, such as taste, texture, even acceptability, of the foods, but also whether or not the foods are safe to eat (Cho et al., 2015). This suggestion is based on previous findings that females outperform males in identifying and discriminating odours (Hummel et al., 2007), and that females are more attentive and dependent on olfactory cues for their daily decisions (Croy et al., 2010; Seo et al., 2011, Seo et al., 2013). Women, in comparison to men, are expected to more easily identify whether or not food is safe to eat, regardless of the lighting colour under which is presented. In contrast, if the male sense of smell is relatively less sensitive and discriminative in comparison, men appear to be more dependent on visual cues, thus being perhaps more susceptible to having their visual cue distorted by blue lighting (Cho et al., 2015).

This assertion by (Cho et al., 2015) in order to explain the differences between the sexes in food consumption under the coloured lighting conditions is very interesting. However, as has been demonstrated by the presentation of the results for the present study there were no differences found between volume of food consumed and any other factor, be that visual palatability, sequence, restraint, appetite, hunger, or mood. If females are more sensitive to olfactory cues (Croy et al., 2010, Seo et al., 2011, Seo et al., 2013) it might be expected that the results of these other factors would also be affected. However, the results for females for these factors are consistent with their male counterparts, suggesting that female participants reacted to the coloured lighting stimulus in the same way as males, with the notable exception of the volume of food they consumed. Therefore, the results of the present study do not support the assertion by Cho et al. (2015) that the reason for differences in food consumption are as a result of any superior olfactory sense in detecting what is safe to eat on the part of females. Or that as a result of males less discriminatory behaviour they are more susceptible to visual clues as a result of the distorting effects of coloured lighting on food.

An alternative view of causation for these differences in food consumption may have inadvertently emerged from the present study as an unintended consequence of blinding the participants. Study participants were blinded in order to guard against bias (Schulz and Grimes, 2002). However, following de-brief sessions revealing the true main objective was to measure volume of food consumed and not mood, 3 participants (2 females G2B1 & G2B2, and 1 male G1B2) were distressed and admitted to having deliberately standardised their food consumption, despite being instructed to eat until 'comfortably full and satisfied'. Further, this self-regulation of food consumption occurred even though these participants had undertaken the TFEQ-18R and were classified as not having restrained eating traits. It was alleged they had eaten a certain number of full plates on the first week, and then had forced themselves to eat the same number on weeks two and three. As can be identified in figure 5 page 90, by code number, in each case their first week was the white control. This potentially resulted in them eating more food than they had wished under blue lighting, and less than they wished under yellow lighting. It could be viewed that this inadvertent standardisation served only to cancel their own results out as they ate the same as under the white lighting control. Further, the incidence of this occurring was higher in females than in males, and whilst the sample sizes are very low, this perhaps suggests that self-regulation of food consumption may be more prevalent in women, acknowledging in the present study the numbers were still small. During analysis of the data these participants were removed but as this did not alter the outcome, their results were included in order to maintain the power of the study.

Much research has been undertaken on the subject of female body image. Johnson and Wardle (2005) studied 1177 adolescent females finding that negative body image was linked to dietary restraint. Grabe and Hyde (2006), and Holmgvist et al. (2007) support this link. In a meta-analysis of 77 studies, Grabe et al. (2008) found that exposure to an 'ideal' thin female image in the media was linked to negative body image. In addition, Caccavale et al. (2012) used survey data of 6909 adolescents and found that social factors effects body image of girls. In further support of this, Burrows (2013) undertook a rapid evidence assessment of 101 research articles and identified the psychosocial factors associated with negative body image to be; being overweight, being exposed to media images, the attitudes and behaviours of family and peers, and personal psychological characteristics. This led to females being more likely to control their eating behaviour as a result, and females being more likely to diet, and females being at a higher risk of having a negative body image (Burrows, 2013). As a result, a possible explanation for the differences in food consumption between the sexes could be a combination of complex psychosocial factors more prevalent in women than in men.

However, if it is the case that women classed as unrestrained eaters are self-regulating food consumption as a result of complex psychosocial factors (Grobe and Hyde, 2006, Holmgvist et al., 2007, Grabe et al., 2008, Caccavale et al., 2012, Burrows, 2013), this could question the hypothesis that coloured lighting potentially manipulates the circadian rhythm in order to modulate food consumption. According to (Siffre, 1975., Boivin et al., 1996., Ellis et al., 2013) light is the zeitgeber of the circadian rhythm, and the circadian rhythm is responsible for signalling to the body when it is time to eat (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008., Munich and Bromundt, 2012, Ellis et al., 2013). Reid et al. (2014) found that exposure to moderate levels of white light at biologically appropriate times can influence weight, independent of sleep timing and duration. Colours selected for use within the present study had the colour temperatures, or hues, of 3425.6k for blue lamps and 2229.6k for yellow lamps. The blue lamp is situated just beneath the colour temperature of the morning and evening sun at 3500k. The yellow lamp is situated near to the colour temperature of sunrise and sunset at 2500k. A white light bulb is

3000k and is situated equidistantly between 2500k of sunrise and sunset and 3500k of morning and evening sun.

The results of the present study suggest that the sample and males consumed more food when exposed to a colour temperature nearest sunrise and sunset, and the difference in food consumption between blue and yellow lighting for males, and for the sample, suggest that less food was eaten closer to the morning and evening sun. Evidence suggests the circadian rhythm can be entrained using external cues, zeitgebers, including light (McEachron, 2012., Ellis et al., 2013., Kent, 2014). However, as yet no research has been undertaken to investigate if coloured lighting is able to mimic natural external cues, such as natural daylight, to modulate food consumption. Therefore, the results of the present study using coloured lighting that mimics kelvin degrees of natural lighting cycles may be the first indication that it is possible, and is a novel finding.

However, if coloured lighting is a zeitgeber of the circadian rhythm and is able to manipulate it, the findings of the present study indicate that women may be able to override physiological feelings of hunger caused by the secretion of ghrelin. Whilst this suggestion does not appear entirely implausible, the present study did not measure ghrelin secretion and no definitive conclusions can be made regarding this. As a result, further research is required to measure ghrelin levels to investigate both the hypothesis, and to investigate if females are able to override physiological effects of differing levels of appetite stimulating hormone secretion caused by different coloured lighting. This recommendation is presented within the conclusion to this chapter. If women are found to be regulating consumption due to psychosocial factors (Grobe and Hyde, 2006. Holmgvist et al., 2007. Grabe et al., 2008. Caccavale et al., 2012., and Burrows, 2013), this also places doubt on the robustness of the study by Hasenbeck et al. (2014) which used 57 participants in total, with 49 females and only 8 males. Had the study included food consumption, the results may well have concluded that coloured lighting did not have any modulating effects on food consumption, which could have had serious consequences for the funding of further research in the field of coloured light and food consumption.

5.2.2 Visual Palatability (Hedonic Impression)

Visual palatability results showed that food was rated as looking the most pleasant to taste before consumption under yellow lighting, and the least pleasant to taste before consumption under blue lighting for the sample. As can be seen in figures 16 (page 120) and 19 (page121), the colour of lighting had a significant effect on the hedonic impression of the sample, and for males and females. Results were very significant for both the sample and by sex. There was no difference for hedonic impression between white lighting and yellow lighting for either the sample or by sex. Relating these results to those of food consumption, it might have been expected that strong interaction would exist between the factors of visual palatability (hedonic impression) and food consumption. However, as has been presented in the results chapter there was no significant interaction.

This could be viewed as somewhat surprising, and it is easy to appreciate how a more superficial review of the results would have presumed links between visual palatability and food consumption, as has occurred within the research looking at photographs of food and not undertaking consumption. Studies by Suk et al. (2012) and Hasenbeck et al. (2014) suggest that coloured lighting had both negative and positive effects on the hedonic impression of food and desire to eat. However, neither study gave participants food to consume; the methods were simply to view sweets or pictures of bell peppers taken under coloured lighting conditions. Therefore, any assertions that positive or negative hedonic ratings would translate into increased or decreased food consumption cannot be made. Further doubt of this link is provided by Cho et al. (2015) who's study design included the consumption of a breakfast meal, and found that the hedonic impression of the overall appearance of the meal was significantly less when the meal (omelettes and pancakes) was served under blue lighting than when it was served under white and yellow lighting. Whilst this result was, to some extent, in accordance with previous findings (Hasenbeck et al., 2014) demonstrating that the hedonic impression of overall appearance of the bell peppers was the most and the least under yellow and blue lighting, respectively (Cho et al., 2015), the absence of any association between hedonic impression, desire to eat and volume of food consumed in the study by Cho et al.(2015) led to their recommendation to undertake further studies measuring mood. It was suggested that coloured lighting may affect mood which could influence food consumption. This assertion is discussed further within mood results discussion. Additionally, the results of the present study and (Cho et al., 2015) found there were no differences between the sexes for hedonic impression, as males and females both rated food under blue lighting the lowest compared to both yellow and white lighting. However, female food consumption was not significantly different under any of the colours, despite their hedonic impression results being remarkably similar to their male counterparts. The results for hedonic impression further support the earlier assertion that women may be more affected than men by psychosocial factors and may be self-regulating their food consumption.

5.2.3 Appetite and Hunger

Results of the present study showed no significant difference in appetite between any of the coloured lighting conditions for either the sample, or by sex. Cho et al. (2015) did not measure appetite using the same methods as the present study. They measured ‘hunger’ once prior to the study, and then measured ‘willingness to eat’ during the study. The subjective nature of the noun ‘appetite’ has already been presented within the review of literature; according to Stubbs et al. (2000) the subjective nature of the term can lead to differences in the gathering of data in research examining appetite. It was as a result of the potential subjectivity of the term ‘appetite’ that led to the method selected for the present study to be an appetite VAS, which was deemed to be a robust method for measuring appetite ratings (Stubbs et al., 2000). Accepting the differences in the methods of data collection, and the definitions used between the present study and (Cho et al., 2015), the results for appetite for the present study will be compared against the results of Cho et al. (2015) for ‘willingness to eat’.

Hunger scores taken from the VAS at multiple time points, 11.00am, 12.00pm, 12.15pm, 12.30pm, and 12.50pm, also showed no significant impact of colour on hunger. As a result of there being no main effect of colour on either the combined appetite scores, or separate hunger scores, no further analysis of the separate components of the appetite were undertaken. Cho et al. (2015) required participants to rate their hunger/fullness status just before the study commenced on a 9-point Likert scales ranging from 1 (extremely hungry) to 9 (extremely full). Overall, prior to being served the meal, participants reported they were “very hungry”.

In addition, prior to consuming the meal, participants were asked to rate their willingness to eat the meal on a 9-point Likert scale ranging from 1 (extremely unwilling) to 9 (extremely willing) (Cho et al., 2015). The results of Cho et al. (2015) found no significant interaction between lighting colour and gender in participants' willingness to eat the meal, additionally the colour of lighting was found to significantly influence hedonic impression of the overall appearance of the meal, but not in the willingness to eat it.

Due to these findings, Cho et al. (2015) suggested it was worthwhile noting that since naturally blue coloured foods are rare, humans may have a doubt as to whether blue coloured foods are safe to eat. From evolutionary and ecological perspectives, there is convincing research demonstrating that the mechanism of colour vision (e.g. retinal cone pigments) has evolved with the colour of their foods in nature (Walls, 1963., Hutchings, 1999., Vorobyev, 2004). The colour pigments of raw foods, such as fruits, were also evolved according to the visual characteristics of the gatherers (e.g., humans, birds, or insects) necessary to their survival (Hutchings, 1999). This view by Cho et al. (2015) supports the findings of (Hasenbeck et al.,2014) who argued that since blue lighting is apt to distort the natural colours and even shapes of foods, participants might have more difficulty in identifying the foods. The participants may then encounter cognitive dissonance causing feelings of uncertainty (Festinger, 1957), which could consequently reduce not only their hedonic impression of the appearance of foods, but also their willingness to eat them. However, in terms of willingness to eat, the study by Cho et al. (2015) disproves this theory, which is further supported by the results for appetite (desire to eat) of the presents study. There are inconsistencies within previous research (Hasenbeck et al., 2014, Cho et al., 2015) which Cho et al.(2015) suggests are as a result of differences in methods between using photographs of foods (Hasenbeck et al., 2014), and real foods (Cho et al., 2015) as is also the case in the present study.

Another reason for the lack of difference in appetite and willingness to eat between the colours was suggested by Cho et al. (2015) due to a requirement for participants to fast overnight. Under these conditions, Cho et al. (2015) assert that a majority of participants were likely to want to consume the meal, whether they favoured its overall appearance or not, which might have lessened any impact of lighting colour on participants appetite or desire to eat. This may also account for the lack of effect of colour on appetite or hunger in the present study. However, there was also another suggestion put forward by Cho et al. (2015) in that the impact of food-related odours should not be ignored (Yeomans, 2006., Ferriday and Brunstrom, 2011; Ramaekers et al., 2014). In both studies participants were given a couple of minutes before beginning to consume the served meal in order to complete VAS or Likert for hedonic impression of the visual palatability of the meal and appetite (desire to eat), or willingness to eat as in Cho et al. (2015). Therefore, before ingesting the served foods, the aromatic volatile compounds could be perceived through external nares [referred to as “orthonasal olfaction” (Rozin, 1982)]. Orthonasally perceived food odours have been found to stimulate salivation (Pangborn, 1968., Engelen et al., 2003;), gastric acid secretion (Feldman and Richardson, 1986), ghrelin level (Massolt et al., 2010), and insulin release (Johnson and Wildman, 1983; Palouzier-Paulignan et al., 2012).

