Sensory Deprivation as an Experimental Model of Psychosis

by Christina Louise Daniel

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UCL Thesis Declaration Form

I, Christina Louise Daniel, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed:

Name: Christina Louise Daniel

Date: 10/02/2017

Abstract

The development of novel experimental models of schizophrenia and psychosis are critical to developing a better understanding of these complex and poorly understood disorders. Existing approaches such as animal and drug models have major limitations to their use. An alternative approach to modelling psychosis is proposed, built upon the premise of continuum theory, focusing on 'high risk' hallucination prone individuals from within the healthy population. A systematic review considered existing non-pharmacological approaches for inducing psychosis-like experiences (PLE's) in such individuals. The thesis then addressed how one such method, short-term sensory deprivation, can successfully induce transient psychosis-like experiences (PLE's) in this population.

The Revised Hallucinations Scale (RHS: Morrison et al. 2002) was found to accurately predict individuals most likely to experience PLE's in sensory deprivation. Individual differences that may contribute to reports of PLE's were explored: the most powerful predictor of PLE's in sensory deprivation was verified to be hallucination proneness. Additional personality traits such as fantasy proneness and suggestibility were not implicated. A revised four factor structure for the RHS was also developed, using Exploratory Structural Equation Modelling (ESEM). This model showed improved fit to the original non-replicable factor structure. The ESEM approach is arguably more appropriate than traditional factor analysis for modelling data with high inter-factorial correlations.

Quantitative Electroencephalogram (EEG) data was collected in order to establish whether this approach could provide a robust neurophysiological correlate for psychosis-like experiences. Initial pilot data suggested hallucination prone individuals may be

characterised by reduced levels of theta, alpha and beta activity, alongside elevated levels of cortical hyper-excitability. These findings support weakened inhibitory processing theories of psychosis.

Overall, sensory deprivation was found to have the potential to contribute significantly to our understanding of psychosis, and could be utilised effectively on a stand-alone basis, or as an adjunct to existing animal and drug models.

Table of Contents

<u>Chapter 5:</u>

Chapter 6:

Chapter 7:

List of Tables

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

List of Figures

List of Photographs

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Chapter 1

Introduction: A new approach for modelling psychosis?

1.1. The Need for Novel Experimental Models of Psychosis

The functional psychoses are a complex and heterogeneous set of mental disorders, the most prominent of which is schizophrenia. This and its derivative diagnoses are commonly described as comprising positive, negative and cognitive signs and symptom domains. Positive symptoms are those that are not normally experienced by healthy individuals without psychosis, and include delusions, disordered thoughts and speech, and auditory, visual, tactile, olfactory and gustatory hallucinations (American Psychiatric Association, 2013). Negative signs and symptoms refer to deficits in the normal emotional and motivational responses seen in healthy individuals. These include diminished expression and experience of emotion, poverty of speech, inability to experience pleasure, lack of desire to form relationships, and lack of motivation (American Psychiatric Association, 2013). The impact of psychosis on cognitive functioning is wide-ranging, with systematic reviews and meta-analyses of this area identifying deficits impacting social cognition (Gauri et al. 2012), working memory (Kurtz et al. 2001), long-term memory (Kurtz et al. 2001), episodic memory (Goldberg et al. 2010), semantic processing (Pomarol-Clotet et al. 2008), attention (Kurtz et al. 2001), and learning (Kurtz et al. 2001). The complexity of the disorder means that our current understanding of the underlying biological and cognitive changes that drive pathogenesis is at a very basic level. The development and testing of experimental models of schizophrenia and psychosis is an important way in which a better understanding can be developed.

In addition, and intrinsically related to, our current lack of understanding of the pathogenesis of psychotic disorders, is the fact that existing treatment options are sub-optimal. Anti-psychotic medications, the mainstay of treatment, target the positive symptoms of psychosis usually by acting on one or more dopamine sub-systems. Approximately only one third of patients respond to antipsychotic treatment and enter full remission, of positive symptoms at least. A further third show limited response, with the remaining third not responding to these medications at all (Meltzer, 1997; Mosolov et al. 2012). It must also be considered that these outcomes are only achievable when patients show good medication compliance. The side effects of medication can be as severe as the symptoms of psychosis itself, with extrapyramidal symptoms (drug-induced movement disorders) being problematic with older typical antipsychotic drugs, and serious weight gain and associated type 2 diabetes being problematic with newer atypical antipsychotic drugs (Liebermann et al. 2005). It is understandable that these side-effects, combined with the cognitive deficits seen in psychosis, make medication compliance a major issue, with many patients relapsing if medication is discontinued. Even when effective in reducing positive symptoms, antipsychotic medications are largely ineffective at reducing negative symptoms and cognitive dysfunction, and it is these that are the most important predictors for long-term social functioning (Stefansson et al. 2008; Pratt et al. 2012).

For these reasons there is a pressing need to develop novel treatments that have more tolerable side-effects, and that are effective in those patients who fail to respond to currently available antipsychotic medication, and also that are effective in treating the negative and cognitive symptoms of the disorder. Novel treatments need not be restricted to pharmacological approaches. Cognitive Behavioural Therapy for Psychosis (CBTp) is now recommended by the National Institute for Health and Care Excellence in its preferred list of treatments for schizophrenia (National Institute for Health and Care Excellence, 2014). In addition to targeting positive symptoms, CBTp has been expanded to also target negative symptoms, and depression and anxiety secondary to psychosis. Wykes et al's (2008) meta-analysis of 34 CBTp trials showed overall beneficial effects for the therapy target symptom (effect size = 0.400 [95% confidence interval = 0.252, 0.548]), and significant effects ranging from 0.35 to 0.44 for positive symptoms, negative symptoms, functioning, mood, and social anxiety. These results appear encouraging, however the beneficial effects should not be over-stated because many of the studies included in the analysis did not use masked assessment methods. When only masked assessment studies were analysed, there was nearly a 60% reduction in the effect sizes reported. In order to continue to improve cognitive models of psychosis and the efficacy of psychological therapies stemming from these, the development and testing of experimental models of psychosis is essential.

1.2. Current Approaches for Modelling Psychosis

Although clinical research continues to explore physiological, pharmacological, psychological and other avenues of enquiry; conducting research with clinical patients has several drawbacks and limitations. First and foremost, there are ethical concerns regarding the testing of early experimental hypotheses on clinical groups where there is insufficient evidence for a potential therapeutic benefit to the individuals involved. The results of clinical research are also easily confounded by the contribution of variables such as hospitalisation, medication effects, illness duration, and cognitive deficits associated with psychosis. It is therefore important that other approaches be developed to enable psychosis to be studied in non-clinical populations. Currently these approaches include using animal models, drug models, and high risk models. The ideal model of psychosis would faithfully mimic the biological changes driving pathogenesis and carry high predictive value for the efficacy of novel treatments (Langer and Halldin, 2002).

1.2.1. Animal Models

Animal models may be considered valuable preclinical tools with which to investigate the neurobiological basis of psychosis. Among their strengths, they offer a more rapid platform to monitor disease progression than in humans, and the possibility to monitor structural and molecular changes that underlie the cause of the disease that would simply be too invasive in human participants. Animal models of psychosis commonly fit into four different 'induction' categories: developmental, drug-induced, lesion, or genetic manipulation. Developmental models most often involve administering MAM, a naturally occurring substance, to pregnant rats at 17 days gestation. The outcome is to produce brain changes in the newborn rats that are similar to those observed in schizophrenia such as ventricular enlargement. Alternatively, isolation rearing may be used, which results in a syndrome that mimics several of the behavioural symptoms of psychosis. Drug-induction models administer drugs known to mimic the symptoms of psychosis in humans, most commonly amphetamines or PCP. Lesion models create a lesion in the ventral hippocampal region, producing progressive onset of deficits in social interaction, and impairments in spatial learning, working memory, and hyper-responsivity to stress. Genetic manipulation models create 'knock-out' mice where an existing gene is replaced or disrupted with an artificial piece of DNA. However, no single genetic alteration has proved successful in sufficiently mimicking the symptoms of psychosis. The major limitation of animal models is that some of the core symptoms of psychosis (such as disordered thoughts and verbal learning and memory impairment) are uniquely human traits (Powell and Miyakawa, 2006). In general, most behaviours can only be indexed rather than directly quantified, and performance in tasks designed to have translational relevance to core symptoms can only be monitored in order to make inferences about the underlying psychiatric state.

Furthermore, putative therapeutic agents do not always have the same effects in animals as in man (Curran et al. 2009).

1.2.2. Drug Models

Drug models are also able to provide valuable insight into the neurobiological mechanisms underlying specific symptom domains in psychosis (Curran et al. 2009). Models targeting individual neurotransmitter systems have highlighted the extent to which these systems interact and understanding these links will be an important step towards building our understanding of psychosis (Japha and Koch, 1999).

D-Lysergic acid diethylamide (LSD), first synthesised in 1938, has been shown to parallel a number of characteristics central to psychosis, being a natural psychotomimetic and hallucinogenic substance. Furthermore, animal studies have demonstrated LSD is able to alter the level of significance of meaningfulness of stimuli leading to distortions of perception (Key, 1961). As early as 1954 the proposal that LSD caused 5HT receptor blockade (Woolley and Shaw, 1954), led to the 'serotonin hypothesis' of psychosis. This possible aetiological explanation actually preceeded the alternative 'dopamine hypothesis' by nearly twenty years. However, despite early research suggesting LSD had great potential as a drug model for psychosis, the 1960's was a decade of widespread disaffection in psychiatry and society at large with psychological, existentialist interpretation of psychosis, with which LSD was strongly associated (Claridge, 1994). Compounded by the issues of LSD being adopted for recreational purposes amongst fringe and hippy groups, and its subsequent proscription in 1966, research using LSD was abandoned. Instead, the dominant model was to become the dopaminergic hypothesis, despite issues with ecological validity which will be discussed subsequently. From the early experiential LSD studies conducted using human participants, it is difficult to form firm conclusions since these studies were largely observational, and usually there were no attempts to make comparisons with schizophrenics on similar tasks (Claridge, 1994). However, the importance of serotonin in CNS function is once again being recognised, as whilst antipsychotic drugs are able to reduce the positive symptoms of psychosis through dopamine D(2) receptor blockade, negative symptoms do not respond as effectively. There is increasing interest in the role of abnormal neurotransmission at 5-HT(2) receptors in the pathophysiology of negative symptoms (Meltzer, 1999).

Dopaminergic psychostimulants such as amphetamine and cocaine increase synaptic levels of dopamine, and have been reported to exacerbate psychotic episodes in people with existing schizophrenia (Farren et al. 2000; Bramness et al. 2012). In early studies of amphetamine administration in healthy volunteers, large single oral doses were found to induce an acute psychosis (Angrist and Gershon, 1970; Bell, 1973). However, at lower doses, paranoid and other psychotic symptoms emerge only with repeated dosing, and only in some individuals. Dopaminergic psychostimulants provide a good model of the paranoid psychosis of schizophrenia but do not accurately mimic the cognitive or negative symptom domains (Pratt et al. 2012). Use of dopaminergic models to predict the efficacy of novel therapeutics is likely to select only the medications that primarily act on dopamine transmission. In contrast, NMDA receptor antagonists such as PCP and ketamine, and THC (the primary active component of cannabis), all generate a more complete model of schizophrenia, including aspects of the positive, negative and frontal cognitive symptoms (Krystal et al. 1994; Morrison et al. 2009; Morrison and Stone, 2011). However, there are several dissimilarities between the ketamine-induced state and psychosis (Steen et al. 2006). For example, auditory hallucinations are one of the most common symptoms in psychosis, but the hallucinations and illusions experienced following acute administration of ketamine are more commonly visual (Abi-Saab et al. 1998; Steen et al. 2006).

1.2.3. 'High-risk' Models

Modern diagnostic systems used in psychiatry (such as the DSM) still maintain a categorical view of psychosis as being distinct from 'normal' healthy states of mind, and clearly there is a clinical need to demark those with mental disorder from healthy individuals without a need for care. However, the categorical view has been challenged for over a century. For example Eugen Bleuler (1911) did not believe there was a clear separation between 'sanity' and 'madness', believing instead that psychosis was simply an extreme expression of thoughts and behaviours that could be present to varying degrees throughout the population. This idea has been developed by psychological theorists including most notably perhaps Sandor Rado and Paul Meehl in the United States, and Hans Eysenck and Gordon Claridge in the UK. Eysenck (1992) sought to understand the variation in unusual thought and behaviour in terms of personality theory, and conceptualised it as a single personality trait named psychoticism. Claridge (1972) similarly took Rado's psychodynamically oriented concept of 'schizotypy' in a psychometric and experimentally inclined direction. Over the course of many studies examining unusual experiences in the general population he and colleagues (1996) ultimately advanced a multi-factorial description of schizotypal traits. The psychometric work suggested the schizotypy domain (or perhaps more accurately that of 'psychosis proneness') could be broken down into four factors:

1. Unusual experiences: The disposition to have unusual perceptual and other cognitive experiences, such as hallucinations, magical or superstitious belief and interpretation of events.

2. Cognitive disorganization: A tendency for thoughts to become derailed, disorganised or tangential.

3. Introverted anhedonia: A tendency to introverted, emotionally flat and asocial behaviour, associated with a deficiency in the ability to feel pleasure from social and physical stimulation.

4. Impulsive nonconformity: The disposition to unstable mood and behaviour particularly with regard to rules and social conventions.

It should be noted that the ultimate factor in this list is not as widely accepted as the remainder, which are very commonly seen in both factorial and measurement models of the 'schizotypy' rubric.

The development of the theoretical construct of schizotypy, or psychosis-proneness, conceived as a continuous dimension along which the normal population may be ranged, has led to the development of high risk models of psychosis. Amongst the first to investigate the 'high-risk' concept were Mednick, Parnas and Schulsinger in the longitudinal Copenhagen High-Risk Project, which followed a sample of 207 children at high risk for schizophrenia and a control group as they progressed through adolescence into adulthood. By early adulthood, 20 of the high risk group had gone on to develop psychiatric disorders, predominantly schizophrenia and related diagnoses.

Mednick et. al (1987) used the concept of schizotypy to argue that whilst all members of the high-risk group could be termed 'schizotypal' by virtue of their high genetic liability (all had a mother with schizophrenia), a deleterious environment was necessary to trigger the development of schizophrenia in these 'high risk' individuals. By comparing the high risk sub-group who went on to develop schizophrenia against the sub-group who remained well, Mednick et al. (1987) confirmed that the ill sub-group could be distinguished on the basis of traumatic birth experiences, disrupted parental care, and public instutional rearing. These findings were amongst the first to provide clinical evidence in support of high risk schizotypal individuals carrying a significantly greater risk of developing future psychosis, as well as positing a potential pathway through which this ‘high risk’ becomes expressed in adverse environmental circumstances.

More recently, studies on the clinical high-risk concept and schizotypy have extended to general population samples, in addition to genetic high risk samples. In a recent review by Debbané et al. (2015), four longitudinal studies were identified (Kwapil et al., 2013; Mieltunen et al., 2011; Bogren et al., 2010; Gooding et al., 2005) that studied the relationship between schizotypal dimensions in the general population and later development of ether psychotic disorders or schizophrenia spectrum disorders over time periods spanning from 5 to 50 year intervals. All studies suggested that higher rates of schizotypy predicted later development of psychosis. In particular, it was the positive dimension of schizotypy (encompassing cognitive-perceptual factors including magical thinking, unusual perceptual experiences, ideas of reference and paranoia), that was most highly associated with the later emergence of psychotic disorders.

In light of the strength of this recent longitudinal evidence supporting the association between schizotypy and psychosis, highly schizotypal individuals represent an interesting population in which to study sub-clinical forms of psychotic symptomatology. Working with a sub-clinical population also confers numerous advantages over studying individuals with a diagnosis of psychosis, such as the effects of medication, and hospitalisation. It also negates many of the ethical issues involved in drug studies such as the potential for participants to experience adverse medical reactions during the study, and the potential for drugs such as THC to trigger enduring psychosis in the longer-term in genetically susceptible individuals (Zamberletti et al. 2012). Whilst the use of high risk models has only been established more recently, there is a small body of research that demonstrates how they have proved a powerful tool for testing a wide range of paradigms including sensorimotor gating (Simons and Giardina, 1992; Chapman et al. 1994; Abel et al 2004), and latent inhibition (Baruch et al. 1988; Allan et al. 1995; Gray et al. 2002). Many of these studies could not have feasibly been carried out with a clinical sample.

1.3 Towards an Alternative Model of Psychosis

Given the recent developments in high risk models of psychosis, and the evidence that schizotypy has proved to be a useful high risk marker within the general population (see Debbane et al. 2014 for a review), there is a need to consider the potential non-pharmacological methods that could be used to induce psychosis-like experiences in susceptible high schizotypy individuals in an experimental setting. A systematic review of the published literature addressing the question of how psychosis-like experiences can be induced in the general population is presented in chapter 2. In summary, it is concluded that whilst several methodologies have proved successful in inducing hallucinations, the type of hallucinations has been shown to be restricted to the sensory modality being experimentally manipulated. Therefore in order to produce complex hallucinations involving tactile, visual and auditory experiences that will most closely mirror clinical psychosis, it is necessary to manipulate several modalities at once. The evidence is clear that sensory deprivation conditions represent the most effective way to approach this manipulation of multiple modalities, as it is possible the restrict sound, light, and also proprioceptive feedback.

1.4 The History of Sensory Deprivation Research

Sensory deprivation has a long history of investigation, most prominently during the 50's and 60's. Research first began in this field, funded predominantly by North American and Canadian intelligence services, who were motivated by concerns over

The Cold War. Hebb was one of the first psychologists to study the effects of restricted environments on human volunteers in the early 1950's , motivated by the need to understand how sensory deprivation could be used to induce 'breakdown' and confessions from enemy agents.

By the peak of the sensory deprivation research in 1963, the American Central Intelligence Agency (CIA) had funded in excess of 140 projects in an attempt to better understand the role of sensory deprivation on behaviour modification and the control of human consciousness (Raz, 2013.) The majority of studies emphasized examination of short- and long-term effects of deprivation on 'normal' participants. The findings were inconsistent, possibly due to an inadequate recognition of the complexity of the variables that enter into the situation of sensory restriction (Ziskind, 1964). Prolonged periods of deprivation were found to produce a range of psychotic phenomena in many, if not all participants. However experiences at shorter durations varied depending on the nature of the deprivation, and the characteristics of the participants involved. Given what is now known about schizotypy and the psychosis spectrum, it seems likely that the inconsistent findings may have been the result of varying degrees of schizotypy amongst participants.

Zuckerman and colleagues were some of the earliest researcher to display an interest in the individual characteristics of the participants involved in sensory deprivation research. Prior to the development of the concept of schizotypy, Zuckermann and colleagues were interested in a tendency towards sensation-seeking in participants who volunteered for experiments in sensory deprivation. In three studies, females volunteering for sensory deprivation experiments were found to score higher on the Sensation-Seeking Scale (Zuckerman et al., 1964) than non-volunteers. However, findings were less consistent amongst male volunteers across the three samples (Zuckerman et al. 1967).

The hay day of sensory deprivation research was not to last, and the reputation of the field was soon to be brought into disrepute by unscrupulous researchers, most notoriously Cameron, whose extreme methods involved administering prolonged sensory deprivation and repeated electro-convulsive therapy to psychiatric patients who were not capable of giving informed consent. Furthermore, political events hastened the decline in respectability of sensory deprivation research after a number of enquiries made public how the information from this research has been used to further interrogation practices and torture, most famously the British Governments torture of 342 IRA members in 1971. Amidst growing public pressure, funding for sensory deprivation was cut, and researchers moved on to pursue other areas of enquiry.

1.5 Theoretical Accounts of Hallucinations During Sensory Deprivation

Turning to the question of how and why psychosis-like experiences arise in susceptible individuals under conditions of sensory deprivation, several modern theories are relevant. Aimed most directly at these phenomena are a range of accounts fundamentally based on the notion of a failure of self-monitoring, either via formal cognitive failure (neuropsychological accounts; e.g. Frith 1992) or through cognitive biases and/or diminished reality testing (meta-cognitive accounts; e.g. Bentall 1990, Beck and Rector 2003). These are probably not mutually exclusive. Couched in neuropsychological terms and originating with observations about motor control is Frith's (1992) model of positive symptoms, this has now been brought to bear most directly on hallucinations.

Bentall (1990) reviewed the psychological literature on hallucinations and advanced an account based on 'a failure of the metacognitive skills involved in discriminating between self-generated and external sources of information'. A range of failures of reality monitoring occur, among them the self-generation of fantasy experiences that are then poorly discriminated from reality. Such fantasy proneness may be relevant to sensory deprivation. Broadly consistent with Bentall's account, Beck and Rector (2003) suggest a long list of potentially causative conditions: 'Hypervalent ("hot") cognitions of sufficient energy to exceed perceptual threshold and consequently to be transformed into hallucinations, a low threshold for auditory perceptualisation exacerbated by stress, isolation, or fatigue, an externalizing bias that reinforces the purported external origin of the voices and resource-sparing strategies that help to fix belief in external origin and diminished reality-testing: detecting and correcting errors; suspending judgment; collecting more data, reappraisal, and alternative explanations'. (p.19). It is currently unclear which of this long list of meta-cognitive skills and processes might be applicable to the sensory deprivation context and is deserving of testing using the paradigm.

Fletcher and Frith (2009) and Corlett et. al (2009) propose a Bayesian information processing model, suggesting that all experimental interventions that induce psychotic symptoms affect the interaction between an individuals' predictions about the world and the sensory inputs that they encounter. Under normal circumstances, this interaction shapes experience and learning but, when it is disrupted, it can lead to the hallucinations and delusional beliefs seen in psychosis. The Bayesian model conceptualises information processing in terms of prior expectancies (top-down predictions) and current input (bottom-up perception). A mismatch between these two processes leads to prediction errors occurring. It is these prediction errors that lead us to update inferences about the world and to generate new predictions for the future. This model suggests that the hallucinations seen in psychosis are produced when bottom-up signalling is weakened in some way. In this event, strong prior expectancies (known as 'priors') exist in the absence of strong reliable bottom-up signals. These strong priors may be sufficient to create the experience of a percept without a basis in external reality (i.e. a hallucination). The Bayesian information processing model provides an account for how sensory deprivation can act as a model of psychosis. In sensory deprivation there is a relative lack of strong bottom-up sensory stimulation, and because sensory deprivation by physical means in never fully complete, some low-level noisy bottom-up signals persist. However, top-down processing remains unaffected. Since sensory stimulation is normally much greater, prediction errors occur as un-impaired top-down signals attempt to impose some meaningful structure on this low-level bottom-up input, and hallucinations result.

1.6 Aims and Objectives of the Thesis

The aim of this thesis is to re-visit the potential for sensory deprivation as an experimental model of psychosis, in the light of post 1960's theoretical developments such as schizotypy and the continuum theory of psychosis. Before the utility of sensory deprivation as an authentic experimental analogue for clinical psychosis can be established, it is essential to address some significant gaps in the existing knowledge base. The research addresses key questions including:

1. What non-pharmacological approaches exist for inducing psychosis like experiences in the general population, and how effective are these approaches?

2. Can the Revised Hallucination Scale (RHS: Morrison et al. 2002) accurately predict individuals most likely to have psychosis-like experiences in sensory deprivation?

3. What is the factor structure of the RHS (Morrison et al. 2002), and can the original factor structure be replicated?

4. How and why do psychosis-like experiences arise under conditions of sensory deprivation?

Prior to presenting my own empirical contributions in chapters 3 - 7, chapter 2 of this thesis consists of a systematic literature review that addresses the first research question, 'What non-pharmacological approaches exist for inducing psychosis like experiences in the general population, and how effective are these approaches?'

Chapter 3 presents methodological developments. The development of a sensory deprivation protocol using an anechoic chamber is discussed, followed by an empirical study that demonstrates the effectiveness of this method for inducing psychosis-like experiences. Chapter 4 then presents a further aspect of this empirical study, detailing the collection and analysis of data on the cognitive appraisal styles of participants who reported psychosis-like experiences.

Chapter 5 moves the discussion on towards addressing my second and third research questions, "Can the Revised Hallucination Scale accurately predict individuals most likely to have psychosis-like experiences in sensory deprivation?" and "What is the factor structure of the RHS?" This chapter discusses hallucination proneness in further detail, covering its links with the associated construct of schizotypy, and the various options available for self-report measurement. One such measure, the Revised Hallucinations Scale (RHS, Morrison et al. 2000) is then the focus of the remainder of the chapter. The proposed factor structures of the RHS are discussed, alongside the difficulties that have been encountered replicating these structures. This is then followed by an empirical study that uses Exploratory Structural Equation Modelling (ESEM) techniques to identify an alternative factor structure for the RHS, one with improved fit and a structure that is able to be replicated.

Clearly question 4, 'How and why do psychosis like experiences arise under conditions of sensory deprivation?' is a question of considerable scope that could represent a life-times work, but as a first-line approach I have focused on addressing debate within the literature concerning whether the psychosis-like experiences reported in sensory deprivation are genuine anomalous experiences, or merely endorsed by certain individuals on self-report questionnaires. Chapter 6 describes an empirical study that provides evidence as to whether psychosis-like experiences during sensory deprivation are genuine anomalous experiences, as opposed to being due to suggestibility, fantasy proneness, or increased anxiety. I feel focusing on this debate and gathering evidence to persuade critics of the approach that the psychosis like experiences reported are not just the products of demand characteristics or fantasy is an essential step towards answering question 3.