In addition, it has been demonstrated that participant's sensitivity to odours, as well as their ability to discriminate food odours, becomes better in a non-satiated rather than in a satiated condition (Stafford and Welbeck, 2011). Cho et al. (2015) assert that the lack of significance in the lighting colour-induced willingness to eat might be due not only to hunger status, but also to orthonasally presented odours that could increase participants' motivation to eat the served meal. However, as Cho et al. (2015) did not measure salivation, gastric acid secretion, ghrelin level or insulin release, this assertion is pure speculation. It is also acknowledged that these measurements were not taken within the present study, a point that will be discussed further in the recommendations at the end of the chapter.

5.2.4 Mood

The absence of any differences between hedonic impression, desire to eat and volume of food consumed by Cho et al. (2015) led to their recommendation to undertake further studies measuring mood, as the suggestion was that coloured lighting may affect mood, and in turn affect food consumption. As a result the present study measured mood using the Profile of Mood State (POMS) questionnaire, a standard validated psychological test that provides a Total Mood Disturbance TMD score (McNair, 1971). Mood was measures a three time points, 11am, 12pm and 12.30pm.

It is possible that lighting colour induced mood or emotional state might have an influence on the results of the present study as Knez and Enmarker, (1998) and Cajochen (2007) found that coloured light had a modulating effect on mood or emotional state. More specifically, Knez and Enmarker (1998) found that in an office work setting, blue coloured light with a Kelvin colour temperature of 4000k induced a negative mood in males, more so than in females. In addition, mood has also been linked to olfactory perception such as odour sensitivity and pleasantness (Chen and Dalton, 2005; Lombion-Pouthier et al., 2006; Pollatos et al., 2007). According to Cho et al. (2015) there is evidence to suggest a link between worsening mood under blue lighting in males and decreasing olfactory sensitivity, leading to reduced food consumption under blue lighting conditions.

5.2.4.1 Mood and Eating Traits

Yeomans and Coughlan (2009) investigated the eating behaviour of 96 women whilst watching neutral, positive and negative film in order to induce positive and negative mood state. Participants who scored high in restraint and disinhibition in the TFEQ consumed more food in the negative affect film condition; whereas participants who scored low in restraint but high in disinhibition consumed more food in the positive affect film condition. Additionally, women who scored low in the disinhibition measure consumed similar amounts in all of the film conditions regardless of restraint score. Yeomans and Coughlan (2009) concluded that mood alone was a poor predictor of food consumption, whilst both positive and negative effect films caused equal states of arousal, emotional valence determined effects on food consumption. The suggestion is that positive mood enhances the tendency to overeat in the absence of restraint (Yeomans and Coughlan, 2009). Therefore, based on the findings of Yeomans and Coughlan (2009) the results of TFEQ-R18 for restraint for the sample may be relevant factors in mood induced food consumption.

One male participant (G3 B5) scored highly for restraint (72), and of the sample 4 participants, 2 males and 2 females, scored lower for restraint and higher for disinhibition, which according to Yeomans and Coughlan (2009) suggests that under a condition causing positive mood these participants are likely to consume more food. However, ANOVA found no effect of mood or restraint on the volume of food consumed for the present study.

Results for the present study show there was a significant difference for positive mood between yellow lighting and white lighting conditions during the period of exposure at 12.00pm. This result might suggest that further studies could look at the period of exposure to the coloured lighting prior to consumption of the food. It might be possible that a pre-load of yellow coloured lighting could increase the significant increase in food consumption found in the present study.

5.3 STUDY LIMITATIONS

5.3.1 Risk of Type I and Type II Error

Power calculations undertaken for the present study in order to identify a minimum sample size of 15 were undertaken at a point when the intention was to analyse the sample group as a whole. However, following the publication by Cho et al in February 2015 which found differences between the sexes in food consumption it was identified that it would be necessary to undertake a sex comparison, thus increasing the sample size. In addition, by increasing the sample (n=30) the risk of order effect was reduced and the ability to counterbalance was increased with 5 out of the possible 6 sequences of exposure being used. The final analysis was undertaken in the knowledge that by analysing smaller samples, (n=16 males, n=14 females) the risk of Type I and Type II (false positive and false negative results) increases (Argyrous, 2011), however the main effect of colour and sex on food consumption was adequately powered.

5.3.2 Risk of Sequence Effect

By producing a Latin square design it was identified there were six possible sequences under which participants could be exposed to the coloured lighting. However, it was not possible to achieve all six sequences due design limitations in the sensory laboratory, where partition walls were not at full height between booths. This resulted in the need to have the same colour lighting for six booths at a time, which severely restricted the range of sequences possible. Five of the six were achieved, which substantially reduced the risk of the effect of sequence.

5.3.3 Limited Research Evidence

A limited amount of evidence from previous research can have both a positive and negative impact (Oliver, 2012). From a positive perspective, the lack of research evidence confirmed the original status of the question and hypothesis and the potential of the present study to contribute knew knowledge to the field of enquiry, a principle objective of research. However, the absence of previous research evidence also served to limit the ability to determine an effect size. The requirement to confirm what constitutes a clinically significant effect size in the context of malnourished patients' forms part of the recommendations of the present study.

5.3.4 Not Measuring Ghrelin

Despite the present study hypothesis indicating that it may be possible for coloured lighting to manipulate the circadian rhythm in order to modulate food consumption via the secretion of the appetite stimulating hormone ghrelin (Demarco and Clarke, 2001., Kuller et al., 2006., Rot et al., 2008., Munich and Bromundt, 2012, Ellis et al., 2013), it was not possible to measure ghrelin due to funding restrictions, as well as the personnel to extract blood. A mechanism by which venous blood samples are drawn for the determination of plasma ghrelin concentration (Broom, 2008), the determining of which could have identified any differences in levels under the different coloured lighting conditions. This will also form part of the recommendations of the present study.

5.3.5 Unintended Participant Controls

Study participants were blinded in order to guard against bias (Schulz and Grimes, 2002). Following de-brief sessions it was established that 3 participants (2 females G2B1 & G2B2, and 1 male G1B2) had self-regulation their food consumption. This occurred despite the absence of restrained eating traits. Whilst it could be argued that the results of these participants should have been removed, statistical analysis demonstrated that significance values were not affected by their inclusion or exclusion. However, power, effect size and potential for order effect would have been detrimentally affected by their omission as the sample size would have reduced, which would have further increased the risk of Type I and Type II error in the sex comparison, more specifically in the female sample.

5.3.6 Meal Selection

The meal selected was that of a pasta lunch, there is no evidence as yet to suggest the same results would occur in different meals choices, and over numerous eating episodes and different times of the day.

5.4 FUTURE RESEARCH RECOMMENDATIONS

Following the interpretation and critical discussion of the findings, the underlying meaning of the present study and implications of findings for other research of the modulation of food consumption using coloured lighting have been identified. As a result, the following recommendations have emerged:

1. to undertake further research measuring ghrelin in order to identify if coloured lighting is able to modulate food consumption by physiologically manipulating the circadian rhythm via the retina and hypothalamus

2. to undertake further research on participants suffering from a misalignment of the circadian rhythm in order to understand if yellow lighting conditions increases food consumption in females as well as males.

3. to undertake further research to understand if there is an optimum colour temperature which further increases consumption, the yellow lighting used in the present study was 2229.6 (K), to understand if there is an optimum duration of exposure, method of delivery, pre-load requirement, and to confirm if coloured lighting is able to mimic the natural cycles of daylight.

As further research is undertaken, the potential to develop a novel non-invasive therapy or treatment using yellow coloured lighting to reduce malnutrition amongst high risk groups of patients becomes more possible. As the present study is recommending using these findings in a novel way, it is appropriate to reflect on the positioning of any new technology that may emerge within the wider field of bioengineering. It has been identified in the review of literature that the potential to use coloured lighting to entrain the circadian rhythm in order to modulate food consumption is original, and appears to be located somewhere between the theories of chromotherapy, phototherapy and chronobioengineering. Therefore, the final recommendation from the present study is:

4. this novel field of exploratory bioengineering to be termed ‘Chromobioengineering’, ‘chromo’ referring to the use of colour as well as light, and ‘bio’ referring to photobiology, the physiological reaction of living things to light (Ellis et al., 2013).

5.5 CONCLUSION AND PRACTICAL APPLICATION

In conclusion, to the authors knowledge this is the first empirical evidence that males consume significantly more food during exposure to yellow lighting conditions whilst consuming their meal compared to white lighting conditions. We therefore reject the null hypothesis that yellow light does not increase food consumption in males. Results found no evidence that males consumed significantly less food during exposure to blue lighting conditions whilst consuming their meal compared to white lighting conditions. We therefore cannot reject the null hypothesis that blue light does not decrease food consumption in males. Results found that female consumption was unaffected by any of the coloured lighting conditions, we therefore cannot reject the null hypothesis that blue or yellow lighting does not modulate food consumption in females. Results found no difference between colours for appetite. We therefore cannot reject the null hypothesis that coloured lighting does not modulate appetite. Additionally, results found a significant difference in consumption between yellow and blue lighting conditions for the sample, and in males. We therefore reject the null hypothesis that it is not possible for coloured lighting to modulate food consumption. Results found no effect on food consumption of any other factor, appetite, hunger, visual palatability, or mood once colour and sex had been taken into account. Results found no effect of sequence or restraint on food consumption. Results found there was a difference in visual palatability (desire to eat) ratings between yellow and blue, blue and white, but not white and yellow. We therefore reject the null hypothesis that coloured lighting does not affect desire to eat, but there was no effect on volume of food consumed.

Research undertaken (Suk et al., 2012, Hasenbeck et al., 2014) found that coloured lighting had modulating effects upon hedonic impression, and (Cho et al., 2015) found that blue lighting decreased consumption in men, but not in women. A further notable finding of the present study was the difference between males and females in food consumption. Whilst this is supported by findings of Cho et al. (2105), the results of the present study do not support the assertion by Cho et al. (2015) that the reason for the differences in food consumption are as a result of any superior olfactory sense in detecting what is safe to eat on the part of females, or due to males less discriminatory behaviour. An alternative view has been presented of causation for these differences in food consumption, based on the results showing that two female participants of the present study had deliberately regulated their food consumption. A possible explanation for this regulation by women has been suggested as a combination of complex psychosocial factors more prevalent in women than men (Grobe and Hyde, 2006. Holmgvist et al., 2007. Grabe et al., 2008. Caccavale et al., 2012., and Burrows, 2013), and that women may be able to override feelings of hunger caused by increased secretion of ghrelin.

Despite some significant differences found for visual palatability between the colours, with yellow lighting being the most pleasing and blue lighting being the least, there were no correlations with food consumption. Appetite was unaffected by the colours, and there was also no significant difference in mood between the colours. The lack of interaction between factors supports the hypothesis that coloured light may be a zeitgeber of food consumption, mimicking the cycles of natural daylight to physiologically manipulate the circadian rhythm stimulate secretion of ghrelin. Whilst white light has been identified as an influence on food consumption (Reid et al., 2014) further research is required to measure ghrelin levels under coloured lighting conditions in order to validate this claim. The implications for those suffering from malnutrition (BNF, 2004., Age Concern, 2006, Age UK, 2010, CFBHF, 2013., Kvamme, 2011., Wellman et al., 1997., Saka et al., 2010., Volkert, 2002), or obesity (Must et al., 1999, Finkelstein, Trogdon, Cohen and Dietz, 2009), could be considerable. The ability to stimulate food consumption physiologically in the context of patient malnutrition, the primary interest of the principle investigator, is very significant for those patients with reduced cognition and/or a misalignment of the circadian rhythm. Coloured lighting could be used therapeutically at mealtimes in a non-invasive way to entrain the circadian rhythm to increase food consumption, and in turn reduce complexity of disease, reliance on drugs, length of stay in hospital, and mortality rates.

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References

AGE CONCERN (2006). Hungry to be heard - the scandal of malnourished older people in hospital. London.

AGE UK (2010). Still Hungry to be Heard - the scandal of people in later life becoming malnurished in hospital. http://hospitalcaterers.org/documents/shtbh.pdf (Accessed 20th June 2016)

AITCHINSON et al (2001) Deciding Together: working with people with learning disabilities to plan services and support.

ALDERSON P (1998) The importance of theories in healthcare. British Medical Journal 317 (7164): 1007-10

ANDERSON, N. H. (2001). Empirical Direction in Design and Analysis. Mahwah, New Jersey: Lawrence Erlbaum Associates.