Chapter 7 then continues to address my fourth research question ‘How and why do psychosis like experiences arise under conditions of sensory deprivation?’ considering the potential utility for electroencephalography (EEG) as a neurophysiological correlate for PLE’s during sensory deprivation. The literature is reviewed, discussing various approaches that have attempted to collect EEG data during hallucinatory experiences, the findings from these studies, and also discussing potential EEG endophenotypes associated with psychosis. I then present my fourth unique contribution, a proposal which outlines a novel protocol for collecting EEG data during sensory deprivation in the anechoic chamber. This is then followed by a description of a small pilot study, which implemented this new approach. Results from the pilot study are presented and the chapter concludes with a critical discussion of the role of EEG correlates for PLE’s during sensory deprivation, and the future directions work of this nature might take.

Chapter 8 then brings this thesis to its conclusion, with a discussion of the potential utility of sensory deprivation as an experimental model of psychosis, in the light of the new contributions my research has made to this area.

Chapter 2

A critical synopsis of experimental techniques for the induction of anomalous experiences in the normal population.

Chapter one has outlined the rationale as to why studying anomalous experiences within the normal population is of potential theoretical and clinical interest. In order to establish what method would be most appropriate to adopt/develop for experimentally inducing anomalous experiences, a systematic review of the published literature between 1990 and July 2016 was conducted, and is presented in the current chapter.

2.1 Method

The search aimed to identify references relating to all types of studies using experimental means of inducing anomalous perceptual experiences (ie. hallucinatory experiences or similar non-veridical perceptions) in healthy 'normal' participants whilst awake.

A computerised search of the literature for relevant articles published between 1990 and 2015 was performed using the databases PsychINFO and PubMed. The following search strategy (boolean/phrase) was used: sensory limitation OR hallucinatory experiences OR false perceptual experiences OR perceptual disturbances OR anomalous experiences OR anomalous sensations OR ganzfeld OR flicker (AND hallucinations) OR mirror gazing OR sensory deprivation.

Studies were restricted to those written in English and published in peer-reviewed journals. The bibliographies of the selected articles were searched manually for any articles not captured by the computerised search. Review articles, abstracts, dissertations and letters were excluded.

Studies investigating hypnogogic or hypnopompic hallucinations were excluded due to being related to a sleep-state. Studies attempting to induce extrasensory perception or psychic 'mindreading' were also excluded on the grounds that these could not be classed as true anomalous experiences according to our definition. Drug studies were also excluded from the review.

2.2 Results

The search resulted in a total of 585 hits. After screening these articles and searching the literature for additional relevant publications, 20 studies were identified matching the inclusion criteria. Two additional studies matched criteria, but were excluded as they solely reported electroencephalogram (EEG) data and not the nature of the experiences themselves.

The selected studies used a variety of techniques to experimentally induce anomalous experiences, and the review is structured into the following areas to improve clarity:

Ambiguous auditory environments (7 papers)

Sensory deprivation (6 papers)

Perceptually ambiguous visual paradigms (3 papers)

Naturalistic experiments (1 paper)

Manipulating electromagnetic fields and infrasound (1 paper)

Face gazing (2 papers)

Table 1 provides an overview of the study characteristics and major findings. Further descriptions of the individual studies, together with discussion of strengths and limitations can be found in the text.

Table 1. Overview of Studies

Study	Design	Participants	Method of anomalous experience induction	Psychometric measures	Outcome
Feelgood and Rantzen (1994)	**Quasi-experimental study** Students split into high or low hallucination prone groups on the basis of LSHS scores. Participants listened to a jumbled voice task. Participants were instructed that at certain points in the recording words and phrases would appear. They were then asked to write these down when they heard them.	Screened 136 first year psychology students for hallucination proneness. Students scoring less than 13 (n=10) were selected as the low scoring group and students scoring higher than 30 (n=12) were selected as the high scoring group.	5 minute audio recording consisting of randomly spliced 1 second sections of a male voice played backwards	Launay-Slade Hallucination Scale (LSHS; Launay and Slade, 1981)	High scorers on the LSHS reported significantly more verbal hallucinations than low scorers (mean scores 1.8 vs 4.33).
Pearson et al. (2001)	**Quasi-experimental study** Children split into high or low hallucination prone groups on the basis of whether they had an imaginary friend. All children listened to a jumbled voice recording. Outcome measure was number of words heard (written down by children).	210 children (85 female and 125 male) between 9 and 11 years of age	3 minute audio recording consisting of randomly spliced 1 second sections of a male voice played backwards	None	Children who reported a current imaginary friend were more likely to report hearing a higher number of words (mean 8.15) than those children who had never experienced an imaginary companion (mean 3.98).

Merckelbach and van de Van (2001)	**Quasi-experimental study** Participants asked to listen to white noise and instructed to press a button when they believed hearing a recording of Bing Crosby's White Christmas (without the record actually being presented).	44 healthy undergraduate students (14 males, 30 female).	Audio recording of white noise, and suggestion.	Social Desirability Scale (Crowne and Marlow, 1964) Launay-Slade Hallucination Scale (LSHS; Launay and Slade, 1981) The Questionnaire upon Mental Imagery (Sheenan, 1976) The Creative Experiences Questionnaire, (Merckelbach et al. 2001).	Fourteen participants (32%) reported hearing the song. Reports were not found to be associated with a heightened sensitivity to situational demand. Imagery ability was also not related. Participants reporting hearing the song were found to have higher score on both the LSHS and the fantasy proneness scale. Follow-up logistic regression analysis suggested that the contribution of fantasy proneness to the White Christmas phenomenon was more substantial than that of hallucinatory disposition.
Galdos et al. (2011)	**Quasi-experimental study** 3 groups of increasing vulnerability to psychosis listened to ambiguous auditory stimuli. Participants asked to press buttons to indicate whether they heard speech, and also whether with was positive, negative, or neutral.	3 groups: patients with a psychotic disorder (n=30); their siblings (n=28); healthy control (n=307).	3 white noise tasks (consisting of either white noise only, white noise and clearly audible neutral speech, or white noise and barely audible neutral speech)	Weschler Adult Intelligence Scale (WAIS-III; Wechsler, 1997) The Flanker Continuous Performance test The Rey Auditory-Verbal Learning test (Rey, 1964) The Operational Criteria Checklist for Psychotic Illness (OPCRIT; McGuffin, Farmer, and Harvey, 1991) Structured Interview for Schizotypy-Revised (Vollema and Ormel, 2000)	Results showed a significant trend across groups for hearing speech illusions with 9% of controls, 14% of siblings of patients, and 30% of clinical patients hearing any speech illusion.

Barkus et al. (2011)	**Quasi-experimental study** Participants from two age groups presented with an auditory signal detection task. Participants asked to indicate whether or not they had heard a voice.	76 healthy participants, split into two groups according to age (15 – 17 yrs (n=46) and 19-30 yrs (n=30).	Auditory signal detection task consisting of 5 second bursts of white noise. On 60% of occasions there was a 1 second snippet of speech for participants to detect (a third of the time the voice was clearly audible; the remainder of the time the voice was presented at auditory threshold).	O-LIFE schizotypy scale (Mason, Linney, and Claridge, 2005) Matrix reasoning measure of nonverbal intelligence (Weschler, 1999) Digit span	Younger participants reported slightly more false alarms than older participants. Male participants reported significantly more false alarms than females.
Vercammen and Aleman (2010)	**Quasi-experimental study** A high and a low hallucination prone group were presented with two verbal word recognition tasks (a semantic and a phonological task). Participants were asked to press a response button to indicate whether or not they heard a word and subsequently to identify this word out loud.	351 undergraduate students screened for hallucination proneness using the LSHS. 42 participants were recruited (17 females) of which half scored in the upper and half in the lower quartile of the LSHS.	Two word recognition tasks (using a combination of speech and white noise bursts). Top-down influences on perceptions were manipulated through sentence context (semantic tasks) or auditory imagery (phonological task).	Launay-Slade Hallucination Scale (LSHS; Launay and Slade, 1981)	On the semantic task, higher levels of hallucination proneness (as measured by the LSHS) were related to an increased likelihood to identify the target word as the word predicted from the sentence context. Higher levels of hallucination proneness were not related to specific error types in the phonological task.
Randell et al. (2011)	**Quasi-experimental study** High and low hallucination prone groups listened to an ambiguous auditory task. Participants were asked to write down any words they heard during each recording	46 healthy undergraduate students (19 male, 27 female). Split into two groups for high/low hallucination proneness using the mean split of scores on the OLIFE-B	Ten 1-minute recordings of white noise. Two of these recordings contained concrete words, and two contained abstract words embedded at an average of 9 second intervals. The remaining 6 recordings were white noise only.	OLIFE-B measure of schizotypy (Mason, Linney, and Claridge, 2005) Beck Depression Inventory (BDI; Beck et al. 1961) State Trait Anxiety Inventory (STAI; Spielberger, 1983)	High hallucination prone participants made more false reports, regardless of type, than low unusual experience scorers. Abstract false reports were more likely to be made than concrete reports, suggesting a bias in hallucinatory content toward more abstract events.

Lloyd et al. (2012)	**Mixed Methods study** Used interpretative phenomenological analysis to analyse participant's real-time descriptions of their experiences during a 30 minute period in sensory deprivation.	31 undergraduate students (27 female, 4 male).	30 minute period of combined auditory and visual perceptual deprivation, achieved by playing white noise through headphones and the wearing of white Ganzfeld field goggles.	The Revised Hallucination Scale (RHS; Morrison et al. 2002) State Trait Anxiety Inventory (STAI; Spielberger, 1983) Marlow-Crowne Social Desirability Scale (MC-10; Strahan and Gerbassi, 1972)	The data revealed two main themes. The first theme concerned reported sensory phenomena having different spatial characteristics ranging from simple percepts to the feeling of immersion in a complex multisensory environment. The second major theme to emerge from the analysis was the prominence of exploratory behaviour.
Merabet et al. (2004)	**Narrative account** Participants were given a tape-recorder to record a narrative of their experiences during sensory deprivation.	13 healthy participants (5 male, 8 female) between the ages of 18 and 35 years.	Participants wore a specially designed blindfold for a period of 96 hours (5 days).	None	Ten (77%) of the 13 blindfolded participants reported visual hallucinations that varied in onset, duration, and content. Generally, the visual hallucinations began between the first day and second day of blindfolding.
Hayashi, Morikawa and Hori (1992)	**Experimental Study** Participants spent 72 hours in sensory deprivation. Participants were given a button to press during or after hallucinatory experiences. EEG alpha activity was monitored throughout the experiment.	7 undergradute students	Participants lived alone in an air conditioned, soundproof dark room for 72 hours. A mattress, blanket, and simple toilet were present, along with all the necessary food and water.	None	Spectral analysis was performed on the consecutive EEG samples from just before button-presses to 10 min before them. For the single button-presses, alpha activity increased two minutes before the button-presses. Right-hemisphere EEG activation was observed in the occipital area for the double button-presses. The results suggest an association between the hallucinatory experiences under sensory deprivation and the amount of EEG alpha activity
Mason and Brady (2009)	**Quasi-experimental study** Two groups of high and low hallucination prone participants spend 15 minutes in sensory deprivation. Participants completed the psychotomimetic states inventory pre- and post-deprivation	211 students were screened for hallucination proneness using the Revised Hallucinations Scale. 19 students were selected for participation in the study, split into a high hallucination prone group (n=10) and a low hallucination prone group (n=9) on the basis of RHS scores.	Sensory deprivation conditions were created using an anechoic chamber (a sound proof environment). The chamber was also sealed to light, and creating conditions of total darkness.	The Psychotomimetic States Inventory (PSI; Mason et al. 2008) The Revised Hallucination Scale (RHS; Morrison et al. 2002)	Psychosis-like experiences taking the form of perceptual disturbances, paranoia, and anhedonia were found across both groups in sensory deprivation. In addition, the hallucination-prone group experienced more perceptual disturbances than non-prone group.