ANGLE, S., ENGBLOM, J., ERIKSSON, T., KAUTIAINEN, S., SAHA, M,T., LINDFORS, P., LEHTINEN, M., RIMPELA, A.(2009). Three factor eating questionnaire-R18as a measure of cognitive restraint, uncontrolled eating and emotional eating in a sampleof young Finnish females. Int J Behav Nutr Phys Act. 2009 Jul 17;6:41. doi: 10.1186/1479-5868-6-41.

ARGYROUS, G. (2011). Statistics for Reseach - A Griude to SPSS. 3rd ed. SAGE. London.

AVEYARD, H. (2010). Doing a literature review in health and social care - A practical guide. 2nd ed., England, Open University Press, McGraw-Hill.

BAPEN (2010). Malnutrition matters: meeting quality standards in nutritional care.

British Association for Parenteral and Enteral Nutrition) www.bapen.org.uk

BARBUT, S. (2001). Effect of illumination source on the appearance of fresh meat cuts. Meat Science, 59, 187–191.

BARBUT, S. (2003). Display light and acceptability of green, red and yellow peppers. Journal of Food Processing and Preservation, 27, 243–252.

BAUSELL, R. B. and LI, Y. (2002). Power Analysis for Experimental Research: A Practical Guide for the Biological, Medical and Social Sciences. Cambridge University Press, New York, New York.

BDA (2006). Delivering Nutritional Care through Food and Beverage Service. British Dietetic Association

BEDWELL, J., et al. (2006). Schizophrenia and red light: FMRI evidence for a novel biobehavioral marker. International journal of neuroscience, 116 (8), 881-894.

BENEDETTI F, COLOMBO C, PONTIGGIA A, BERNASCONI A, FLORITAI M, SMERALDIE, (2003) *Morning light treatment hastens the antidepressant effect of citalopram: a placebo-controlled trial*, *J Clin Psychiatry.* Jun; 64(6) 648-53.

BENJAMINI, Y; HOCHBERG, Y(1995). "Controlling the false discovery rate: a practicaland powerful approach to multiple testing". Journal of the Royal Statistical Society, SeriesB 57 (1): 125 –133. JSTOR 2346101.

BERG, K. and SIEVER, D. (2009). A controlled comparison of audio-visual entrainment for treating seasonal affective disorder. Journal of neurotherapy, 13 (3), 166-175.

BERNER, L, A., ALLISON, K, C.(2013). Behavioral management of night eating disorders. Psychology Research and Behavior Management, vol. 6

BERTHOUD, Hans-Rudolf. (2002). Multiple neural systems controlling food intake and body weight. Neuroscience and behavioural Reviews 26. P 393-428

BICKMAN, L., Editor. (2000). Research Design: Donald Campbell's Legacy, Volume 2.Thousand Oaks, CA: Sage Publications.

BICKMAN, L., Editor. (2000). Validity and Social Experimentation. Thousand Oaks,CA: Sage Publications.

BLAKEY H, PEARCE, J, CHESTERS G, (2006) Minorities within minorities: beneath the surface of South Asian participation, Joseph Rowntree Foundation. York

BLOUIN, A, G. BLOUIN J,H., IVERSON, H., CARTER, J., GOLDSTEIN, C., GOLDFIELD, G., PEREZ, E (1996). “Light therapy in bulimia nervosa: a double-blind, placebo-controlled study.” *Psychiatry research* 60.1: 1-9.

BLUNDELL, J,E., CAUDWELL P., GIBBONS, C., HOPKINS, M., NASLUND, E., KING, N., & FINLAYSON, G (2012) Role of resting metabolic rate and energy expenditure in hunger and appetite control: a new formulation. *Disease Models & Mechanisms* 5 608–613.

BLUNDELL, J., DE GRAFF, K., FINLAYSON, G., HALFORD, J, C, G., HETHERINGTON, M., KING, N., STUBBS, J., (2009) Measuring food intake, hunger satiety, and satiation in thelaboratory. In *Handbook of Assessment Methods for Eating Bahaviours and Weight-realted Problems: measures, Theory and Research,* pp 283-326. Eds DB Allison & ML Baskin. Thousand oaks, California, USA: SAGE Publications Inc.

BLUNDELL, J., CEES DE GRAFF, HULSHOF, T., JEBB, S., LIVINGSTONE, B., LLUCH, A., MELA, D., SALAH, S., SCHURING, E., VAN DER KNAAP, H., WESTERP, M., (2010). Appetite Control: Methodological Aspects of the Evaluation of Foods.

http://www.ncbi.nlm.gov/pmc/articles/PMC3609405/accessed 12/06/16

BOIVIN, D. B., DUFFY, J.F., KRONAUER, R. E. & CZEISLER,C. A. (1996: Feb). Dose-response relationships for resetting of human circadian clock by light. Letters to Nature, 379, 540 – 542. doi:10.1038/379540a0

BOLOTOVA, N. V., VOSKRESENSKAIA, O. N. and SLASTUKHINA, G. A. (2007). Colour andrhythm therapy in the correction of psychoemotional disorders in children with obesity. 107(9), 73-75.

BOWERS, D. (2014). Medical Statistics from Scratch - An Introduction for Health Professionals. Wiley Blackwell. West Sussex. PO19 8SQ, UK

BRAUN, D, L., SUNDAY S, R., FORNARI V, M., HALMI, K, A.,(1999) "Bright light therapy decreases winter binge frequency in women with bulimia nervosa: a double-blind, placebo-controlled study." *Comprehensive psychiatry* 40.6 : 442-448.

BRITISH NUTRITION FOUNDATION (2004), Better Hospital Food www.britishnutritionfoundation.co.uk

BROEKMANN, Neil C. (1970). A psychophysiological investigation of the Rorschach colour and form determinants. Journal of projective techniques & personality assessment, 34 (2), 98-103.

BROOM, D, R., BATTERHAM, R, L., King, J, A., STENSEL, D, J (2008). Influence of resistance and aerobic exercise on hunger, circulating levels of acylated ghrelin, and peptide YY in healthy males. Am J Physiol Regul Integr Comp Physiol. 2009 Jan;296(1):R29-35. doi: 10.1152/ajpregu.90706.2008. Epub 2008 Nov 5.

BURNHAM (2006), NHS to save £1bn with new supply chain arrangements.

BURNHAM, Clarke A. (1975). Review of the psychology of color and design.

Psyccritiques, 20 (9), 754-755.

BURROWS, N (20130. Body Image – a rapid review of evidence of the literature. A Project on behalf of the Government Equalities Office. https://www.gov.uk/government/uploads/system/uploads/attachment_ data/file/202946/120715_RAE_on_body_image_final.pdf accessed 10.05.16

BUTTRISS, J, L (2011), Feeding the planet: an unprecedented confluence of pressures anticipated' British Nutrition Foundation Nutrition Bulletin, 36, 235-241, British Nutrition Foundation, London, UK

BYRNE, Alex and HILBERT, David R. (2003). Color realism and color science. Behavioral and brain sciences, 26 (1), 3-63.

CACCAVALE, L., FARHAT, T., & IANNOTTI, R., (2012). Social engagement in adolescence moderates the association between weight status and body image. Body Image, 92(2), 221-226.

CAJOCHEN, C. (2007). Alerting effects of lights. Sleep Medicine Reviews, 11,453–464.

CAIVANO, José Luis and DE MATTIELLO, María L. F. (2003). Fixed range scales applied to the evaluation of color: Comparative analysis between the munsell system and the natural color system. Color research and application, 28 (2), 103-112.

CAMGÖZ, Nilgün, YENER, Cengiz and GÜVENÇ, Dilek (2004). Effects of hue, saturation, and brightness: Part 2: Attention. Color research and application, 29 (1), 20-28.

CAMPBELL, D. T. and RUSSO, M. J. (2001). Social Measurement. Thousand Oaks, CA: Sage Publications.

CAMPBELL, D. T. and STANLEY, J. C. (1963). Experimental and

Quasi-experimental Designs for Research. Reprinted from Handbook of Research on Teaching. Palo Alto,
CA: Houghton Mifflin Co.

CAMPBELL, S. E., AVENELL, A., WALKER, A. E., Tempest, G. R. P. (2002). Assessmentof nutritional status in hospital patients. International journal of medicine, 95 (2), 83-87.

CAPPELLERI, J,C., BUSHMAKIN, A,G., GERBER, R,A., LEIDY, N, K., SEXTON, C,C., LOWE, M,R., KARLSSON, J. (2009). Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large divers sample of obese and non-obese participants. Int J Obes (Lond). 2009 Jun; 33(6):611-20. doi: 10.1038/ijo.2009.74. Epub 2009 Apr 28

CARDELLO, A. V. (1996). The role of the human senses in food acceptance. In H. L. Meiselman & H. J. H. MacFie (Eds.), Food choice, acceptance, and consumption(pp. 1–82). London: Blackie Academic & Professional.

CAREY R G (1974) Emotional Adjustment in Terminal Patients: A Quantitative Approach, Journal of Counselling Psychology, 21, 5, 433-439

CASTANEDA, T. R., TONG J., DATTA R., CULLER M., TSCHOP M. H. (2010). Ghrelin in the regulation of body weight and metabolism. Front. Neuroendocrinol. 31, 44–60 10.1016/j.yfrne.2009.10.008

CFBHF (2013) Hospitals are wasting 82,000 meals a day - Campaigners call for quality control as NHS figures show some hospitals have been throwing away up to a quarter of their food, the Guardian on line, http://www.theguardian.com/society/2013/jun/29/hospitals-throw-away-quarter-of-food, accessed on line 11/06/2014

CHARMAZ, K (2006) Constructing Grounded Theory. London: Sage

CHEN C. Y., ASAKAWA, A., FUJIMIYA M., LEE S. D., INUI A. (2009). Ghrelin gene products and the regulation of food intake and gut motility. Pharmacol. Rev. 61, 430–481,10.1124/pr.109.001958

CHEN, D., & DALTON, P. (2005). The effect of emotion and personality on olfactory perception. Chemical Senses, 30, 345–351.

CHEN, P. and POPOVICH, P. M. (2002). Correlation: Parametric and Nonparametric Measures. Thousand Oaks, CA: Sage Publications.

CHIEF MEDICAL OFFICER (2002) Health Check on the state of public health – Annual report 2002. London: Department of Health

CHRISTENSEN, C. M. (1983). Effects of color on aroma, flavor and texture Judgments of foods. Journal of Food Science, 48, 787–790.

CHO, S., HAN, A., TAYLOR, M, H., HUCK, A, C., MISHLER, A, M., MATTAL, K, L., BARKER, C, A., SEO, H (2015) Blue lighting decreases the amount of food consumed in men, but not in women. *Appetite.* 85, 111-117.

CLARKE A E (2005) Situational analysis: Grounded theory after the postmodern turn. Thousand Oaks, CA: Sage

COCILOVO A. (1999). Colored light therapy: Overview of its history, theory, Recent developments and clinical applications combined with acupuncture. *American Journal of Acupuncture,* vol./is. 27/1-2(71-83)

COHEN, J. (1988). Statistical Power Analysis for the Behavioral Sciences, Second Edition. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

COMMONS (2005) Commons Hansard debates (online) (26 May 2005) Hansard, http://www.parliment.thestationaryoffice.co.uk/pa/cm200506/ cmhansrd/cm050526w19.htm

COOK, T. D. and CAMPBELL, D. T. Quasi-experimentation: Design and

Analysis Issues for Field Settings. (1979). Palo Alto, CA: Houghton Mifflin Co.

COOPER, H.M (1988) Organising knowledge synthesis: A taxonomy of literature review. *Knowledge in Society* 1. 104 – 126pp

COOTE, A, ed. (2002) Claiming the Health Dividend. The Kings Fund. London

COREC (2001) Governance Arrangements for research Ethics Committees, Central Office For Research Ethics Committees.

CORNÉLISSEN, G., et al. (1999). Chronomes, time structures, for chronobioengineeringfor "a full life". Biomedical instrumentation & technology / association for the advancement of medical instrumentation, 33 (2), 152-187.

CORNIER, M. A., SALZBERG, A. K., ENDLY, D. C., BESSESEN, D. H., & TREGELLAS J. R. (2010). Sex-based differences in the behavioral and neuronal response to food. *Hysiology & Behavior*, 99, 538–543.

CORYELL, Jacqui A. (2003) The therapeutic use of color in a clinical environment. Wright Institute, Graduate School of Psychology

COTTRELL, S. (2005). Critical thinking skills: Developing effective analysis and argument. 1st ed., UK, Palgrave Macmillan.

COWLEY M. A., SMITH R. G., DIANO S., TSCHOP M., PRONCHUK N., GROVE K. L., et al. (2003).The distribution and mechanism of action of ghrelin in the CNS demonstrates a novel hypothalamic circuit regulating energy homeostasis. Neuron 37, 649–661

CRD (2009). Systematic reviews: CRD's guidance for undertaking reviews in health carecentre for reviews and dissemination. http://www.york.ac.uk/ inst/crd/pdf/Systematic reviews pdf. (accessed 3rd December 2013), .