McCreery and Claridge (1996a; 1996b)	**Quasi-experimental study** Two groups of participants (an OBE group and a control group) were asked to lie down and fitted with ganzfeld field goggles. Participants followed a tape of a 20 minute relaxation exercise. Participants were then instructed to imagine themselves floating up to the ceiling and looking down on their physical body. 10 minutes of pink noise followed. Participants then completed questions regarding relaxation, and a schizotypy measure.	20 participants who had previous experience of OBE's (mean age 41) were matched with a control participant of the same gender and age.	Sensory deprivation conditions were created using pink noise and ganzfeld field goggles. Participants also followed a progressive relaxation exercise.	Abbreviated form of the Combined Schizotypal Traits Questionnaire (CSTQ; Bentall, Claridge and Slade, 1989).	Reporters of previous OBE's scored higher on the measure of schizotypy than the controls, and showed greater responsiveness to the procedure. A significant proportion of the OBE group reported imagery experiences (15 versus 8 in the control group). Examination of EEG data from the participants (McCreery and Claridge, 1996b) revealed some differences between groups.
Taskanikos and Reed (2005)	**Experimental study** Participants completed a word detection task, and were randomly signed to either a 'loose criterion' group asked to make a yes/no judgement about whether a word was present or a 'strict criterion' group asked to read aloud every word they detected.	160 undergraduate students (69 males, 91 female).	Computer-based word detection task involving the detection of words from non-words.	O-LIFE measure of schizotypy (Mason, Linney, and Claridge, 2005)	Participants scoring high on positive schizotypy reported seeing words that were not presented. When the task required a yes/no reponse, high schizotypy scorers demonstrated a positive response bias as predicted, although their accuracy remained intact. When the task required a detailed description of the target (strict condition), positive schizotypal symptoms predicted false perceptions of words.
Taskanikos (2006)	**Experimental study** Participants completed a word detection task, and were asked to make a yes/no judgement about whether a word was present	80 undergraduate students (25 males, 55 female).	Computer-based word detection task involving the detection of words from non-words under conditions of increasing perceptual load.	O-LIFE measure of schizotypy (Mason, Linney, and Claridge, 2005)	Participants with high positive schizotypy scores showed a greater bias towards believing seeing words in non-word trials. Overall, the perceptual load of the task enhanced bias generation, as more biased responses were made under conditions of high perceptual load. However, such biases were predicted by symptoms of positive schizotypy only under conditions of medium perceptual load.
Reed et al. (2007)	**Experimental study**	61 undergraduate students (17	Computer-based word detection task involving	O-LIFE measure of schizotypy	When the speed of stimulus presentation increased, the number of false perceptions

	Participants completed a word detection task, and were asked to make a yes/no judgement about whether a word was present	males, 44 females)	the detection of words from non-words under conditions of increasing perceptual ambiguity.	(Mason, Linney, and Claridge, 2005) Launay-Slade Hallucination Scale (LSHS; Launay and Slade, 1981) Peters Delusions Inventory (PDI; Peters et al. 2004) Beck Depression Inventory (BDI; Beck et al. 1961) State Trait Anxiety Inventory (STAI; Spielberger, 1983)	also increased, although participants with elevated schizotypy scores had increased false perceptions in both fast and slow conditions.
Polito, Langdon and Brown (2012)	**Naturalistic Experiment** Participants completed questionnaires assessing altered states of consciousness, paranormal beliefs, mood, and alexithymia before and after participating in a shamanic sweat lodge ceremony.	55 attendees (29 male, 26 female) age range 19 – 62, at shamanic sweat lodge ceremonies around the Sydney area in Australia.	Attendance at a shamanic sweat lodge ceremony.	The APZ questionnaire (altered state of consciousness scale; Dittrich, 1998) The paranormal belief scale (PBS; Tobacyk and Milford, 1983) Profile of mood states questionnaire (POMS; McNair, Lorr and Droppleman, 1971) Toronto alexithymia scale (TAS; Bagby, Parker and Taylor 1994)	Participation in the sweat lodge ceremony induced higher ratings on measures of altered state experience compared to baseline. There were also marked changes in the profile of mood state questionnaire scores after the ceremony, with participants reporting reductions in tension, depression, anger, fatigue, and confusion. No measures of paranormal beliefs were related to overall altered state scores. There was a positive relationship between alexithymia and intensity of the altered state of consciousness, and this was found to be the only significant predictor of altered state experience.

French et al. (2009)	**Experimental study** Participants were randomly allocated to one of four conditions. Participants were asked to spend 50 minutes in the room and to record on a floor plan a brief description of any anomalous sensations they experienced, where they were when the experience occurred, and the time at which it occurred. The EXIT scale was given to participants to complete once they had left the room.	79 healthy participants (45 male, 34 female) age range 21 – 61 years.	A specially designed room was built, with the ability to vary electromagnetic fields and infrasound. There were 4 conditions with electromagnetic fields either present or absent, and infrasound either present or absent.	EXIT scale (measuring specific anomalous sensations) Australian Sheep-Goat Scale (a measure of belief in and experience of the paranormal; Thalbourne and Delin, 1993) Persinger's Personal Philosophy Inventory (measuring psychological experiences associated with temporal lobe epilepsy; Makarec and Persinger, 1990)	Many of the participants in the experiment reported experiencing mildly anomalous sensations. However, the degree to which these anomalous sensations were reported was unrelated to the experimental conditions employed.
Caputo (2015)	**Experimental Study** Participants were randomly allocated to either a control or a dyadic gazing group and instructed they would take part in a meditative experience. The control group were sat in a room with low illumination facing towards a wall, and the dyadic group gazed at their partners face in the same low illumination setting for 10 minutes.	40 healthy participants (10 male, 30 female) age range 20-26 years.	Gazing at another person's face under conditions of low background illumination	The Clinician Administered Dissociative States Scale (Bremner at al. 1998) Non-validated measures of dysmorphic face perceptions and hallucination-like strange face apparitions were devised for the study.	Results indicated significantly higher levels of dissociative symptoms, dysmorphic face perceptions and hallucination-like strange face apparitions in the dyadic gazing group compared to controls.
Terhune and Smith (2006)	**Experimental Study** Participants were randomly allocated to either a control or suggestion condition, wherein they received different suggestions about the types of experiences they might expect to have. Participants were then sat in a comfortable chair in front of a mirror in an environment that was otherwise draped in black	40 healthy participants (27 female, 13 male) age range 19 – 62 years.	Gazing into a mirror whilst listening to white noise under conditions of low background illumination	Hyperesthesia Scale (Thalbourne, 1996) Intrusive Thoughts subscale of the White Bear Supression Inventory (Blumberg 2000) Revised Paranormal Belief Scale (Tobacyk, 1988) Visual Style of Processing Scale (Childers et al., 1985)	Participants in both groups reported anomalous experiences whilst mirror gazing. Those in the suggestion condition reported a significantly greater number of visual apparitions and a greater number of vocal apparitions than those allocated to the control condition.

	velvet. Participants spent 45 minutes gazing into the mirror, and during this time they were also played white noise. They were then asked to report any anomalous experiences.		Haunt Experience Checklist (Houran, 2002) Phenomenology of Consciousness Inventory (Pekala, 1991)

2.2.1 Ambiguous auditory environments

In response to the claim that ambiguity in the environment is implicated in the experience of hallucinations (Jakes and Hemsley, 1986) Feelgood and Rantzen (1994) tested the hypothesis that individuals scoring high on the LSHS would experience significantly more verbal hallucinations during a jumbled voice task than low scorers. They used the LSHS to screen 136 first year psychology students for hallucination proneness. Students scoring less than 13 (n=10) were selected as the low scoring group and students scoring higher than 30 (n=12) were selected as the high scoring group. The full experiment consisted of an auditory task (discussed here) and also a visual task. During the auditory task, participants listened to a 5 minute recording of a male voice consisting of randomly spliced 1 second sections played backwards via headphones. Participants were instructed that at certain points in the recording words and phrases would appear. They were then asked to write these down when they heard them. As Feelgood and Rantzen predicted, high scorers on the LSHS reported significantly more verbal hallucinations than low scorers (mean scores 1.8 vs 4.33).

In a subsequent replication study, Pearson et al. (2001) replicated Feelgood and Rantzen's findings in a group of 210 children aged between 9 and 11 years. Minor modifications were made to the method (the spliced tape recording being played out loud in a classroom for a shorter length of time of 3 minutes due to the possible shorter attention span of the children). Children were also asked whether they had a current imaginary friend, and this data was used to split the children into high and low hallucination prone groups instead of LSHS scores. As predicted, the results indicated that children who reported a current imaginary friend were more likely to report hearing a higher number of words (mean 8.15) than those children who had never experienced an imaginary companion (mean 3.98).

The combination of Pearson's and Feelgood and Rantzen's data provides evidence that scrambled voice paradigms are effective in inducing auditory hallucinations in both normal adult and child populations. The authors also suggest the data is evidence of a continuum between normal and pathological hallucinations, proposing that non-pathological, developmental hallucination experiences may become pathological if combined with adverse life experiences such as trauma. However, weaknesses in both studies are the possibility of counting what could potentially be considered illusions as true hallucinations. Neither study collected data regarding the certainty with which participants heard the words, or whether participants thought they could have imagined their experiences. Pearson et al. (2001) did attempt to control for the effect of speech illusions by removing any word that was reported by 10% of any class or by 10% of the whole group from the scoring. Even after removing these possible illusions, the results remained significant. It is also possible that demand characteristics could account for the findings: it may be that high hallucination prone participants respond more to the demands of the task and were therefore predisposed to report hearing words while being aware that their reports were untrue. Pearson et al. (2001) were careful to instruct the children in their study that there were no right or wrong answers, and that some children do, and some children do not, hear any words. This may have negated potential demand characteristics, but they cannot be fully ruled out using this methodology.

Merckelbach and van de Van (2001) attempted to account for the potential impact of demand characteristics in their white noise study by incorporating the Social Desirability Scale (Crowne and Marlow, 1964), a commonly used measure of tendency to provide socially desirable responses across many situations. In this study, 44 healthy undergraduate students were asked to listen to white noise and instructed to press a button when they believed hearing a recording of Bing Crosby's White Christmas (without the record actually being presented). Besides the Social Desirability Scale and the LSHS, questionnaires were also given to participants to assess imagery ability (the Questionnaire upon Mental Imagery, Sheenan, 1976), and fantasy proneness (the Creative Experiences Questionnaire, Merckelbach et al. 2001). Fourteen participants (32%) pressed the button at least once to indicate they had heard the White Christmas song. Of note, reports of hallucinatory experiences were not found to be associated with a heightened sensitivity to situational demand, indicating that suggestibility or compliance to demand characteristics is not able to account for the hallucinatory findings. Imagery ability was also not related. Participants reporting hearing the song were found to have higher scores on both the LSHS and the fantasy proneness scale. Follow-up logistic regression analysis suggested that the contribution of fantasy proneness to the White Christmas phenomenon was more substantial than that of hallucinatory disposition.

Merckelbach et al. 2001 have thus provided evidence that demand characteristics and suggestibility are unlikely to account for reports of hallucinatory experiences induced by ambiguous auditory stimuli, and instead call into question the validity of conclusions drawn from previous research that show a significant proportion of the normal population may have hallucinatory experiences. They suggest that rather hallucination proneness in the normal population is closely associated with fantasy proneness, and it is fantasy proneness that leads participants to endorse odd experiences (even if they have not actually experienced them). Previous research corroborating this idea has shown that, as a rule, fantasy prone individuals do not have life-like hallucinations. Specifically, Lynn and Rhue (1988) suggest that fantasy prone people adopt lax criteria when they classify internal experiences as hallucinations. However, an alternative interpretation of Merckelbach et al's (2001) findings could be that fantasy proneness mediates the process by which highly prone individuals experience hallucinations. For example, Bentall (1990) has suggested that fantasy proneness drives a specific response bias reflecting impaired reality testing, which in turn leads to reports of hallucinations. Clearly this issue requires further study, as although there is a wide literature regarding hallucinations experienced by highly-prone individuals in the normal population, fantasy proneness has not routinely been measured.

Further evidence in support of the normal population experiencing true hallucinatory experiences during ambiguous auditory paradigms (as opposed to merely endorsing them) comes from experimental studies that have examined similarities between clinical groups with a diagnosis of psychosis and high hallucination prone individuals from within the normal population. In accordance with a continuum model of psychosis (van Os, Hanssen, Bijl and Ravelli, 2000) the rate that individuals from the normal population report hearing hallucinations in random noise has been shown to be progressively greater across groups with increasing familial risk for psychosis (Galdos et al. 2011). Although this study had a main focus on examining differences between clinical, sibling, and control groups in affectively salient meaning in speech detected during a white noise task, the incidence of speech illusions reported in sibling and control groups is of relevance to this review. Following a white noise task (consisting of either white noise only, white noise and clearly audible neutral speech, or white noise and barely audible neutral speech) participants were asked to press buttons to indicate whether they heard speech, and also whether this was positive, negative, or neutral. There was also an option for participants to report that they were unsure of what they had heard, to reduce the likelihood of guessing. Results showed a significant trend across groups for hearing speech illusions with 9% of controls, 14% of siblings of patients, and 30% of clinical patients hearing any speech illusion, indicating that the experience of speech illusion during the task mirrors the continuum of psychosis across clinical and normal populations. The findings of this study are of particular interest as it has several design strengths, particularly the large sample of controls (n=307). Interview-based measures of schizotypy were also used rather than questionnaire-based measures, and neurocognitive factors including IQ, executive control of attention, and auditory verbal episodic memory were controlled for.

Individuals from the normal population reporting hallucinations during ambiguous auditory tasks have also been shown to mirror clinical populations in terms of psychosis risk factors, including being younger in age, and more likely to be male than female (Barkus et al. 2011). Barkus et al. (in a refinement of an original study (Barkus et al. 2007) split their sample of 76 participants from the normal population into two groups according to age (15 – 17, and 19 – 30 years) in an attempt to capture the differences in social and developmental aspects of late adolescence and early adulthood, peak times for the onset of psychosis. Participants were presented with an auditory signal detection task consisting of 5 second bursts of white noise. On 60% of occasions there was a 1 second snippet of speech for participants to detect (a third of the time the voice was clearly audible; the remainder of the time the voice was presented at auditory threshold). After each burst of white noise, participants were asked to indicate whether or not they had heard a voice. Younger participants reported slightly more false alarms than older participants, however this difference was not large enough to reach significance. Male participants reported significantly more false alarms than females. Clearly, due to the cross-sectional design, the effect of age can only be inferred by this study. A longitudinal study would be necessary to examine this in further detail.

This small, but growing number of experimental studies support the notion that hallucinations experienced by the normal population during ambiguous auditory tasks are a similar phenomenon to hallucinations experienced by clinical populations, albeit it to a lesser extent and with reduced intensity.

Since evidence for the efficacy of ambiguous noise paradigms for inducing auditory false perceptions has become better established, two studies were identified during the search of the literature that have used this method to investigate possible cognitive mechanisms of auditory verbal hallucinations. Vercammen and Aleman (2010) devised two word recognition tasks in which top-down influences on perception were manipulated through sentence context (semantic task) or auditory imagery (phonological task). Because patients with schizophrenia and healthy hallucinators tend to hear meaningful messages and not random auditory stimuli, they hypothesized that semantic expectations play a role in priming hallucinatory perceptual experiences.

The semantic task consisted of playing participants short sentences of 5-7 words. They devised 50 predictable sentences (as determined by prior pilot study) and 50 unpredictable sentences with the same construction but with an unexpected final word. For example, a predictable sentence used was 'The thief reported to the Police', and the corresponding unpredictable sentence was 'The thief reported to the owner'. Participants were played 150 trials of sentences in random sequence. In one third of trials, participants heard a predictable sentence with the final word masked by a burst of white noise. In another third of the trials participants heard an unpredictable sentence with the final word masked by a burst of white noise. In the final third of trials, participants heard a sentence from the same stimuli, but the final word was missing, and only white noise was presented. Participants were asked to listen to the sentences and identify the target word embedded in the noise. Participants were asked to press a response button to indicate whether or not they heard a word and subsequently to identify this word out loud. Participants were encouraged to identify the word only in they were positively convinced, and otherwise to state that they were uncertain of its identity.

In a second, phonological task, participants were presented with a spoken adjective prime word. After hearing the prime word, there followed a delay of two seconds during which participants were asked to form an auditory mental image of the word. Participants were then presented with a burst of white noise. On half of the trials, only white noise was presented. In the other trials, a target word was embedded in the noise. On half of these trials the target word was identical to the 'imaged' prime. On the other trials, the word was different. Participants responded in the same fashion as in the semantic task.

On both tasks, faster reaction times were observed when the prime word was identical or the sentence context was congruent with the presented target word, confirming that top-down influences were effectively manipulated in both tasks. On the semantic task, higher levels of hallucination proneness (as measured by the LSHS) were related to an increased likelihood to identify the target word as the word predicted from the sentence context. Higher levels of hallucination proneness were not related to more unsure responses, but only to responses where participants were certain of the word they had heard. The authors conclude that this reasonably ensured that the effect was not driven by a higher likelihood to guess amongst hallucination prone participants, but represented true erroneous perception. Contrary to the findings from the semantic task, higher levels of hallucination proneness were not related to specific error types in the phonological task. The authors concluded that these findings are consistent with the hypothesis regarding an exaggerated impact of top-down influences on perception in the case of hallucinatory experiences. Specifically, in these nonclinical participants, this seems to take place at the level of semantic processing.

As with the other studies utilising ambiguous auditory paradigms previous discussed, even though attempts were made to minimize suggestibility effects, they cannot be completely ruled out. However, the authors put forward a convincing argument that had suggestion played a major role in the findings, then this would have had a similar effect on both tasks. It can be argued that suggestibility effects are even more likely in the phonological task because this task is less automatic and requires controlled processing. Therefore the authors conclude that because hallucination proneness was only related to top-down errors in the semantic task, it seems that the effect of suggestion was minimal.

One limitation of the correlational design of this study is that no causal inference can be drawn from the association identified between hallucination proneness and a greater number of top-down errors, and therefore it remains unclear whether greater top-down influences are a cause or an effect of hallucinations. It seems most logical that top-down influences are an antecedent to hallucinations, however an alternative possibility is that people experiencing hallucinations develop heightened sensitivity to internal experiences, which in turn could impact the way incoming stimuli are processed.

A second study (Randell et al, 2011) has used an ambiguous auditory paradigm to examine the occurrence and content of auditory hallucinatory experiences in 41 participants from a normal population. Participants were split into two groups depending on whether they scored high or low on the unusual experiences subscale on the Oxford-Liverpool Inventory of Feelings and Experiences (short version; s-OLIFE) measure of schizotypy (Mason, Linney, and Claridge, 2005). Participants completed an experimental task where they listened to ten 1-minute recordings of white noise. Two of these recording contained concrete words, and two contained abstract words embedded at an average of 9 second intervals. The remaining 6 recordings were white noise only. The sets of concrete words (e.g. desk, arm, letter), and abstract words (e.g. myth, abyss, sorrow) were randomly chosen from a pool for each participant (so no two participants received the same combination). The words in the pool were randomly chosen from a larger set formulated by the experimenter, with the only common features of each set being their concrete, or abstract, characteristics. Participants were asked to write down any words they heard during each recording. Participants were asked not to guess what they believed a word to be if they were unsure, but simply just to tick that they had heard a word.

Consistent with previous studies, high hallucination prone participants (as measured on the s-OLIFE Unusual Experiences subscale) made more false reports, regardless of type, than low unusual experience scorers. Abstract false reports were more likely to be made than concrete reports, suggesting a bias in hallucinatory content toward more abstract events. The authors conclude that the fact this finding was particularly strong for high unusual experience scorers implies a strong bias toward more abstract content in individuals particularly prone to hallucinatory experiences. However, a major limitation of the study is that the average frequency of use for the concrete and abstract words sets differed considerably (concrete words average was 7092, whilst for the abstract words this was 42043) (calculated from a database of one hundred million words taken from samples of written and spoken English). Therefore the differences reported may have been due to the much greater frequency with which the abstract words are encountered in daily language use rather than representing a true bias in hallucinatory content.

2.2.2 Sensory Deprivation/Restriction

Six studies were identified from the recent literature that have used sensory deprivation to attempt to induce hallucinations in healthy participants. Lloyd et al. (2012) subjected 31 participants to a 30 minute period of combined auditory and visual perceptual deprivation, achieved by playing white noise through headphones and the wearing of white Ganzfeld field goggles. Merabet et al. (2004) carried out a more prolonged experiment, during which 13 healthy participants wore a specially designed blindfold for a period of five consecutive days (for a total of 96 continuous hours). Hayashi, Morikawa and Hori (1992) demonstrated that hallucinations during a prolonged period of 72 hours in sensory deprivation were associated with changes in EEG wave alpha activity (activity associated with vivid dream like states). Mason and Brady (2009) explored whether perceptual disturbances could be elicited by only a brief period (15 minutes) of complete isolation from sound and vision. McCreery and Claridge (1996a; 1996b) combined sensory deprivation with the use of physical relaxation techniques in an attempt to induce out of body experiences (OBE's) in individuals reporting this phenomenon. All studies were successful in inducing hallucinations of varying complexity in many of the participants.

Lloyd et al. (2012) used a qualitative approach (a variant of interpretative phenomenological analysis) to analyse participants real-time descriptions of their experiences during a 30 minute period in sensory deprivation. Participants spontaneously reported a large number of visual, auditory and bodily sensations. Following the period in sensory deprivation, participants also completed the Revised Hallucination Scale (Morrison et al. 2002), the State-Trait Anxiety Inventory (Spielberger, 1983) and the Marlowe-Crowne Social Desirability Scale (Strahan and Gerbassi, 1972). A correlational analysis revealed a positive correlation between the number of percepts reported and scores on the RHS, indicating that participants who scored highly on the RHS also reported more distinct perceptions during perceptual deprivation. Scores on the RHS did not correlate with the STAI or the MC-10, suggesting that hallucination proneness was not mediated by high anxiety or suggestibility.

Being a predominantly qualitative piece of research, there are a number of inherent issues with this study concerning the validity of findings, and the poor extent to which findings can be generalised to a wider population. However, the study has several strengths, particularly the large sample size (n=31) for qualitative research. Interpretive phenomenological analysis is also well suited to the research question. The authors acknowledge that previous attempts to relate reports of experiences during sensory deprivation to the concept of 'hallucination' have resulted in conflicting views, and the study aimed to provide a detailed account of experiences during perceptual deprivation without the constraint of this concept.

The data revealed two main themes. The first theme concerned reported sensory phenomena having different spatial characteristics ranging from simple percepts to the feeling of immersion in a complex multisensory environment. The most basic reports described noticing variation within the audiovisual environment (for example hearing a beep or seeing flashes of light). The more complex reports incorporated meaningful descriptions of physical aspects of the perceptual phenomena such as its cause, location, direction of movement and effects of the environment. The second major theme to emerge from the analysis was the prominence of exploratory behaviour. Participants interacted with their perceptions through their degree of attention or focus, or through moving their body to explore the qualities of the perception. This theme is of particular interest, as the fact that participants attempted to interrogate their perceptions argues against the suggestion that experiences in sensory deprivation are believed by the experiencer to be purely imaginary.

Merabet et al. (2004) report the occurrence of visual hallucinations during a period of prolonged blind-folding. The 13 healthy participants discussed were part of a larger study investigating the effects of visual deprivation on short-term brain plasticity. As such, the paper provides a narrative description of the participants' experiences, however no formal approach for analysing the data has been adopted, and standard qualitative procedures for quality-checking have not been followed or reported. With these caveats in mind, there are several interesting findings that arise. Ten (77%) of the 13 blindfolded participants reported visual hallucinations that varied in onset, duration, and content. Generally, the visual hallucinations began between the first day and second day of blindfolding and were of sudden onset, occurring while the participants were alert, and vanished spontaneously. No participants reported the ability to control the appearance or disappearance of the hallucinations. The hallucinations were either simple (flashing lights or phosphenes) or complex (faces, hands, landscapes, ornate objects). In two participants, simple visual hallucinations evolved into more complex hallucinations as the blindfold period progressed. For example, one participant initially reported seeing flashing lights, followed by mirrors, lamps, trees, and then full landscapes. At the end of the second day, the images became more complex, and he reported difficulty walking because of the "obstacles" that he saw in his path. All participants who experienced hallucinations did so during the blindfolded period. With one exception, the hallucinations ceased after the blindfold was removed on the fifth day. In one participant, they continued for a few hours after the blindfold had been removed, but then ceased.

Hayashi, Morikawa and Hori (1992) studied the relationship between hallucinatory experiences in sensory deprivation and EEG alpha activity (the type of brain activity involved in vivid dream states). Conducted in Japan, the study recruited seven male students to live alone in an air conditioned, soundproof dark room for 72 hours. A mattress, blanket, and simple toilet were present, along with all the necessary food and water. When hallucinatory experiences occurred, the students pressed a button at once. If they could not press the button during the experience, they were required to press it two times when the hallucinatory experience was finished. Spectral analysis was performed on the consecutive EEG samples from just before button-presses to 10 min before them. For the single button-presses, alpha activity increased two minutes before the button-presses. Right-hemisphere EEG activation was observed in the occipital area for the double button-presses. The results suggest an association between the hallucinatory experiences under sensory deprivation and the amount of EEG alpha activity. However, the analysis was made using the data from only five participants since one participant dropped out after 7 hours, and another dropped out after 32 hours, and therefore it is difficult to draw meaningful conclusions from the findings. The high drop-out rate is not surprising given the prolonged period of sensory deprivation participants were expected to endure. It would seem that the potential gains from such a study do not outweigh the distress caused to participants, making further studies of this kind ethically dubious.