CRESWELL J W. (2013) Qualitative Inquiry & research Design: Choosing

Among Five Approaches. 3rd ed. Sage Publications, Inc

CROFT S, BERESFORD, P (1993) Getting Involved, Open Services Project & Joseph Rowntree Foundation. York

CROOKES, P. A. and DAVIES, S. (2004). Research into practice: Essential skills forinterpreting and applying research in nursing and health care. Edinburgh, UK, Bailliere Tindall.

CROTTY, M. (1998). The foundations of social research: Meaning and perspective in the research process. London, SAGE.

CROY, I., BUSCHHUTER, D., SEO, H. S., NEGOIAS, S., & HUMMEL, T. (2010). Individual significance of olfaction. Development of a questionnaire. European Archives of Otorhinolaryngology, 267, 67–71.

CUGINI P., PASSYNKOVA N.R., DI CRISTOFANO F., DE ROSA R., DE FRANCESCO G.P., CODA S., PELLEGRINO M.A., D'AGOSTINI-COSTA C., FONTANA S.(2001).Daily sensation of hunger, before and after phototherapy, in subjects with depression-type seasonal affective disorder. La *Clinica terapeutica*, November 2001, vol./is. 152/6(353-362),

CUMMINGS D. E., PURNELL J. Q., FRAYO R. S., SCHMIDOVA K., WISSE B. E., WEIGLE D. S. (2001). A preprandial rise in plasma ghrelin levels suggests a role in meal initiation in humans. Diabetes 50, 1714–1719 10.2337/diabetes.50.8.1714

DALTON, M., BLUNDELL, J., & FINLAYSON, G,S (*2013)* Examination of food reward and energy intake under laboratory and free-living conditions in a trait binge eating subtype of obesity. *Frontiers in Psychology **4**757.*

DAANSEN, P.J., HAFFMANS J. (2010) Reducing symptoms in women with chronic anorexia nervosa. A pilot study on the effects of bright light therapy.

Neuroendocrinology Letters, 2010, vol./is. 31/3(290-296), 0172-780X

DAUCHY R.T., WREN M.A., HOFFMAN A.E., HANIFIN J.P., WARFIELD B., BRAINARD G.C., HILL S.M., BELANCIO V.P., DAUCHY E.M., DUPEPE L.M., DOBEK G.L., BLASK D.E. (2015). Daytime blue light spectral transmittance enhances night time circadian melatonin regulatory dynamics of rodent metabolism and physiology. *Journal of the American Association for Laboratory Animal Science*, vol./is. 54/5(653)

DAW, N. W. (1984). The psychology and physiology of colour vision. Trends in neurosciences, 7 (9), 330-335.

DEFRA (2002) Department for Environment, Food and Rural Affairs, Strategy for Sustainable, Farming and Food.

DEFRA (2006) Best Practice in sustainable public-sector food procurement Food Links UK, F3. London Department for Environment, Food and Rural Affairs www.defra.gov.uk

DEFRA (2006) Department for Environment, Food and Rural Affairs, Food Industry Sustainability Strategy.

DEFRA (2006) The National Action Plan www.defra.gov.uk/sustainable/government/documents/full-document.pdf

DEFRA (2007) Highlights of progress made during the first year of the Food Industry Sustainability Strategy. Department for Environment, Food and Rural Affairs www.defra.gov.uk

DEFRA (2008) Public Sector Food Procurement Initiative, Proportion of domestically produced food used by government departments and also supplied to hospitals and prisons under contracts negotiated by NHS Supply Chain and National Offender Management Service(previously HM Prison Service)

second report: 1 April 2007 to 31 March 2008.
www.defra.gov.uk/farm/policy/sustain/procurement/awareness.htm.

DEFRA(a) (2006) The National Action Plan www.defra.gov.uk/sustainable/government/documents/full-document.pdf

DEFRA(b) (2006) Food Industry Sustainability Strategy. Department for Environment,

DE GRAAF C (1993) The validity of appetite ratings. *Appetite* **21** 156–160.

DE GRAAF C, DE JONG LS & LAMBERS, A,C. (1999) Palatability affects satiation but not satiety. *Physiology & Behavior* **66** 681–688.

DE LAUZON, B., ROMON, M., DESCHAMP, V., LAFAY, L., BORYS J,M., KARLSSON, J., DUCIMETIERE, P., CHARLES, M,A. (2004). The Three-Factor Eating Questionnaire-R18is able to distinguish among different eating patterns in a general population. Journal of Nutrition. 2004 Sep;134(9) :2372-80

De YOUNG, K, P. THIEL, A., GLODMAN, E, L., MURTHA-BERG, E., JOHNSON, N, K. (2016) A preliminary mechanistic test of the effects of light therapy in bulimia nervosa. *Advances in Eating Disorders* (2016): 1-13.

DEMARCO, A. (1998). Colour therapy for anorexia and depression. Positive health, (35), 27-29.

DEMARCO, A. and CLARKE, N. (2001). An interview with Alison Demarco and Nichol Clarke: Light and colour therapy explained. Complementary therapies in nursing & midwifery, 7 (2), 95-103.

DEMATTE, M. L., ENDRIZZI, I., BIASIOLI, F., COROLLARO, M. L., POJER, N., ZAMPINI, M.,et al. (2013). Food neophobia and its relation with olfactory ability in common odour identification. Appetite, 68, 112–117.

DENZIN N K, LINCOLN Y S (2005) Introduction: The Discipline and Practice of Qualitative Research. In Denzin N K, Lincoln Y S, eds The Sage Handbook of Qualitative Research. 3rd ed. Sage , California: 1-32

DEPARTMENT FOR INTERNATIONAL DEVELOPMENT (2012) An update of 'The Neglected Crisis of Undernutrition: Evidence for Action (PDF). www.gov.uk.. Retrieved 5 July 2014.

DEPARTMENT OF HEALTH (2000). The NHS plan. London, Department of Health.

DH (2001) Nothing About us Without Us, Department of Health, HMSO, London

DH (2001) Valuing People: A New Strategy for Learning Disability for the 21st Century, Department of Health, HMSO, London

DH (2005) Research Governance Framework, Department of Health HMSO, London

DH (2006) Let me in – I'm a researcher! Getting involved in research, Department of Health

DH(a) (2005) Annual Report of the Chief Medical Officer, A Fresh Look: Realigning Food Procurement in the Public Sector. London

DIFFEY BL (1980). "Ultraviolet radiation physics and the skin". *Phys. Med. Biol.* **25** (3):405–426

DISABILITY RIGHTS COMMISSION (2007) The Disability Equality Duty and involvement: guidance for public authorities on how to effectively involve disabled people, www.opm.co.uk/default.htm

DOH (2005) Annual Report of the Chief Medical Officer, A Fresh Look: Realigning Food Procurement in the Public Sector. www.dh.gov.uk/prod_ consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4115781.pdf

DOH (2005) ‘Choosing a better diet: A food and health action plan’ London

DOH (2008) Recognising healthier eating in the public sector, www.dh.gov.uk/en/News/Recentstories/DH_086033

DOH (2009) Department of Health, Sustainable food, A guide for hospitals

DOTY, R. L., SHAMAN, P., APPLEBAUM, S. L., GILBERSON, R., SIKSORSKI, L., & ROSENBERG, L. (1984). Smell identification ability. Changes with age. Science, 226,1441–1443.

DOWLING, G, A., GRAF, C, L., HUBBARD, E, M., LUXENBERG, J, S.(2007). Light treatment for neuropsychiatric behaviors in Alzheimer's disease. *Western Journal of Nursing Research,* vol. 29, no. 8, p. 961-975

EAGLES J.M. (2006). Light therapy and seasonal affective disorder. *Psychiatry,* vol./is. 5/6(199-203)

EDHOLM, O,G., FLETCHER, J,G., WIDDOWSON, E,M., & McCANCE, R,A (1955) The energy expenditure and food intake of individual men. *British Journal of Nutrition* **9** 286–300.

EDMONDSON-JONES (2010) Sustainable Food Procurement and the NHS. *Hospital Caterer,* October Issue, 31-32. Lansdowne. Manchester. http://www.hospitalcaterers.org/publications/journals/hcaj1010.pdf. Retrieved 17 June 2016.

EDWARD J S A, HARTWELL H J (2006) Hospital food service: a comparative analysis of systems and introducing the ‘Steamplicity’ concept. Journal of Human Nutrition and Dietetics, Iss 19: pp 421-430.

EDWARDS J S A, NASH A H M (1999) The nutritional implications of food wastage in hospital food service management. Nutrition & Food Science, Vol. 99 Iss: 2, pp.89-98

ELIA, M. (2000). Hunger disease. Clinical nutrition (Edinburgh, Scotland), 19 (6), 379-386.

ELIA M, STRATTON R, RUSSELL C, GREEN C, PANG F. (2005) The cost of disease-related malnutrition in the UK and economic considerations for the use of oral nutritional supplements (ONS) in adults. Health Economic Report on Malnutrition in the UK. Redditch: BAPEN, .

ELLIOT, A J. and MAIER, M A. (2007). Color and psychological functioning. Current directions in psychological science, 16 (5), 250-254.

ELLIOT, Andrew J., et al. (2007). Color and psychological functioning: The effect of red on performance attainment. Journal of experimental psychology: General, 136 (1), 154-168.

ELLIOT, A, J. and MAIER, M, A. (2007). Color and psychological functioning. Current directions in psychological science, 16 (5), 250-254.

ELLIS, E. V., GONZALEZ, E. W. and MCEACHRON, D. L. (2013). Chronobioengineering indoor lighting to enhance facilities for ageing and Alzheimer's disorder. Intelligent buildings international, 5 (SUPPL1), 48-60.

ENGELEN, L., DE WIJK, R. A., PRINZ, J. F., VAN DER BILT, A., & BOSMAN, F. (2003). The relation between saliva flow after different stimulations and the perception of flavor and texture attributes in custard desserts. Physiology & Behavior, 78, 165–169.

ERIC (2008) www.dh.gov.uk>/Home>Managing your organisation

ESRC (2005), Research Ethics Framework, Economic & Social Research Council

EVANS, B. J. and DRASDO, N. (1991). Tinted lenses and related therapies for learning disabilities--a review. Ophthalmic & physiological optics: The journal of the British college of ophthalmic opticians (optometrists), 11 (3), 206-217.

EVANS, RALPH M. and SWENHOLT, BONNIE K. (1968). Chromatic strengths of colors: Ii. the munsell system. Journal of the optical society of America, 58 (4), 580-584.

EVANS C, JONES R, (2004) Engagement and empowerment, research and relevance: comments on user controlled research, Research Policy and Planning, vol.22 no.2. Social Services Research Group (SSRG)

EVANS R, BANTON M (2001), Learning from experience: involving black disabled people in shaping services, Council of Disabled People. Warwickshire

FIELD, A. (2011). *Discovering Statistics Using SPSS.* (3rd ed.). (pp. 15-18).

Thousand Oaks, California: SAGE Publications

FELDMAN, M., & RICHARDSON, C. T. (1986). Role of thought, sight, smell, and taste of food in the cephalic phase of gastric acid secretion in humans. Gastroenterology, 90, 428–433.

FENGE LA, (2006), Empowering Older Volunteers: learning to research, Research Policy and Planning. vol. 24 no.1. Social Services Research Group (SSRG)

FERRIDEY, D., & BRUNSTROM, J. M. (2011). ‘I just can’t help myself’. Effects of food-cue exposure in overweight and lean individuals. *International Journal of Obesity*, 35,142–149.

FESTINGER, L. (1957). A theory of cognitive dissonance. Stanford, CA:

Stanford University Press.

FINKELSTEIN, E. A., TROGDON, J. G., COHEN, J. W., & DIETZ, W. (2009). Annual medical spending attributable to obesity. Payer-and service-specific estimates. Health Affairs, 28, w822–w831.

FLINT A, RABEN A, BLUNDELL JE, ASTRUP A (2000). Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. Int J Obesity. 2000;24(1):38–48. [PubMed]

FONKEN L.K., NELSON R.J. (2011). Illuminating the deleterious effects of light at night. F1000 Medicine Reports, vol./is. 3/1

FOOD STANDARDS AGENCY (2007) Guidance on Temperature Control Legislation in the United Kingdom, EC Regulation 852/2004, The Food Hygiene Regulations2006 (as amended) accessed 17/01/2015 http://www.food.gov.uk/sites/default/files/multimedia/pdfs/tempcontrolguiduk.pdf

FORTIER, R, H. (1953). The response to color and ego functions. Psychological bulletin, 50 (1), 41-63.

FRANCIS, F. J. (1995). Quality as influenced by color. *Food Quality and Preference*, 6, 149–155.

GARCÍA-SEGOVIA, P., HARRINGTON, R. J., & Seo, H. S. (2015). Influences of table setting and eating location on food acceptance and intake. *Food Quality and Preference*, 39, 1–7.