Mason and Brady’s (2009) experimental study demonstrated that prolonged exposure to sensory deprivation is not necessary to induce perceptual disturbances. Mason and Brady selected two groups of healthy participants, a high hallucination prone (n=10), and a low hallucination prone group (n=9) (on the basis of scores on the RHS). The sensory deprivation conditions were created using an anechoic chamber (a chamber constructed as a room within a room lined with glass fibre wedges and metallic acoustic panels) that results in a sound-proof environment. The room was also sealed to light, creating conditions of total darkness. After spending 15 minutes in the anechoic chamber, participants completed The Psychotomimetic States Inventory (a measure of “psychosis-like” experiences developed initially for use in drug studies; Mason et al. 2008). This was then re-administered following a 20 minute rest period back in a normal sensory environment. Psychosis-like experiences taking the form of perceptual disturbances, paranoia, and anhedonia were found across both groups in sensory deprivation. In addition, the hallucination-prone group experienced more perceptual disturbances than the non-prone group.

Mason and Brady’s (2009) study was on a relatively small scale (n=19), and is therefore likely to have been underpowered in respect of trait/state interactions. However, it corroborates findings from other areas of experimental research attempting to induce hallucinations, namely the majority of healthy individuals report perceptual disturbances to some extent, and those shown to be highly-prone to experiencing hallucinations can be reliably predicted to have greater disturbance. This study also shows that perceptual disturbances can be successfully induced using this method in a very short period of time. The study has been criticised for the fact that the experimental set-up included a panic button (Bell, 2010) on the basis that a previous study (Orne and Scheibe, 1964) exploring the impact of a panic button showed the group with the button reported many more perceptual aberrations, cognitive and emotional disturbance, including heightened anxiety. Bell (2010) also suggests that the increased psychosis-like experiences in the high hallucination prone group might be accounted for by differential anxiety levels between the high and low-prone group since hallucination proneness has been linked to trait anxiety (e.g. Allen et al. 2005).

McCreery and Claridge (1996a; 1996b) reported a study of sensory deprivation, combined with the use of physical relaxation techniques in an attempt to induce out of body experiences (OBE's). Two groups of participants were recruited (via a newspaper advert and word of mouth), 20 (mean age 41 years) who had previously experienced at least one OBE, and 20 (mean age 41years) who had no such experience. Each OBE participant was matched with a control of the same gender and as close as possible the same age. Participants were asked to lie on a sun-lounger, set in a nearly horizontal position, in a shielded cubicle. They were then fitted with goggles with ping-pong ball eyepieces (producing a ganzfeld visual field), and earphones were used to play the 30 minute experimental tape. The tape consisted of a 20 minute exercise based on the 'progressive relaxation' technique of Jacobson (1929). Participants were then instructed to imagine themselves floating up to the ceiling and looking down on their physical body. 10 minutes of pink noise then followed (similar to white noise, but of a different frequency). Following the experiment, participants completed questions regarding their state of relaxation during the experiment, and a questionnaire measuring schizoptypy (an abbreviated form of the CSTQ (Bentall, Claridge and Slade, 1989).

The experiment confirmed that reporters of previous OBE's scored higher on the measure of schizotypy than the controls, and showed greater responsiveness to the procedure. A significant proportion of the OBE group reported imagery experiences (15 versus 8 in the control group). One participant in the OBE group reported a clear out of body experience during the procedure. Examination of EEG data from the participants (McCreery and Claridge, 1996b) revealed some differences between groups. Median frequency of EEG signals across both hemispheres started off approximately equal in both groups, declined substantially in both hemispheres by the end of the experiment in the control group, but declined less markedly in the left hemisphere of the OBE'rs and actually increased over the course of the experiment in their right hemisphere.

The findings demonstrate that sensory deprivation conditions can be combined with relaxation to successfully induce anomalous experiences in healthy individuals with varying degrees of schizotypy. The anomalous experiences reported are corroborated by associated EEG changes. However, weaknesses with this experiment are that participants were given very specific instructions to "imagine themselves floating up to the ceiling and looking down on their physical body." This may have potentially influenced the way in which participants reported and described any anomalous experiences they encountered. It is also not reported whether the study was double-blind or if the researchers were aware of the status of the participants as they were testing them and analysing the EEG data, and clearly this may have inadvertently influenced the results.

2.2.3 Perceptually Ambiguous Visual Paradigms

Given evidence from studies (previously discussed) that have utilised ambiguous auditory stimuli to successfully induce auditory hallucinations (e.g. Feelgood and Rantzen ,1994; Pearson et al., 2001), attention has turned to whether similar results can be achieved by targeting other sensory modalities. Tsakanikos and Reed (2005) employed a computer-based word detection task to present a sequence of short animated images to

160 healthy participants. Half of the trials contained a word among non-words (word trials), and half of them contained only non-words. Each trial depicted a display of four round blocks, one in each quadrant of the computer screen. In each block, there was either a non-word or a real word. The words were five-letter concrete nouns matched for frequency of occurrence. The non-words were meaningless strings of five consonants. The animations produced an impression of motion, such that the four-block configuration appeared to loom from a distance toward the observer. Each animation was composed of 74 frames and was presented at a rate of 9 frames/second. Participants were assigned either to a 'loose criterion' group asked to make a yes/no judgement about whether a word was present or a 'strict criterion' group asked to read aloud every word they detected. Tsakanikos and Reed (2005) hypothesised that positive schizotypy would predict false perceptual experiences during the task, but not accuracy, replicating in the visual modality past evidence from auditory studies (e.g. Feelgood and Rantzen ,1994; Pearson et al., 2001).

Participants scoring high on positive schizotypy reported seeing words that were not presented. When the task required a yes/no response, high schizotypy scorers demonstrated a positive response bias as predicted, although their accuracy remained intact. Furthermore, when the task required a detailed description of the target (strict condition), positive schizotypal symptoms predicted false perceptions of words. The results provide further support for the theory of hallucinations being generated through the misattribution of internally generated events to an external source (Brebion et al. 1998; Morrison and Haddock, 1997.) The authors suggest it is possible that a psychosis-like bias towards believing that a non-existing stimulus is present may result from internally generated task-irrelevant stimuli, such as loose word associations, being attributed to an external source.

A second study using the same word detection task has investigated the theory of misattributing internal stimuli as external (Tsakanikos (2006). Tsakanikos (2006) additionally proposed that if this was the case, increasing the perceptual load of the task to engage full capacity in processing task-relevant stimuli would prevent false perceptions by leaving no spare capacity for perception of internal task-irrelevant stimuli. In this study, stimulus motion was introduced to experimentally increase the perceptual load. Each animation was presented at a rate of 7 (slow speed) 9 (medium speed) or 11 frames/s (high speed) depending on the experimental condition. In this study, participants were just instructed to report 'yes/no' to seeing real words, and were not required to name them. Once again, participants with high positive schizotypy scores showed a greater bias towards believing seeing words in non-word trials. Overall, the perceptual load of the task enhanced bias generation, as more biased responses were made under conditions of high perceptual load. However, such biases were predicted by symptoms of positive schizotypy only under conditions of medium perceptual load. This suggests that, although some degree of perceptual ambiguity (medium load) is necessary for the generation of psychosis-like biases, when detection of events becomes either effortless (low load) or too cognitively demanding (high load), generation of such biases can be prevented in those with positive schizotypal symptoms. This suggests a mechanism may be in operation whereby high perceptual load inhibits bias generation by preventing perception of irrelevant internally generated word associations. In contrast, under low-load conditions, there would be insufficient ambiguity to generate a processing bias.

In a third study using a related word detection task, Reed et al. (2007) examined the effects of some of the other experimental parameters, including perceptual ambiguity (manipulated through stimulus presentation duration). When the speed of stimulus presentation increased, the number of false perceptions also increased, although participants with elevated schizotypy scores had increased false perceptions in both fast and slow conditions. Therefore, in the way it was manipulated in this experiment, perceptual ambiguity was not critical in the generation of schizotypal biases. This differs from the findings reported by Tsakanikos (2006) in the previous study that showed participants with elevated schizotypy scores only experienced increase false perceptions in the 9 frames/second condition (medium speed), suggesting the amount of perceptual ambiguity was critically involved in the generation of schizotypal biases. This discrepancy might be due to the different methods employed to manipulate perceptual ambiguity (i.e. stimulus duration in Reed et al.'s (2007) study versus stimulus motion in Taskanikos' (2006)). The authors suggest that the conflicting findings may be due to the different ways static and dynamic visual stimuli are processed. This would indicate that the perceptual component of a schizotypal bias might be more critically involved than initially thought, and this area requires further investigation.

2.2.4 Naturalistic Experiments

One naturalistic experiment was identified in the literature. Polito, Langdon and Brown (2010) examined the top-down influence of pre-existing beliefs and affective factors in shaping an individual's characterisation of anomalous sensory experiences. They investigated the effects of paranormal beliefs and alexithymia in determining the intensity and quality of an altered state of consciousness (ASC) achieved during a shamanic sweat lodge ceremony. A sweat lodge is a small dome shaped structure, consisting of bent wooden poles or sticks covered with thick hides and blankets. Inside, participants sit silently in near total darkness, surrounding a small pit into which heated rocks are placed. The ceremony is led by a shaman who pours water over the rocks, which then evaporates creating heat like a sauna. The shaman sings songs, tells stories, chants and plays rhythmic, repetitive drum beats. The sweat lodge ceremony has previously been shown by several researchers to induce an altered state of consciousness (Bucko, 1999; Eliade, 1972; McWhorter, 1994; Price-Williams and Hughes, 1994; Smith 2005).

Participants completed questionnaires before and after participating in the ceremony. At baseline, participants completed the profile of mood states questionnaire (McNair, Lorr and Droppleman, 1971), rating their emotions during the previous week; the APZ questionnaire (altered state of consciousness scale; Dittrich, 1998), rating their state of consciousness in the preceding few hours; and the paranormal belief scale (Tobacyk and Milford, 1983.) Following the ceremony, participants again completed the profile of mood states and APZ, with instructions to base response on their experiences during the sweat lodge.

As predicted, participation in the sweat lodge ceremony induced higher ratings on measures of altered state experience compared to baseline. Specifically, there were significantly greater experiences in the subscale dimensions of ‘oceanic boundlessness’ (referring to experiences of heightened mood, wellbeing, loss of boundaries and intense feelings of connectedness) and ‘visionary restructuralization’ (referring to sensory illusions, altered sense of meaning, synaesthesias, and ideas of reference). There were also marked changes in the profile of mood state questionnaire scores after the ceremony, with participants reporting reductions in tension, depression, anger, fatigue, and confusion. No measures of paranormal beliefs were related to overall altered state scores, although three specific paranormal beliefs (psi, spiritualism and precognition) were associated with higher ‘oceanic boundlessness’ scores. There was a positive relationship between alexithymia and intensity of the altered state of consciousness, and this was found to be the only significant predictor of altered state experience.

Polito, Langdon and Brown’s (2010) research suggests that affective factors may have a facilitatory impact on altered states of consciousness. The authors hypothesise alexithymia may lead to an enhanced ability to detach from personal experience, increasing the intensity with which altered states may be experienced. The relationship between paranormal beliefs and overall intensity of altered states was less clear. Given the frequency with which schizotypal traits have been reported to predict intensity of altered states of consciousness in the literature, it would have been interesting to see whether this may have also been a significant predictor of altered state experience in the sweat lodge, however the authors did not include any schizotypy measure in the study. Given that this was a naturalistic study, the participants had arranged to attend the sweat lodge event of their own volition, rather than being recruited directly into the study. Therefore it seems likely that the sample was self-selecting to some extent for holding unusual beliefs. The majority of the participants would have held positive beliefs and expectations about the purpose of taking part in the sweat lodge ceremony which is not a part of main-stream Australian culture (where the study took place).

2.2.5 Manipulating electromagnetic fields and infrasound

It has recently been argued that certain environmental factors associated with particular locations may directly cause susceptible individuals to experience anomalous sensations. In particular ‘haunting’ phenomena (such as perceived sudden changes in temperature, unusual odours, a sense of presence, or full-blown apparitions) have been suggested to be induced by exposure to unusual geomagnetic and electromagnetic fields (EMF) (Braithwaite, 2004; Persinger and Koren, 2001). Another suggested cause of haunting-like anomalous experiences is the presence of infrasound, that is, sounds of such a low frequency that they are outside the audible range for human beings (Tandy and Lawrence, 1998). In light of these suggestions, French et al (2009) have conducted the

“Haunt” project, in which they attempted to construct an artificial “haunted” room by systematically varying environmental electromagnetic fields and infrasound.