FRECKA J. M., MATTES R. D. (2008). Possible entrainment of ghrelin to habitual meal patterns in humans. *J. Physiol. Gastrointest. Liver Physiol*. 294, G699–G707

FRENCH, C A. and ALEXANDER, A. B (1972). The luscher color test: An investigation of validity and underlying assumptions. Journal of personality assessment, 36 (4), 361-365.

GARAVINI A., SCHIAVELLO V., Bersani G.(2000). Behavioral disturbances by circadian rhythms alterations in man and mechanism of action of light-therapy. *Rivista di Psichiatria*, 2000, vol./is. 35/2(57-68)

GATENBY SJ (1997) Eating frequency: methodological and dietary aspects. *British Journal of Nutrition* **77** S7–S20.

GIBBONS, C., FINLAYSON, G., DALTON, M., CAUDWELL, P., BLUNDELL, J, E., (2014). METABOLIC PHENOTYPING GIUDLINES -Studying eating behaviour in humans. Biopsychology Group, Institute of Psychological Sciences, University of Leeds.UK. *Journal of Endocrinology,* 222:2, G1-G12.

GILBERT, H (2006) What the doctor ordered? Supply Management.com, www.supplymanagment.com/EDIT/CURRENT_ISSUE-pages/CI-features-item.a

GINER, M., LAVIANO, A., MEGUID, M,M., GLEASON, J, R. (1996) In 1995 a Correlation between malnutrition and poor outcome in critically ill patients still exists. *Nutrition,* Vol 12, Issue 1. 23-29

GOEL N., STUNKARD A.J., ROGERS N.L., VAN DONGEN H.P.A., ALLISONK.C., O'REARDON J.P., AHIMA R.S., CUMMINGS D.E., HEO M., DINGES D.F. (2009). Circadian rhythm profiles in women with night eating syndrome. *Journal of biological rhythms*, 24 (1), 85-94.

GOLDSTEIN, K. (1942). Some experimental observations concerning the influence of colors on the function of the organism. Occupational therapy, 21 , 147-151.

GOODFELLOW, R. A. and SMITH, Patricia C. (1973). Effects of environmental color on two psychomotor tasks. Perceptual and motor skills, 37 (1), 296-298.

GRABE, S., and HYDE, J. (2006). Ethnicity and Body Dissatisfaction Among Women in the United States: A Meta-Analysis. Psychological Bulletin, 132(4), 622-640.

GRABE, S., WARD, L., & HYDE, J. (2008). The role of the media in body image concerns among women: a meta-analysis of experimental and correlational studies. Psychological Bulletin, 134(3), 460-476

GRAHAM, J. W., CUMSILLE, P. E., and ELEK-FISK, E. (2003). Methods for handling missing data. In J. A. Schinka and W. F. Velicer (Eds.), Handbook of psychology (Vol. 2, pp. 87-114). New York: Wiley.

GRANT, M. J. and BOOTH, A. (2009). A typlogy of reviews: An analysis of 14 review types and associated methodologies. Health information & libraries journal, 26 (2), 91-108.

GREEN, S. B. (1991). How many subjects does it take to do a regression analysis? Multivariate Behavioral Research, 26(3), 499-510.

GREEN S, DELARGY H, JOANES D & BLUNDELL J(1997) A satiety quotient: a formulation to assess the satiating effect of food. *Appetite* **29** 291–304.

GREEN, Wanda K. (1982). Effect of viewing selected colors on the performance of gross and fine motor tasks. Perceptual and motor skills, 54 (3, Pt 1), 778.

GREENFEILD, T. (2002). Research methods for postgraduates. 2nd ed., London, Arnold.

GREGERSON NT, FLINT A, BITZ C, BLUNDELL JE, RABEN A & ASTRUP A (2008) Reproducibility and power of ad libitum energy intake assessed by repeated single meals. *The American Journal of Clinical Nutrition* **87** 1277–1281.

GRIFFITH, A. (2010). SPSS for Dummies. John Wiley & Sons, Inc. Hoboken, New Jersey.

GWALTNEY C, SHIELDS A & SHIFFMAN S (2008) Equivalence of electronic and paper-and-pencil administration of patient-reported outcome measures: a meta-analytic review. *Value in Health* **11** 322–333.

HALBERG, F., TAMURA, K. and CORNÉLISSEN, G. (1994). Chronobioengineering toward a cost-effective quality health care. Frontiers of medical and biological engineering: The international journal of the japan society of medical electronics and biological engineering, 6 (2), 83-102.

HALFORD JCG & BLUNDELL JE (2000) Separate systems for serotonin and leptin in appetite control. *Annals of Medicine*. 32 222–232.

HAMILTON FL, Car J, LYONS C, Car M, LAYTON A, MAJEEDA (2009). Laser and other light therapies for the treatment of acne vulgaris: systematic review. *Br. J. Dermatol.* **160** (6): 1273–85

HAMMES, J. A. and WIGGINS, S. L. (1962). Perceptual-motor steadiness, manifest anxiety, and color illumination. Perceptual and motor skills, 14 (1), 59-61.

HANISAH, R., SUZANA, S. and LEE, F. S. (2012). Validation of screening tools to assess appetite among geriatric patients. The journal of nutrition, health & aging, 16 (7), 660-665.

HANKEY A., EWING E. (2007). New light on chromotherapy: Grakov's 'virtual scanning' system of medical assessment and treatment. *Evidence-based Complementary and Alternative Medicine*, vol./is. 4/2(139-144)

HANNAH, D., DEMPSTER, M. (2012). Psychology Statistics for Dummies. John Wiley & Sons, Ltd. West Sussex, England

HANLEY B, BRADBURN J, BARNES M, EVANS C, GOODARE H, KELSON M, KENT A, OLIVER S, THOMAS S and WALLCRAFT J (2003) Involving the public in the NHS, public health and social care research: briefing notes for researchers. INVOLVE. www.invo.org.uk

HART, C. (2001). Doing a literature search: A comprehensive guide for the social sciences. London, SAGE.

HART C, (1998) Doing a literature Review, Releasing the Social Science Research Imagination. The Open University. SAGE. London

HASENBECK, A., CHO, S., MEULLENET, J. F., TOKAR, T., YANG, F., HUDDLESTON, E. A., et al. (2014). Color and illuminance level of lighting can modulate willingness to eat bell peppers. Journal of the Science of Food and Agriculture, 94, 2049–2056.

HATTA, Takeshi, et al. (2002). Color of computer display frame in work performance, mood, and physiological response. Perceptual and motor skills, 94 (1), 39-46.

HERMANS, R. C. J., LARSEN, J. K., HERMAN, C. P., & ENGELS, R. C. M. E. (2012). How much should I eat? Situational norms affect young women's food intake during meal time. British Journal of Nutrition, 107, 588–594.

HIGGINS, J. P. T. and GREEN, S. (2008). Cochrane handbook for systematic reviews of interventions. 5.0.1 ed., http://www.cochrane-handbook.org Retrieved 3rd December 2013.

HILL, R A. and BARTON, R A. (2005). Red enhances human performance in contests. Nature, 435 (7040), 293.

HILL A & BLUNDELL J (1982) Nutrients and behaviour: research strategies for the investigation of taste characteristics, food preferences, hunger sensations and eating patterns in man. *Journal of Psychiatric Research* **17** 203–212.

HILL AJ, ROGERS PJ, BLUNDELL JE. (1995) Techniques for the measurement of human eating behaviour and food intake: a practical guide. *Int J Obesity*. 1995;19:361–375. [PubMed]

HILME N, HANMORE R, (1998) Consulting with disabled children and young persons: a methodological framework, Social Services Research Group (SSRG)

HOCHEL, M., et al. (2009). Congruence or coherence? emotional and physiological responses to colours in synaesthesia. European journal of cognitive psychology, 21 (5), 703-723.

HOENIG, J. M. and HEISEY, D. M. (2001). The Abuse of Power: The Pervasive Fallacy of Power Calculations for Data Analysis. The American Statistician, 55(1), 19-24.

HOLMES, Cooper B., et al. (1986). The barnum effect in luscher color test interpretation. Journal of clinical psychology, 42 (1), 133-136.

HOMQVIST, K., LUNDE, C., & FRISEN, A., (2007). Dieting behaviours, body shape perceptions, and body satisfaction: cross-cultural differences in Argentinean and Swedish 13-year-olds. Body Image, 4(2), 191-200

HOTTA, Mari, et al. (2009). Ghrelin increases hunger and food intake in patients with restricting-type anorexia nervosa: A pilot study. Endocrine journal, 56 (9), 1119-1128.

HOWITT, D., & CRAMER, D. (2011). *Introduction to Research Methods in Psychology* (3rd ed.). (pp. 164, 179-181). Harlow, Essex: Pearson Education Limited

HSCIC (2015) National ERIC Return 14/15 http://www.hscic.gov.uk/catalogue/PUB18726/est-ret-info-col-2014-2015-rep.pdf, accessed 11/06/16

HUCK, S.W., & CORMIER, W.H. (1996). <u>Reading statistics and research</u> (2nd ed.). New York: Harper Collins

HUMMEL, T., KOBAL, G., GUDZIOL, H., & MACKAY-SIM, A. (2007). Normative data for the “Sniffin’ Sticks” including tests of odor identification, odor discrimination, and olfactory thresholds. An upgrade based on a group of more than 3,000 subjects. European Archives of Otorhinolaryngology, 264, 237–243.

HUMMEL, T., KONNERTH, C. G., ROSENHEIM, K., & KOBAL, G. (2001). Screening of olfactory function with a four-minute odor identification test. Reliability, normative data, and investigations in patients with olfactory loss. Annals of Otology, Rhinology, and Laryngology, 110, 976–981.

HURSTI, U-K. K., & SJODEN, P.-O. (1997). Food and general neophobia and their relationship with self-reported food choice. Familial resemblance in Swedish families with children of ages 7–17 years. Appetite, 29, 89–103.

HUTCHINGS, J. B. (1999). Food color and appearance (2nd ed.). Gaithersburg, MD: Aspen Publishers, Inc.

ISAACS, Larry D. (1980). Effects of ball size, ball color, and preferred color on catching by young children. Perceptual and motor skills, 51 (2), 583-586.

ISHIHARA, S. (1986). Ishihara’s tests for colour-blindness (Concise ed.). Tokyo: KANEHARA & Co. J,W. JOHNSON &WILDMAN, H. E. (1983). Influence of external and covert food stimuli on insulin secretion in obese and normal persons. *Behavioral Neuroscience*, 97, 1025–1028.

JACOBS, K. W. and HUSTMYER JR., F. E. (1974). Effects of four psychological primary colors on GSR, heart rate and respiration rate. *Perceptual and motor skills*, 38 (3), 763-766.

JAMES, W. T. and DOMINGOS, William R. (1953). The effect of color shock on motor performance and tremor. Journal of general psychology, 48 , 187-193.

JOHNSON, F., & WARDLE, J. (2005). Dietary Restraint, Body Dissatisfaction, and Psychological Distress: A Prospective Analysis. *Journal of Abnormal Psychology*, 114(1),119-125

KARLSON, J., PERSSON, L. O., SJOSTROM, L., & SULLIVAN, M. (2000). Psychometric properties and factor structure of the three-factor eating questionnaire (TFEQ) in obese men and women. Results from the Swedish obese subjects (SOS) study. *International Journal of Obesity and Related Metabolic Disorders*: *Journal of the International Association for the Study of Obesity,* 24(12), 1715-1725.

KAYA, N., EPPS, H, H. (2004). Relationship between color and emotion: A study of college students. College student journal, 38 (3), 396-405.

KAYA, Naz and EPPS, Helen H. (2004). Relationship between color and emotion: A study of college students. College student journal, 38 (3), 396-405.

KEELE UNIVERSITY (2004) Health Services Investment Analysis of New Hospitals, \\medical School and related developments in North Staffordshire. Keele: Keele University

KELLEY, K and MAXWELL, S. E. (2003). Sample size for multiple regression: Obtaining regression coefficients that are accurate, not simply significant. Psychological Methods, 8(3), 305-321.

KENT, B, A. (2014). Synchronizing an aging brain: can entraining circadian clocks by food slow Alzheimer's disease?. Aging Neuroscience, Retrieved 27th March 2016at http://journal.frontiersin.org/article/10.3389/fnagi.2014.00234/full#h8

KEPPEL, G. and WICKENS, T. D. (2004). Design and Analysis: A Researcher's Handbook, Fourth Edition. Pearson Prentice Hall: Upper Saddle River, New Jersey.

KILLGORE,W. D. S., & YURGELUN-TODD, D. A. (2010). Sex differences in cerebral responses to images of high vs low calorie food. *Neuroreport*, 21, 354–358.

KIM J.-S., JUNG G.-I., CHOI J.-H., LEE T.-H., KIM A.-H., OH H.-B., KWON Y., LEE E.-S., CHO Y.B., JUN J.-H. (2015). Development of multi-colored LED system for therapeutic application. *Technology and Health Care*, vol./is. 23

KIR'IANOVA V.V., BABURIN I.N., GRONCHAROVA V.G., VESELOVSKII A.B. (2012). The useof phototherapy and photochromotherapy in the combined treatment of the patients presenting with astheno-depressive syndrome and neurotic disorders. Voprosy kurortologii, fizioterapii, i lechebnoi fizicheskoi kultury, vol./is. /1(3-6), 0042-8787

KLINE, R. B. (2004). Beyond Significance Testing: Reforming Data Analysis Methods in Behavioral Research. American Psychological Association: Washington, D.C.

KNEZ, I., & ENMARKER, I. (1998). Effects of office lighting on mood and cognitive performance and a gender effect in work-related judgment. Environment and Behavior,30, 553–567.

KOCK, N (2015). One-tailed or two-tailed P values in PLS-SEM. *International Journal of e-collaboration.* 11(2), 1-7.

KODAMA, T, et al. (2010). Neurophysiological analyses in different color environments of cognitive function in patients with traumatic brain injury. *Journal of Neurotrauma*, 27 (9), 1577-1584.

KOJIMA M., HOSODA H., DATE Y., NAKAZATO M., MATSUO H., KANGAWA K. (1999). Ghrelin is a growth-hormone-releasing acylated peptide from stomach. Nature 402, 656–660 10.1038/45230

KOJIMA M., KANGAWA K. (2005). Ghrelin: structure and function. Physiol. Rev. 85, 495–522 10.1152/physrev.00012.2004

KOZA, B. J., CILMI, A., DOLESE, M., & ZELLNER, D. A. (2005). Color enhances orthonasal olfactory intensity and reduces retronasal olfactory intensity. Chemical Senses, 30, 643–649.

KRZYSZTOF, K., KRZYSTANEK, M, JANAS-KOZIK, MALGORZATA, KRUPKA-MATUSZCZYK, I. (2012) Bright light therapy in the treatment of childhood and adolescence depression, antepartum depression, and eating disorders. *Journal of Neural Transmission*, vol. 119, no. 10, p. 1167-1172,

KULLER, R. BALLAL, S. LAIKE, T. MIKELLIDES, B. and TONELLO, G. (2006) The impact of light and colour on psychological mood: a cross-cultural study of indoor work environments. *Journal of Ergonomics*. Nov 15;29(14): 1496-507

KUCUKGONCU S., MIDURA M., TEK C.(2015). Optimal management of night eating syndrome: Challenges and solutions. *Neuropsychiatric Disease and Treatment,* vol./is. 11/(751-760), 1176-6328;1178-2021

KVAMME, J–M., OLSEN, J, A., FLORHOLMEN, J., JACOBSEN, B, K. (2011). Risk of malnutrition and health-related quality of life in community-living elderly men and women: The Tromsø study. Quality of Life Research 20 (4): 575–582.

KWALLEK, N., et al. (1996). Effects of nine monochromatic office interior colors on clerical tasks and worker mood. Color research and application, 21 (6), 448-458.

KWALLEK, N., et al. (1997). Impact of three interior color schemes on worker mood and performance relative to individual environmental sensitivity. Color research and application, 22 (2), 121-132.

KWALLEK, N. and LEWIS, C. M. (1990). Effects of environmental colour on males and females: A red or white or green office. Applied ergonomics, 21 (4), 275-278.

KWALLEK, Nancy, LEWIS, Carol M. and ROBBINS, Ann S. (1988). Effects of office interior color on workers' mood and productivity. Perceptual and motor skills, 66 (1), 123-128.

LAM RW; LEVITT AJ; LEVITAN RD; et al. (2016-01-01). "Efficacy of bright light treatment, fluoxetine, and the combination in patients with nonseasonal major depressive disorder: A randomized clinical trial". JAMA Psychiatry **73** (1): 56–63. *doi:10.1001/jamapsychiatry.2015.2235. ISSN 2168-622X.*

LARSSON, M., LOVDEN, M., & NILSSON, L. G. (2003). Sex differences in recollective experience for olfactory and verbal information. Acta Psychological, 112, 89–103.

LAWSON OJ, WILLIAMSON DA, CHAMPAGNE CM, DELANY JP, BROOKS ER, HOWAT PM. (1995). The association of body weight, dietary intake, and energy expenditure with dietary restraint and disinhibition. *Obesity Research*. 3:153–61.

LEEDY P D, ORMROD J E (2005) Practical Research, Planning and Design (8th ed) Pearson Merrill Prentice Hall, New Jersey

LEIDY, H. J., ORTINAU, L. C., DOUGLAS, S. M., & HOERTEL, H. A. (2013). Beneficial effects of a higher-protein breakfast on the appetitive, hormonal, and neural signals controlling energy intake regulation in overweight/obese, “breakfast-skipping,” late-adolescent girls. *American Journal of Clinical Nutrition*, 97, 677–688.

LEVINE, M., and ENSOM M. H. H. (2001). Post Hoc Power Analysis: An Idea Whose Time Has Passed? Pharmacotherapy, 21(4), 405-409.

LOMBION-POITHIER, S., VANDEL, P., NEZELOF, S., HAFFEN, E., & MILOT, J. L. (2006). Odor perception in patients with mood disorders. *Journal of Affective Disorder*, 90, 187–191.

LOVING R.T., KRIPKE D.F., KNICKERBOCKER N.C., GRANDNER M.A. (2005). Bright green light treatment of depression for older adults. *BMC Psychiatry*, vol./is. 5/(no pagination),

LEVY, B, I. (1984). Research into the psychological meaning of color. *American journal of art therapy*, 23 (2), 58-62.

LI, X., et al. (2012). The visual effects of flower colors on university students' psycho-physiological responses. J. Food Agric. Environ., 10 (3-4), 1294-1300 .

LINTON, H. (2001). Expanding color design methods for architecture and allied disciplines. In: Chung R and Rodrigues A (eds.). 9th Congress of the International Colour Association, 24 June 2001 through 29 June 2001. 996-999.

LIPSEY, M. W. and WILSON, D. B. (1993). The Efficacy of Psychological, Educational, and Behavioral Treatment: Confirmation from Meta-analysis. *American Psychologist*, 48(12), 1181-1209.

LONDON DEVELOPMENT AGENCY (2005) Better Food for London: the Mayor's Draft Food Strategy. London

LONG, J. S. (1997). Regression Models for Categorical and Limited Dependent Variables. Thousand Oaks, CA: Sage Publications.

LUBORSKY L, AUERBACH A, ARTHUR H, CHANDLER M, COHEN J, BACHRACH H M (1971)Factors influencing the outcome of psychotherapy: A review of quantitative research. *Psychological Bulletin*, Vol 75(3), Mar 1971, 145-185

MACHT, M. (2008). How emotions affect eating. A five-way model. Appetite, 50, 1–11.

MAGNANI, L. (2001) "Abduction, Reason, and Science: Processes of Discovery and Explanation". Kluwer Academic Plenum Publishers, New York, xvii. 205 pages. Hard cover, ISBN 0-306-46514-0.

MARSTENKOVS'KYI, ,I.A. (1995). [Lateral photo-color therapy in the combined ambulatory treatment of mental disorders]. Likars'ka sprava / ministerstvo okhorony zdorov'ia ukraïny, (7-8), 111.

MASSOLT, E. T., VAN HAARD, P. M., REHFELD, J. F., POSTHUMA, E. F., VAN DER VEER , E., & SCHWEITZER, D. H. (2010). Appetite suppression through smelling of dark chocolate correlates with changes in ghrelin in young women. *Regulatory Peptides*, 161, 81–86.

MAXWELLl, S. E. and DELANY, H. D. (2004). Designing Experiments and Analyzing Data: A Model Comparison Perspective, Second Edition. Lawrence Erlbaum Associates, Mahwah, New Jersey.

MAXWELL, S. E. (2000). Sample size and multiple regression analysis. Psychological Methods, 5(4), 434-458.

MAYER, J. (1953). Glucostatic mechanism of regulation of food intake. N Engl JMed. 249: p13-16

McDURY, J. and ALTERI, M. (2003) Learning Through Storytelling in Higher Education: Using Reflection and Experience to Improve Learning.

London, Kogan Page Ltd.

MCEACHRON, D. (2012). Chronobioengineering: Introduction to biological rhythms with applications, volume 1. 43.

McCune, A, M. (2014) *Bright Light Therapy for the Treatment of Night Eating Syndrome.* Diss. University of Missouri-Kansas City.

McNAIR, D.M., LORR, M. DROPPELMAN, L. F (1971). Manual for the profile of mood states. Education and Industrial Testing Service, P.27. San Diego, CA

McCUNE, A M., LUNDGREN, J D. (2015). Bright light therapy for the treatment of night eating syndrome: A pilot study. *Psychiatry Research,* vol. 229, no. 1-2, p. 577-579, 0165-1781

MEHRABIAN, A (1996). Pleasure-arousal-dominance: A general framework for describing and measuring individual differences in temperament . *Current Psychology*, 14 (4), 261-292.

MILES A, LOUGHLIN M. POLOYCHRONIS A (2008) Evidence-based healthcare, clinical knowledge and the rise of personalised medicine. *Journal of Evaluating Clinical Practice* 14 (5): 621-49

MILLER, Richard S. (1958). The munsell system of color notation. *Journal of Mammalogy*, 39 , 278-286.

MILLER, R S. (1958). The munsell system of color notation. *Journal of Mammalogy*, 39 , 278-286.

MINKE, A (1997). Conducting Repeated Measures Analysis: Experimental Design Considerations. Texas AM University, USA (*accessed 04/06/17) http://ericae.net/ft/tamu/Rm.htm*

MOLLON, J, D. (1997). "Tho' she kneel'd in that place where they grew...": The uses and origins of primate colour visual information. Cambridge, MA, US, The MIT Press, Cambridge, MA. Readings on color, Vol. 2: The science of color.

MONELLO, L. F., & MAYER, J. (1967). Hunger and satiety sensations in men, women, boys, and girls. American Journal of Clinical Nutrition, 20, 253–261.

MORROT, G., BROCHET, F., & DUBOURDIE, D. (2001). The color of odors. Brain Language, 79, 309–320.

MOSCO DECLARATION (1943) http://avalon.law.yale.edu/wwii/moscow.asp (accessed 15/04/13)

MUDGE, A, M., et al. (2011). Helping understand nutritional gaps in the elderly (HUNGER): A prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. *Clinical nutrition* (Edinburgh, Scotland), 30 (3), 320-325.

MULHOLLAND, B, M. (1997). Introduction to color theory. In: Proceedings of the 1997 55th Annual Technical Conference, ANTEC. Part 3 (of 3), 27 April 1997 through 2 May 1997. Brookfield, CT, United States, Society of Plastics Engineers, 2730-2734.

MULLEN, R (2006) Caterer and Hotelkeeper, Inside Contract Catering: Hospital food purchasing, www.caterersearch.com/Articles/2006/10/19/309547/inside-contract-catering

MUNCH M., BROMUNDT V. (2012). Light and chronobiology: Implications for health and disease. *Dialogues in Clinical Neuroscience*, vol./is. 14/4

MUNSELL, A. H. (ed.) (1961). A color notation. 11th ed., Baltimore, Md., Munsell.

MURPHY, K. R. and MYORS, B. (2004). Statistical Power Analysis: A Simple and General Model for Traditional and Modern Hypothesis Tests. Mahwah, New Jersey: Lawrence Erlbaum Associates.

MUST, A., SPANDANO, J., COACKLEY, E. H., FIELD, A. E., COLDITZ, G., & DIETZ, W. H. (1999). The disease burden associated with overweight and obesity. JAMA: *The Journal of the American Medical Association*, 282, 1523–1529.

NAKAZATO M., MURAKAMI N., DATE Y., KOJIMA M., MATSUO H., KANGAWA K., et al. (2001). A role for ghrelin in the central regulation of feeding. *Nature* 409, 194–198 10.1038/35051

NAKSHIAN, J, S. (1964). The effects of red and green surroundings on behavior. *Journal of general psychology*, 70 (1), 143-161.

NEGOIAS, S. R., VISSCHERS, A., BOELRIJK, A., & HUMMEL, T. (2008). New ways to understand aroma perception. Food Chemistry, 108, 1247–1254.

NIJS, I. M. T., MURIS, P., EUSER, A. S., & FRANKEN, I. H. A. (2010). Differences in attention to food and food intake between overweight/obese and normal-weight females under conditions of hunger and satiety. *Appetite,* 54, 243–254.

NHS (2000) The NHS Plan www.dh.gov.uk/en/Publicationsandstatistics/ Publications/PublicationsPolicyAndGuidacne/DH_4002960

NHS ESTATES (2001). Better hospital food. London, Department of Health.

NHS Estates (2001) Better Hospital Food http://195.92.246.148/nhsestates/ better_hospital_food/bhf_content/introduction/home.asp.

NHS Estates (2004) Patient Environment Action Team results 2004 London: NHS Estates 2004.