In French et al.’s (2009) experiment, participants were asked to spend 50 minutes in an empty, white, circular room that was dimly lit and a cool temperature. The study employed a 2x2 design (EMF present vs. EMF absent) and (infrasound present vs. infrasound absent). 79 healthy participants were randomly allocated to one of the four conditions. Participants were asked to spend 50 minutes in the room and to record on a floor plan a brief description of any anomalous sensations they experienced, where they were when the experience occurred, and the time at which it occurred. The EXIT scale (a scale containing 20 items asking about specific anomalous sensations) was given to participants to complete once they had left the room. Participants also completed the Australian Sheep-Goat Scale (a widely used measure of belief in and experience of the paranormal; Thalbourne and Delin, 1993) and items from the temporal-lobe signs sub-section of Persinger’s Personal Philosophy Inventory (measuring psychological experiences associated with temporal lobe epilepsy but normally distributed throughout the normal population; Makarec and Persinger, 1990).

Many of the participants in the experiment reported experiencing mildly anomalous sensations. However, the degree to which these anomalous sensations were reported was unrelated to the experimental conditions employed. The authors conclude that, given all participants were informed in advance that they might experience unusual sensations whilst in the room (in line with ethical requirements), the most parsimonious explanation of the findings is in terms of participant suggestibility. The explanation is also supported by the fact that TLS scores, known to correlate with suggestibility (Granqvist et al. 2005) significantly predicted the total number of anomalous experiences reported on the floor plan and the scores on the EXIT scale.

Although participant suggestibility does seem the most parsimonious explanation of the findings, there were a number of methodological issues with the study that may have affected the results. Participants were allowed to walk freely around the room (maximising ecological validity), however this meant that the amount of electromagnetic activity that the participants were exposed to varied depending on where they moved within the room. This factor was not systematically recorded and therefore could not be taken into account during the analysis. Double-blinding was also not used in this study, and the experimenters were aware of the condition participants had been allocated to. Clearly, since the results were not in support of the EMF hypothesis this is unlikely to have been a serious issue, but it would have been preferable to have employed double-blind methodology.

2.2.6 Face Gazing

A technique known as 'scrying', involving gazing into a reflective surface to facilitate the appearance of apparitions was popular in the late 19th century, and has recently resurfaced in the context of bereavement therapy with the use of a mirror-gazing chamber (Moody 1992; Moody and Perry, 1993). Effects similar to mirror-gazing have also been reported in dyads by gazing at another person's face instead of one's own. Caputo (2015) investigated interpersonal gazing in dyads with a sample of 20 healthy individuals over a 10 minute period in a low illumination setting. The dyadic gazing group was compared to a control group who also spent 10 minutes seated in the low illumination setting looking forwards towards a wall. Results indicated significantly higher levels of dissociative symptoms, dysmorphic face perceptions and hallucination-like strange face apparitions in the dyadic gazing group compared to controls. The study used a well validated measure of dissociation (The Clinician Administered Dissociative States Scale, Bremner et al. 1998) however it should be noted that the measures for dysmorphic face perceptions and strange-face apparitions were designed specifically for this study, without any reliability and validity checks. Furthermore, the experimenter administering the questionnaire measures was not blind to the condition of the subjects.

Turning to studies of more traditional mirror-gazing, although there is evidence to suggest that mirror-gazing provides a suitable environment for apparitions (Moody, 1994) many of the reported experiences have not been formally studied. Terhune and Smith (2006) sought to investigate the variables involved in the induction of mirror-gazing hallucinations, particularly focusing on the role of suggestion. Forty participants were randomly allocated to either a control or suggestion condition, wherein they received different suggestions about the types of experiences they might expect to have. Participants were then sat in a comfortable chair in front of a mirror in an environment that was otherwise draped in black velvet. Participants spent 45 minutes gazing into the mirror, and during this time they were also played white noise.

Participants in both groups reported anomalous experiences whilst mirror gazing. Those in the suggestion condition reported a significantly greater number of visual apparitions and a greater number of vocal apparitions than those allocated to the control condition. Therefore, although the mirror gazing procedure is shown to be effective in inducing hallucinations, the incidence of hallucinations is in part a function of the presentation of suggestions given before the procedure. A complication of the study's design is that the procedure did not adhere to a double-blind protocol, and the experimenter was not blind to the participants' condition. This may have affected the results in that the experimenter could have implicitly influenced the frequency and type of experiences reported by participants in the two conditions. The use of self-report instruments is likely to have minimized experimenter influence, but a double-blind protocol would be superior. The simultaneous presentation of white noise along with the mirror also makes it difficult to establish the effect of the mirror separately from the effect that listening to white noise in a sensory-limited environment alone may have had on anomalous experiences.

2.3 Discussion

The present review aims at offering a comprehensive synopsis of the variety of experimental techniques available for the induction of anomalous experiences in the normal population. A number of substantive and methodological issues arise from the review, each of which will be discussed in turn.

2.3.1 Predicting individuals likely to experience hallucinations

Screening tools for hallucination-proneness such as the LSHS and the O-LIFE have consistently been shown to accurately predict individuals most likely to experience hallucinations in experimental settings. There is also limited evidence from family studies (Galdos et al, 2011) to suggest that siblings of an individual with a clinical diagnosis of psychosis are more likely to score highly on these measures, providing additional evidence that hallucination-proneness in the general population is on a continuum with psychosis.

2.3.2 Effectiveness

A variety of ambiguous auditory environments and perceptually ambiguous visual paradigms have proved successful in inducing hallucinations (for an overview see Table 1). The type of hallucinations induced has been shown to be restricted to the sensory modality being experimentally manipulated. In sensory deprivation conditions, where several sensory modalities are restricted simultaneously, more complex hallucinations involving tactile, visual and auditory experiences have been reported. Whilst it has previously been demonstrated that such experiences occur following prolonged periods of deprivation, new evidence is emerging to suggest that brief periods of exposure of no more than 15 minutes can also be effective. Although only a small number of studies have investigated manipulation of electromagnetic fields or infrasound, no evidence has been found to suggest that these methods are successful in inducing hallucinations. It remains unclear whether mirror gazing can be considered as an effective method for inducing hallucinations due to methodological limitations of the current research.

2.3.2.1 Distinguishing hallucinations from illusions

In its broadest sense, the term 'hallucination' can apply to any non-voluntary perception that does not match external stimulation (Lloyd et al. 2012). A methodological limitation of the review is that the criteria used to select papers studying hallucinations (as opposed to illusions) was essentially a qualitative judgement, and this reflects the lack of a well-established criterion within the field. From an experimental perspective, there remains an important need to establish whether some of the more fleeting misperceptions reported are truly on the same continuum as hallucinations seen in psychosis. Lloyd et al's (2012) qualitative study of experiences in sensory deprivation has yielded some interesting themes to consider when defining what constitutes a true 'hallucination', including the degree of immersion in the experience, and the prominence of exploratory behaviour. There is a need for further quantitative studies in order to establish a working criterion for defining hallucinations.

2.4 Conclusion

The review of the literature indicates that whilst several methodologies have proved successful in inducing hallucinations, the type of hallucinations has been shown to be restricted to the sensory modality being experimentally manipulated. Therefore in order to produce complex hallucinations involving tactile, visual and auditory experiences that will most closely mirror clinical psychosis, it is necessary to manipulate several modalities at once. The evidence is clear that sensory deprivation conditions represent the most effective way to approach this manipulation of multiple modalities, as it is possible the restrict sound, light, and also proprioceptive feedback.

In the following chapter, Mason and Brady's (2009) research that made use of an anechoic chamber (an environment of total light-and-sound deprivation) is discussed in further detail. It is proposed that a modification of this method represents a promising technique for the induction of psychosis like experiences in healthy individuals, and this method is developed and discussed throughout the remainder of this thesis.

Chapter 3

Sensory Deprivation Protocol Development

This chapter focuses on the development of the sensory deprivation protocol. The limitations of Mason and Brady's (2009) study that was described within the review of the literature in chapter two are discussed. A pilot study is then presented, trialling a modified sensory deprivation protocol.

3.1 The Anechoic Chamber

An anechoic chamber (see figure 1) was used to produce the sensory deprivation conditions. The anechoic chamber is constructed as a room within a room (see http://www.langsci.ucl.ac.uk/resource/anechoicroom.html). The outer walls are 330mm thick and the inner room is formed of metallic acoustic panels mounted on a floating floor which is then lined with large glass fibre wedges. This results in a very low noise environment in which the sound pressure due to outside levels is below the threshold of human hearing. It is also possible to remove all sources of light from the room, and thus create an environment with near complete deprivation of sight and sound. A chair with a high back rest, arm rests, and head support provided comfortable seating, and also limited the amount of ongoing proprioceptive feedback participants could receive about their body position within the chamber.

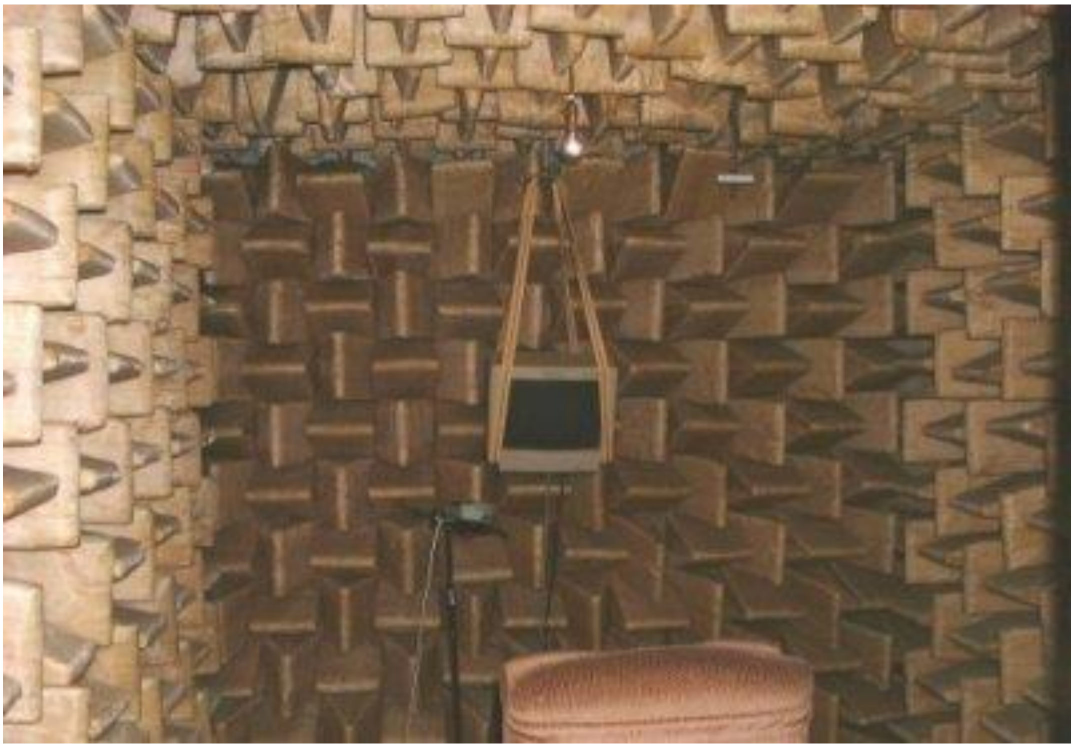

Photo. 1: The anechoic chamber

3.2 Modification of Mason and Brady's (2009) Protocol

Mason and Brady (2009) initially piloted the anechoic chamber to induce PLEs (perceptual disturbances, paranoia, and anhedonia) particularly in those prone to hallucinatory experiences. This pilot study had a number of methodological limitations, not least its sample size of only 19 in total. The study was also criticized for the fact that the procedure included a "panic" button (Bell, 2010) on the basis that a previous study (Orne and Scheibe, 1964) showed the group with just such a button reported many more perceptual aberrations, and cognitive and emotional disturbances, including heightened anxiety. Bell (2010) also suggested that the increased PLEs in the high hallucination prone group might be accounted for by differential anxiety levels between high and low-prone groups. This is a serious potential confound, as it has been demonstrated that hallucination proneness is linked to trait anxiety (Allen et al. 2005), and in individuals with psychosis, acute anxiety is clearly linked to an increase in hallucinatory experiences (Delespaul et al. 2003). Therefore, it is feasible that an increase in anxiety brought about by sensory deprivation acts to mediate the relationship between PLEs and hallucination proneness. Anxiety was not measured in the original study and this omission was a major limitation. Assessment at baseline was also an area for technical improvement. Mason and Brady (2009) assessed this prior to entering the anechoic chamber when preparatory anxiety may have been influential.

The modifications introduced to Mason and Brady's (2009) protocol were as follows:

1) The panic button was replaced with a one-way microphone that allowed participants to be continuously monitored whilst inside the chamber in an attempt to reduce potential demand characteristics.
2) State and trait anxiety were measured as potential confounds/covariates.
3) A "secluded office" environment condition was introduced as a potentially better matched control condition than standard "baseline" in an attempt to minimise the impact of preparatory anxiety.

The modified sensory deprivation protocol was then piloted. Part of this pilot also included collecting data about participants cognitive appraisals of their PLE's in the chamber. Whilst the method for collecting data on appraisal styles is included in the pilot methodology section in this chapter, the data itself is presented and discussed separately in chapter four.