NHS Estates (2005) Managing Food Waste in the NHS gateway ref: 4619 London: NHS Estates 2005. http://www.hospitalcaterers.org/documents/ foodwst.pdf

NICHOLLS D, (2009) Research methodology series, Qualitative research: Part two: Methodologies. *International Journal of Therapy and Rehabilitation*, Vol 16, No 11: 586-592

NICHOLLS J, WATSON K, (2000) The use of the qualitative research methodology tool 'participatory appraisal' with mental health service users as a method of consultation andcommunity capacity building, International Institute for Environment and development (PLA notes 38)

NICKERSON, D. (1940). History of the munsell color system and its scientific application. *Journal of the optical society of America*, 30 , 575-586.

NIKITINA, N. V. and URVANTSEV, L. P. (1988). Color testing approach to emotionality studies in neurotic patients. Zhurnal nevropatologii i psikhiatrii imeni S.S.korsakova, 88 (12), 82-85.

NUSSBAUMER, B. , KAMINSKI-HARTENTHALER, A. , FORNERIS ,C, A. MORGAN, L, C., SONIS, J, H., GAYNES, B, N., GREENBLATT, A. , WIPPLINGER, J., LUX, L, J., WINKLER, D., VAN NOORD, M, G., HOFMANN, J., GARTLEHNER, G.(2015) Light therapy for preventing seasonal affective disorder. (Cochrane Systematic Review)

OBERFELD, D., HECHT, H., ALLENDORF, U., & WOCKELMAIER, F. (2009). Ambient lighting modifies the flavor of wine. Journal of Sensory Studies, 24, 797–832.

OED (1990) Oxford English Dictionary of Current English.8th ed. Clarendon Press, Oxford, England.

OED (2011) Oxford English Dictionary on line www.oed.com/ accessed
May 2011

O'FLYNN, J., PEAKE, H., HICKSON, M., FOSTER, D., FROST, G. (2005). The prevalence of malnutrition in hospitals can be reduced: results from three cross-sectional studies. "*Clinical Nutrition* 24.6 (2005): 1078-1088

OLIVER (2009) www.jamieoliver.com/school-dinner

OLIVER, P. (2012). Succeeding with your literature review: A handbook for students. New York, USA, Open University Press, McGraw-Hill, Education.

PALINKAS, L, A. (2010). Nutritional interventions for treatment of seasonal affective disorder.*CNS Neuroscience & Therapeutics*, Feb 2010, vol. 16, no. 1, p. 3-5

PALOUZIER-PAULIGNAN, B., LACROIX, M. C., AIME, P., Baly, C., CAILLOL, M., CONGAR, P.,et al. (2012). Olfaction under metabolic influences. *Chemical Senses,* 37, 769–797.

PAN, C. S., SHELL, R. L., & SCHLEIFEr, L. M. (1994). Performance variability as an indicator of fatigue and boredom effects in a VDT data-entry task. *International Journal of Human-Computer Interaction, 6,* 37-45. doi: 10.1080/10447319409526082

PANGBORN, R. M. (1968). Parotid flow stimulated by the sight, feel, and odor of lemon. *Perceptual and Motor Skills*, 8, 339–346.

PASA (2002) Environmental Procurement within the NHS – Final report NHS Purchasing and Supply Agency www.pasa.nhs.uk

PEI S, INAMADAR AC, ADYA KA, TSOUKAS MM (2015). Light-based therapies in acne treatment. *Indian Dermatol Online J* 6 (3): 145–57.

PICCO, R, D. and DZINDOLET, M, T. (1994). Examining the lüscher color test. Perceptual and motor skills, 79 (3, Pt 2), 1555-1558.

PIERCE, D. H. and WEINLAND, J. D. (1934). The effect of color on workmen. Personnel journal, 13 , 34-38.

PLINER, P., & HOBDEN, K. (1992). Development of a scale to measure the trait food neophobia. *Appetite*, 19, 105–120.

POLGAR S, THOMAS S, A (2000) Introduction to Research in the Health Sciences Fourth Edition, Elsevier Churchill Livingstone.

POLLATOS, O., KOPIETZ, R., LINN, J., ALBRECHT, J., SAKAR, V., ANZINGER, A., et al. (2007). Emotional stimulation alters olfactory sensitivity and odor judgement. *Chemical Senses*, 32, 583–589.

PRASKO J 2008). "Bright light therapy". *Neuro Endocrinol.* Lett. 29 Suppl 1: 33–64.

PRESSEY, S. L. (1921). The influence of color upon mental and motor efficiency. The American journal of psychology, 32 , 326-356.

RADELJAK S., ZARKOVIC--PALIJAN T., KOVACEVIC D., KOVAC M. (2008). Chromotherapy in the regulation of neurohormonal balance in human brain—complementary application in modern psychiatric treatment. *Collegium antropologicum,* vol./is. 32 Suppl 2/(185-188),

RAMAEKERS, M. G., BOESVELDT, S., LAKEMOND, C. M. M., VANBOEKEL, M. A. J. S., & LUNING, P. A. (2014). Odors. Appetizing or satiating? Development of appetite during odor exposure over time. *International Journal of Obesity*, 38, 650–656.

REID K.J., SANTOSTASIG., BARON K.G., WILSON J., KANG J., ZEE P.C. (2014).Timing and intensity of light correlate with body weight in adults.

PloS one, vol./is. 9/4

ROBSON C (2002) Real World Research (2nd ed) Blackwell Publishing, Oxford

ROGERS, J (2009) Over the top tendering Health Service Journal

ROLLS, E. T. (2006). Brain mechanisms underlying flavour and appetite. Philosophical Transactions of the Royal Society. B 361: 1123-1136.

ROLLS, B. J., ROWE, E. A., & ROLLS, E. T. (1982). How sensory properties of foods affect human feeding behavior. Physiology & Behavior, 29, 409–417.

ROSE, J. and GLASS, N. (2008) The importance of emancipatory research to contemporary nursing practice. Contemporary Nurse. 29(1):8-22

ROSE D, FORD R, LINDLEY P, GAWITH L & KCW Mental Health Monitoring Users' Group (1998) In our experience: user-focused monitoring of mental health services, Sainsbury Centre for Mental Health

ROSENSTEIN, L. D. (1985). Effect of color of the environment on task performance and mood of males and females with high or low scores on the scholastic aptitude test. Perceptual and motor skills, 60 , 550.

ROSS M.J., GUTHRIE P., DUMONT J.-C (2013).The impact of modulated, colored light on the autonomic nervous system. *Advances in mind-body medicine*, vol./is. 27/4

ROT, M. H, MOSKOWITZ, D. S and YOUNG, S.N. (2008) Exposure to bright light is associated with positive social interaction and good mood over short time periods: A naturalistic study in mildly seasonal people. Journal of Psychiatric Research. March issue 42 (4):311-9

ROYAL COLLEGE OF NURSING (RCN) (2007) Research Ethics – RCN Guidance for Nurses

ROYAL COLLEGE PAEDIATRICS AND CHOLD HEALTH (2005) Coming out of the shadows: a strategy to promote participation of children and young people in RCPCH activity.

ROZIN, P. (1982). “Taste-smell confusion” and the duality of the olfactory sense. *Percept Psychophysics*, 31, 397–401.

RUGGIERI, V. and PETRUZZIELLO, M. G. (1988). Psychophysiology of analysis of connotative decodification: The role of thermic and somesthetic systems in decodification of chromatic stimuli. Perceptual and motor skills, 66 (2), 435-442.

RUSSEL, J., SWITZ, G. M., and THOMPSON, K. (1980). Pharmacology Biochemistry and Behaviour, 13(5), 737–738

SAKA, BULENT; KAYA, OMER, OZTURK, GULISTAN BAHAT, ERTEN, NILGUN, KARAN, M. AKIF (2010). "Malnutrition in the elderly and its relationship with other geriatric syndromes". *Clinical Nutrition* 29 (6): 745 –748.

SALMAN, Y. G and LONDON, N. J. M., and SHAISTA, S. G. (2014). Ethics in medical research Pages 121–126. *Journal of Microscopy and Ultrastructure*. Volume 2, Issue 3,

SATYAM, C. (2004). Colour light therapy. Positive health, (99), 9-11.

SAVAGE, J., SCOTT, C., (2005). Patients' nutritional care in hospital: An ethnographic study of nurses' role and patients' experience. RCN Institute, 20 Cavendish Square, London, W1G 0RN, Royal College of Nursing.

SAVINA, C., et al. (2003). Administering the "AHSP questionnaire" (appetite, hunger, sensory perception) in a geriatric rehabilitation care. *The journal of nutrition, health & aging*, 7 (6), 385-389.

SCHAIBLE, U. E.; KAUFMANN, S. H. E. (2007). "Malnutrition and Infection: Complex Mechanisms and Global Impacts". PLoS Medicine 4 (5): e115. doi:10.1371/journal.pmed.0040115. PMC 1858706. PMID 17472433.

SCHLACHT, I. L. (2006). Color design requirement in microgravity long duration missions. In: AIAA 57th International Astronautical Congress, IAC 2006, 2 October 2006 through 6 October 2006. 434-440.

SCHON, D. A. (1983) The Reflective Practitioner: how professionals think in action. Aldershot, Ashgate Publishing.

SCHULZ, K, F., GRIMES, D, A. (2002). Blinding in randomised trials: hiding who got what; 359: 696–700. *THE LANCET*, Vol 359 , February 23, 2002 . www.thelancet.com

SCOTT, S., BROWN, A., LUNT, I., THORNE, L (2004). Professional doctorates: Integrating professional and academic knowledge. London, Open University Press, McGraw-Hill education.

SEDLMEIER, P. and GIGERENZER, G. (1989). Do Studies of Statistical Power Have an Effect on the Power of Studies? Psychological Bulletin, 105(2), 309-316.

SEO, H. S., BUSCHHUTER, D., & HUMMEL, T. (2008). Contextual influences on the relationship between familiarity and hedonicity of odors. Journal of Food Science, 73, S273–S278.

SEO, H. S., GUARNEROSs, M., HUDSON, R., DISTEN, H., MIN, B. C., KANG, J. K., et al. (2011). Attitudes toward olfaction. A cross-regional study. Chemical Senses, 36, 177–187

SEO, H. S., & HUMMEL, T. (2012). Smell, taste, and flavor. In H. Jelen´ (Ed.), *Food flavors, chemical, sensory and technological properties* (pp. 35–63).

New York: CRC Press.

SEO, H. S., LEE, S., CHO, S. (2013). Relationships between personality traits and attitudes toward the sense of smell. *Frontiers in Psychology,* 4, 901. doi:10.3389/ fpsyg.2013.00901.

SHADISH, W. R., COOK, T. D. and CAMPBELL, D. T. (2002). Experimental and Quasi-experimental Designs for Generalized Causal Inference. Boston: Houghton Mifflin Co.

SHANKAR, M. U., LEVITAN, C. A., & SPENCE, C. (2010). Grape expectations. The role of cognitive influences in color-flavor interactions. *Consciousness and Cognition*, 19, 380–390.

SHU (2012) Sheffield Hallam University Research Students Webpage. (last accessed 8th June 2016).

SHU (2014) Doctorate in Professional Studies -Programme Handbook for 2014/15 , Dprof Handbook%20Prof%20Doc%202014-15[1]

SHU (2015) Research Ethics Policy and Procedure, 6th Edition, June 2016. University Research Ethics Committee. Sheffield Hallam University, Sheffield. https://www.shu.ac.uk/research/ethics-integrity-and-practice. Accessed 16th June 2016.

SHULZ, K, F., GRIMES, D, A (2002) Blinding in randomised trials: hiding who got what. *Lancet.* Feb 23;359(9307):696-700

SIFFRE, M. (1975). Six months alone in a cave. *National Geographic*, 147(3), 426-435.

SKOTTUN, B. C. (2004). On the use of red stimuli to isolate magnocellular responses in psychophysical experiments: A perspective. *Visual neuroscience,* 21 (1), 63-68.

SOCIAL RESEARCH ASSOCIATION (SRA) (2003) Ethical Guidelines, pp 30

SOLDAT, A. S., SINCLEAR, R. C., MARK, M. M. (1997). Color as an environmental processing cue: External affective cues can directly affect processing strategy without affecting mood. Social cognition, 15 , 55-71.

SORENSEN, L. B., MOLLER, P., FLINT, A., MARTENS, M. RABEN, A. (2003) Effect of sensory perception of foods on appetite and food intake: a review of studies on humans. *International Journal of Obesity*, Issue 27, pp1152 – 1166.

SPENWYN, J., BARRETT, D. J. K. and GRIFFITHS, M. D. (2010). The role of light and music in gambling behaviour: An empirical pilot study. *International journal of mental health and addiction*, 8 (1), 107-118.

ST-ARNAUD-MCKENZIE, Danielle, et al. (2004). Hunger and aversion: Drives that influence food intake of hospitalized geriatric patients. *The journals of gerontology.* Series A, biological sciences and medical sciences, 59 (12), 1304-1309.

STAFFORD, L. D., & WELBECK, K. (2011). High hunger state increases olfactory sensitivity to neutral but not food odors. *Chemical Senses*, 36, 189–198.

STARK, G. M., SAUNDERS, D. M. and WOOKEY, P. E. (1982). Differential effects of red and blue coloured lighting on gambling behaviour. Current psychological research, 2 (2), 95-99.

STILLWAGGON, E (2008). "Race, Sex, and the Neglected Risks for Women and Girls in Sub-Saharan Africa". Feminist Economics 14 (4): 67–86. doi:10.1080/13545700802262923.

STOLPER, Jane H. (1977). Color induced physiological response. *Man-environment systems*, 7 (2), 101-108.

STOUGHTON, C. M., et al. (2012). Psychophysical chromatic mechanisms in macaque monkey. *Journal of neuroscience*, 32 (43), 15216-15226.

STRATTON, I. M. and NEIL, A. (2004). How to ensure your paper is rejected by the statistical reviewer. *Diabetic Medicine*, 22, 371-373.

STRATTON RJ, KING CL, STROUD MA, JACKSON AA, ELIA M. Malnutrition Universal Screenin Tool predicts mortality and length of hospital stay in acutely ill elderly. *British Journal of Nutrition* 2006: 95:325-330.

STRATTON R, STUBBS R, HUGHES D, KING N, BLUNDELL J & ELIA M (1998) Comparison of the traditional paper visual analogue scale questionnaire with an Apple Newton electronic appetite rating system (EARS) in free living subjects feeding ad libitum. *European Journal of Clinical Nutrition* **52** 737.

SUAREZ-PINILLA, P, PENA-PEREZ, C, ARBAIZER-BARRENECHEA, B, CRESPO-FACORRO, B, DEL BARRIO, J A G, TREASURE, J, LLORCA-DIAZ, J (2015) Inpatient treatment for anorexia nervosa: A systematic review of randomized controlled trials. *Journal of Psychiatric Practice*, vol. 21, no. 1, p. 49-59, 1527-4160

STUBBS, R. J., HUGHESs, D. A., JONHSTONE, A.M., ROWLEY, E., REID, C., ELIA, M., STRATTON, R., DELARGY, R., KING, N., BLUNDELL, J. E. (2000). The use of visual analogue scales to assess motivation to eat in human subjects: a review of their reliability and validity with an evaluation of new hand-held computerized systems for temporal tracking of appetite ratings *British Journal of Nutrition* / Volume 84 / Issue 04 / October 2000, pp 405-415

STUNKARD, A.J., & MESSICK, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research*, 29, 71-83

STURM, K., et al. (2003). Appetite, food intake, and plasma concentrations of cholecystokinin, ghrelin, and other gastrointestinal hormones in undernourished older women and well-nourished young and older women. *The journal of clinical endocrinology and metabolism*, 88 (8), 3747-3755.

SUK, H. J., PARK, G. L., & KIM, Y. (2012). Bon appétit! An investigation about the best and worst color combinations of lighting and food. *Journal of Literature and Art Studies*, 2, 559–566.

SCHWAARTZ MW, WOODS SC, PORTE D, SEELEY RJ & BASKIN DG (2000). Central nervous system control of food intake. *Nature* 404 661–671.

SZENTIRMAI E., KAPASL., KRUEGER J. M. (2006). Ghrelin microinjection into forebrain sites induces wakefulness and feeding in rats. *J. Physiol*. Regul. Integr. Comp. Physiol. 292,R575–R585 10.1152/ajpregu.00448.2006

TERMAN M (2007). "Evolving applications of light therapy" (PDF). *Sleep Med Rev 11* (6): 497–507.

TERMAN, M. and TERMAN, J. S. (1999). Bright light therapy: Side effects and benefits across the symptom spectrum. Journal of clinical psychiatry, (60), 799-808.

TERRY, P. C., LANE, A. M., & FOGARTY, G. J. (2003). Construct validity of the POMS-A for use with adults. Psychology of Sport and Exercise, 4 (2), 125-139

THOPSON A., BATTERHAM A.M., JONES H., GREGSON W., SCOTT D., ATKINSON G. (2013). The practicality and effectiveness of supplementary bright light for reducing jet-lag in elite female athletes. *International journal of sports medicine*, vol./is. 34/7(582-589)

THOMPSON C, STINSON D, SMITH A (September 1990). "Seasonal affective disorder and season-dependent abnormalities of melatonin suppression by light". *Lancet* **336** (8717): 703–6

TITUS S, HODGE J (2012). Diagnosis and treatment of acne. *Am Fam Physician* 86 (8): 734–40.

TOBIN A.-M., HACKETT C., ROGERS S., O'SHEA D., KIRBY B. (2011). The impact of obesity on psoriasis. *British Journal of Dermatology,* vol./is. 165

TOSHINAI K., YAMAGUCHI H., SUN Y., SMITH R. G., YAMANAKA A., SAKURAI T., et al. (2006). Des-acyl ghrelin induces food intake by a mechanism independent of the growth hormone secretagogue receptor. *Endocrinology* 147, 2306–2314 10.1210/en.2005-1357

TRAYNOR V., FERNANDEZ R., CALDWELL K. (2013). What are the effects of spending time outdoors in daylight on the physical health of older people and family carers: A systematic review protocol. *JBI Library of Systematic Reviews*, 2013, vol./is. 11/10

TSCHOP M. H., SMILEY D. L., HEIMAN M. L. (2000). Ghrelin induces adiposity in rodents. *Nature* 407, 908–913 10.1038/35038090

TUORILA, H., LAHTEENMAKI, L., POHJALAINEN, L., & LOTTI, L. (2001). Food neophobia among the Finns and related responses to familiar and unfamiliar foods. *Food Quality and Preference*, 12, 29–37.

TVERSKY, A. and KAHNEMAN, D. (1971). Belief in the Law of Small Numbers. *Psychological Bulletin*, 76(23), 105-110.

TYLER, J. C. and HARDY, A. C. (1940). An analysis of the original munsell color system. *Journal of the optical society of America*, 30 , 587-590.

UNITED NATIONS CHILDRENS FUND (UNCF) (2010). Facts for life (PDF) (4th ed.). New York: pp. 61 and 75. ISBN 978-92-806-4466-1.

VALDEZ, P. and MEHRABIAN, A. (1994). Effects of color on emotions. *Journal of experimental psychology*: General, 123 (4), 394-409.

VAN HOOF, J., et al. (2012). Light therapy: Methodological issues from an engineering perspective. *Technol. Health Care*, 20 (1), 11-23 .

VAN MANEN (1990) Researching Lived Experience. SUNY Press. New York.

VENNEMANN, M. M., HUMMEL, T., & BERGER, K. (2008). The association between smoking and smell and taste impairment in the general population. *Journal of Neurology*, 255, 1121–1126.

VOLKERT, D. (2002). "Malnutrition in the elderly — prevalence, causes and corrective strategies". Clinical Nutrition 21: 110–112. doi:10.1016/ S0261-5614(02)80014-0.

VOROBYEV, M. (2004). Ecology and evolution of primate colour vision. *Clinical and Experimental Optometry,* 87, 230–238.

WALLS, G. L. (1963). The vertebrate eye and its adaptive radiation. New York: Hafner Publisher, Co.

WALSH, L. M., TOMA, R. B., TUVESON, R. V., & SONDHI, L. (1990). Color preference and food choice among children. *Journal of Psychology*, 124, 645–653.

WANSINK, B. (2004). Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition*, 24, 455–479.

WANSINK, B (2012). Specific environmental drivers of eating. Food and addiction: A comprehensive handbook., p. 159-620

WANSINK B., VAN ITTERSUM K. (2012) Fast food restaurant lighting and music can reduce calorie intake and increase satisfaction. Psychological Reports, vol./is. 111/1(228-232), 0033-2941;1558-691X

WALTERS, J, APTER, M J. and SVEBAK, S (1982). Color preference, arousal, and the theory of psychological reversals. Motivation and emotion, 6 (3), 193-215.

WARNER, LORD (2004) Speech by Lord Warner, Parliamentary Under-Secretary of State in the Lords, The Changing Face of Hospital Food. www.dh.gov.uk/en/News/Speeches/Speechlist/DH_4081421

WEBB, E., CAMPBELL, D. T., SCHWARTZ, R. D., and SECHREST, L. (2000). Unobtrusive Measures, Revised Edition. Thousand Oaks, CA: Sage Publications.

WELLMAN, N.S; WEDDLE, D.O, KRANZ, S, BRAIN, C.T (1997). Elder Insecurities: Poverty, Hunger, and Malnutrition. *Journal of the American Dietetic Association* 97 (10): S120–S122.

WILLIAMS S J, GABLE J, CALNAN M (2000) Health, medicine, and society. Routledge, London

WILLIG C (2008) Introducing Qualitative Research in Psychology, (2nd ed) McGrawHill, Open University Press

WILSON, G. D. (1966). Arousal properties of red versus green. Perceptual and motor skills, (23), 947-949.

WILSON, G. D., & GREGSON, R. A. M. (1967). Effects of illumination on perceived intensity of acid tastes. *Australian Journal of Psychology*, 19, 69–73.

WINTERS, R. W. (1974). Some relationships between the psychophysics and neurophysiology of color vision. *American journal of optometry and physiological optics*, 51 (8), 550-566.

WIRZ-JUSTICE, A. (2003). Chronobiology and mood disorders. *Dialogues in clinical neuroscience,* 5 (4), 315-325.

WORLD MEDICAL ASSOCIATION – Declaration of Helsinki, Ethical Principles for medical research involving Human Subjects, www.wma.net/e/policy/b3.htm (accessed 20/07/08)

WRAY, J (2008) Sensitive Subjects, Vulnerable Citizens: Risks, Rights and responsibilities University of Hull (Blackboard accessed 20/07/08)

WRIGHT, Mark, et al. (2004). Cholecystokinin and leptin: Their influence upon the eating behaviour and nutrient intake of dialysis patients. *Nephrology, dialysis, transplantation*: Official publication of the European dialysis and transplant association - European renal association, 19 (1), 133-140.

WREN A. M., SMALL C. J., WARD H. L., MURPHY K. G., DAKIN C. L., TAHERI S., et al. (2000). The novel hypothalamic peptide ghrelin stimulates food intake and growth hormone secretion. *Endocrinology* 141, 4325–4328 10.1210/en.141.11.4325

WURTMAN, R. J. The effects of light on the human body. [online].

Retrieved 12/03/2015 at: http://web.mit.edu/dick/www/pdf/286.pdf.

WYSE C.A., BIELLO S.M., GILL J.M.R. (2014). The bright-nights and dim-days of the urban photoperiod: Implications for circadian rhythmicity, metabolism and obesity. *Annals of Medicine*, vol./is. 46/5(253-263)

YAMAMOTOVA A., PAPEZOVA H., VEVERA J.(2008). Normalizing effect of bright light therapy on temperature circadian rhythm in patients with eating disorders. *Neuro endocrinology letters*, vol./is. 29/1(168-172)

YEOMANS, M, R (2006) Olfactory influences on appetite and satiety in humans. *Physiology and Behavior*, 89 (1). pp. 10-14. ISSN 0031-9384

YEOMANS, M, R., BLUNDELL, J, E., LESHEM, M (2004). Palatability: response to nutritional need or need-free stimulation of appetite? *British Journal of Nutrition*, 92, Suppl. 1, S3–S14
DOI: 10.1079/BJN20041134

YEOMANS, M. R., CHAMBERS, L., BLUMENTHAL, H., & BLAKE, A. (2008). The role of expectancy in sensory and hedonic evaluation. The case of smoked salmon ice-cream. *Food Quality and Preference*, 19, 565–573.

YEOMANS, M and COUGHLIN, E (2009) Mood-induced eating. Interactive effects of restraint and tendency to overeat. *Appetite,* 52 (2). pp. 290-298. ISSN 0195-6663

YEOMANS, M and MOBINI, S (2006). Hunger alters the expression of acquired hedonic but not sensory qualities of food-paired odors in humans. *Journal of Experimental Psychology: Animal Behavior Processes*, 32 (4). pp. 460-466. ISSN 0097-7403

YERKES, R. M and DODSON, J. D (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of comparative neurology and psychology,* 18 , 459-482.

YI C.-X., VAN DER VLIET J., DAI J., YIN G., RU L., BUIJS R. M. (2006). Ventromedial arcuate nucleus communicates peripheral metabolic information to the suprachiasmatic nucleus. *Endocrinology* 147, 283–294 10.1210/en.2005-1051

YOUNG, E, M. (2012). Food and development. Abingdon, Oxon: Routledge. pp. 36–38. ISBN 9781135999414.

YOUSUF AZEEMI, S. T. and RAZA, S. M. (2005). A critical analysis of chromotherapy and its scientific evolution. *Evidence-based complementary and alternative medicine*, 2 (4), 481-488.

ZELLNER, D. A., & KAUTZ, M. A. (1990). Color affects perceived odor intensity. *Journal of Experimental Psychology*. Human Perception and Performance, 16, 391–397.

ZELLNER, D. A., & WHITTEN, L. A. (1999). The effect of color intensity and appropriateness on color-induced odor enhancement. *American Journal of Psychology*, 112, 585–604.