3.3 Sensory Deprivation Pilot Study Part 1 – Psychosis Like Experiences

3.3.1 Aims and Hypotheses

The presence of any anomalous/psychosis-like symptoms, and participants' interpretations of these were evaluated in 3 different settings: under normal conditions, in a 'seclusion' style environment, and in near-total sensory deprivation. A group of participants who rated highly for hallucination proneness was compared against a group who rated low for such traits. It was hypothesised that:

1. The high hallucination prone group would exhibit a greater degree of psychotic-like symptoms than the low group under normal base-line conditions.
2. Short-term 'seclusion' would lead to a significant reduction in base-line psychotic-like symptoms in the high hallucination prone group.
3. Short-term 'seclusion' would produce no significant change in base-line psychotic-like symptoms in the low hallucination prone group.
4. Both high and low hallucination prone groups would experience a significant increase in psychotic-like symptoms from base-line in near-total sensory deprivation.
5. The increase in psychotic-like symptoms in near-total sensory deprivation would be significantly greater for the high hallucination prone group than the low hallucination prone group.

3.3.2 Method

3.3.2.1 Participants

Participants between the ages of 18 and 65 years were recruited via a university psychology department website that advertises to both students and the general public.

Exclusion criteria included a history of a major psychiatric or neurological disorder, or current recreational drug use. An advert was placed inviting participants to complete an online version of the Revised Hallucinations Scale (RHS), a measure of hallucination-proneness (Morrison et al. 2002). 317 participants from a wide range of ethnic backgrounds returned data. From this sample, 76 low scorers and 39 high scorers were identified as these conformed to the upper and lower 20^{th} percentiles, according to questionnaire norms. Both groups were then formed into randomised lists using an online randomisation tool (www.random.org), and participants were invited to take-part in list-wise order. 29 participants in the high scoring group and 22 in the low scoring group were invited to participate in the experiment. Of these, 18 low scorers (7 males, 11 females, mean age = 25.39 years, SD = 6.09, mean score = 26.22, SD = 1.77) and 18 high scorers (4 males, 14 females, mean age = 24.94 years, SD = 3.95, mean score = 54.94, SD = 5.25) gave informed consent, consistent with University ethical approval, and completed the experimental procedure.

3.3.2.2 Power Analysis

Very little is known about the effects of sensory deprivation on people who rate highly for hallucination proneness, and so it was challenging to accurately estimate effect sizes from existing literature. The most similar study to date (Mason and Brady 2009) reported large effect sizes for increases in perceptual distortions (partial eta squared = 0.56) and anhedonia (partial eta squared = 0.58) measured using the Psychotomimetic States Inventory (Mason et al 2008) immediately after 15 minutes of sensory deprivation. The power calculation for the current study was based on the smallest of these effect sizes reported by Mason and Brady (2009): partial eta squared = 0.56. This is a conservative estimate for current purposes since participants in the current study spent a longer length of time in sensory deprivation (25 minutes) presumably providing greater opportunity for perceptual distortions to arise. Power calculations suggested that a minimum total sample of N= 36 (i.e.18 high schizotypy and 18 low schizotypy) would provide statistical power for a between-within participants repeated measures ANOVA design that exceeded 80% (β= .80), with α= .05.

3.3.2.3 Measures

The Revised Hallucinations Scale (RHS), Morrison et al. 2002: This is a 24-item questionnaire based on the Launay-Slade Hallucination Scale (Launay and Slade, 1981) measuring a predisposition to experience hallucinations. It uses a revised scoring method which allows participants to respond on a 4-point scale (1 = never to 4 = almost always). The scale has been shown to have good reliability and predictive validity, and moderately stable internal consistency over a period of 4-6 weeks (Morrison et al. 2002).

The Psychotomimetic States Inventory (PSI), Mason et al. 2008: This is a 48 item questionnaire measuring psychosis-like experiences. Items are rated on a 4-point scale (from 0 = never to 3 = strongly), with some items being reverse scored. The Psychotomimetic States Inventory has sub-scales of Delusory Thinking, Perceptual Distortions, Cognitive Disorganization, Anhedonia, Mania and Paranoia. It was originally developed for use in drug studies, and it was used here because there are currently no validated measures available specifically for studying the effects of sensory deprivation. Despite the limitations of using a non-validated measure, the PSI has produced meaningful results in a previous preliminary study of sensory deprivation (Mason and Brady 2009), and therefore it was included in the current study to further validate the measure in this context.

The State-Trait Anxiety Inventory (STAI), Spielberger 1983: A pair of two 20-item questionnaires that measure the temporary condition of state anxiety, and the more longstanding quality of trait anxiety. Items are rated of a 4-point scale. The STAI has been shown to have good construct validity with multiple other assessment tools (Smeets et al., 1996). It has also been shown to have good test-retest reliability (.54 correlation for state, and .86 correlation for trait anxiety (Spielberger et al. 1983).

Appraisals of Anomalous Experiences Interview (AANEX), Brett et al 2007: A multidimensional measure of psychological responses to anomalies associated with psychosis. The first section (the AANEX inventory) includes items reflecting Schneiderian first-rank symptoms and anomalies of perception, cognition, affect, and 'individuation' (sense of distinction between self and others), as well as some 'paranormal' experiences. The inventory generates two sets of scores: lifetime (not used in this study), and state. For state scores, items are rated between 0 and 2 (absent, marginal, and present).

The second section (the AANEX-CAR) is a structured interview that assesses appraisals, context, and responses pertaining to any anomalous experiences endorsed from the inventory. It can also be used independently from the inventory to explore anomalies elicited with other clinical instruments (in this instance, the Psychotomimetic States Inventory). The format is flexible, and different sub-sections can be used to assess current anomalous experiences, lifetime anomalous experiences, and also changes in interpretation and response style over time. Assessing a person's current style of appraising and responding takes approximately 10-15 minutes.

The AANEX has been shown to be a reliable measure as evidenced by its ability to successfully differentiate between clinical and non-clinical groups (Brett et al. 2007).

3.3.2.4 Equipment

An empty office without windows was used to create the seclusion condition. The room had electric strip-lighting, and no-soundproofing. It was furnished with an office chair and a desk, but was otherwise empty, with bare walls.

An anechoic chamber was used to produce the sensory deprivation condition, details of which are presented above.

3.3.2.5 Procedure

Baseline data was collected from participants a few weeks prior to attending the testing facility (in order to minimise any anticipatory anxiety this may have caused on the day of the experiment itself). The baseline data-set for both groups included AANEX Inventory state scores; State-Trait Anxiety Inventory (full version); Psychotomimetic States Inventory. All participants submitted their data via an online website.

In order to minimise order effects, participants in both groups were randomly split into two halves. The first half completed the deprivation condition first, followed by the seclusion condition. The remaining half completed the seclusion condition first, followed by the deprivation condition. A diagrammatic summary of the experimental procedure is given in Figure 1.

<u>Deprivation condition:</u> Participants were given a demonstration of the anechoic chamber prior to the start of the experiment so that they could familiarise themselves with the environment. They were then asked to sit in silence in the anechoic chamber in a padded armchair in the middle of the room. Participants were informed that they would be spending approximately 25 minutes in the chamber in complete silence and darkness. A microphone was present in the chamber so that participants could be heard by the experimenter outside should they become distressed. This was a one-way set-up, and they

could not converse with the experimenter. Participants were informed that if they wished to terminate the experiment at any point they should remain seated and tell the experimenter, who would immediately restore light and communication. No participants chose to terminate the experiment early.

After completion of 25 minutes within the chamber, participants were moved to an ante-room where they were immediately asked to complete questionnaires referring to the time that they had spent in the anechoic chamber: the AANEX Inventory (state items only); State-Trait Anxiety Inventory (state items only); Psychotomimetic States Inventory. For participants who reported clear anomalous experiences, the AANEX CAR interview was also administered to gather data on appraisal and responding styles.

Following data collection, participants were invited to take a 30 minute break prior to completing the second half of the experiment.

Seclusion condition: Participants were asked to sit in an office-style chair in silence for 25 minutes in the 'seclusion' room with electric lighting and no-soundproofing. After completion of the 25 minutes, participants were moved back to a nearby office where they were immediately asked to complete the same questionnaires/interview as following sensory deprivation, referring to the time that they had spent in the seclusion room: AANEX Inventory (state items only); State-Trait Anxiety Inventory (state items only); Psychotomimetic States Inventory. Once again, if participants reported clear anomalous experiences, the AANEX CAR interview was administered to gather data on appraisal and responding styles.

Following completion of the experiment, participants were de-briefed, and received a nominal fee for their time in taking part.

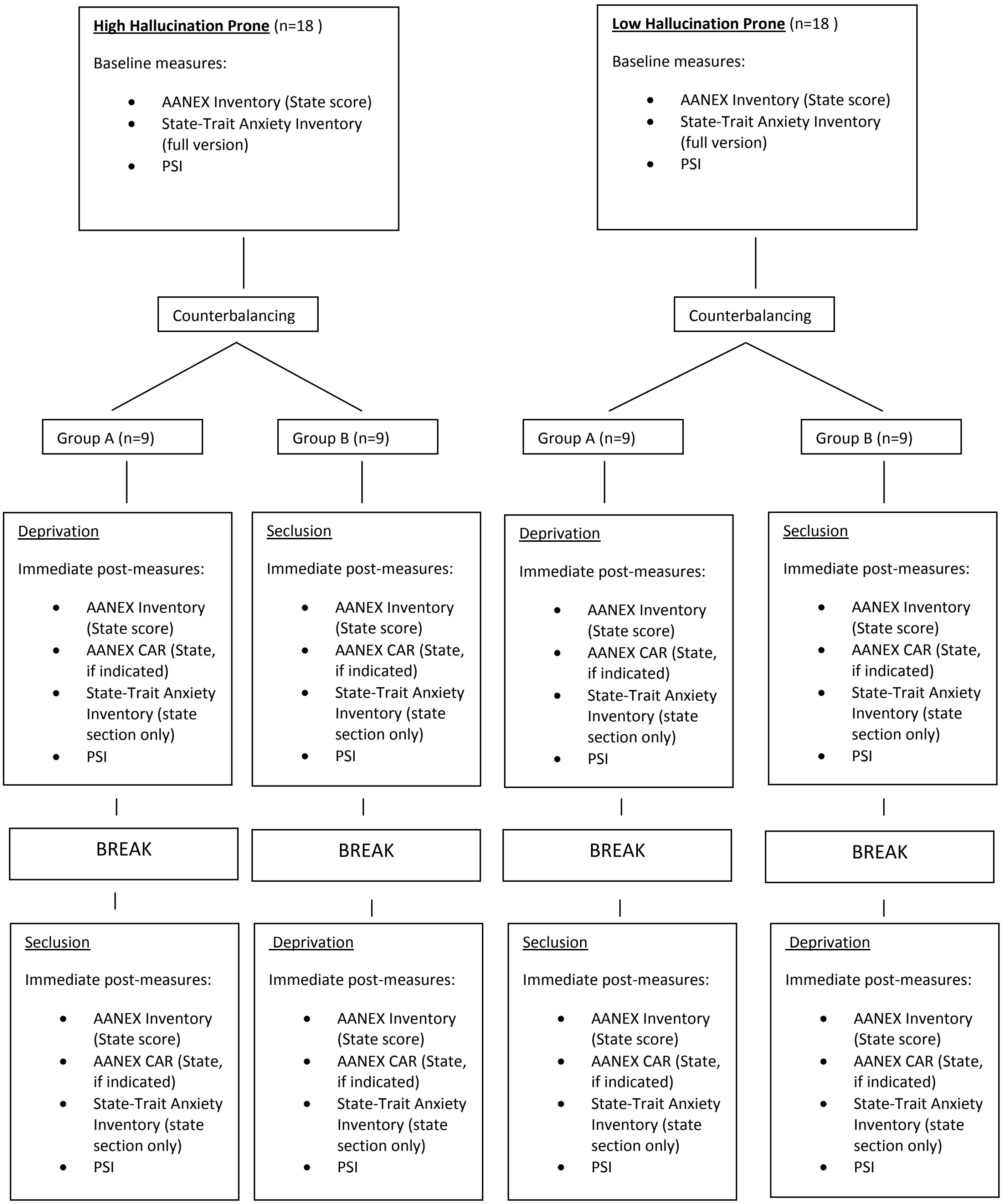

Fig. 1. Summary of Experimental Procedure

3.4 Results

3.4.1 Preliminary Statistical Analyses

All statistical analyses were conducted using SPSS 17.0. Data were checked for normality before analysis using descriptive statistics and histograms with normal distribution curves.

The order in which participants experienced seclusion and deprivation conditions was counterbalanced as part of the experimental procedure, however a preliminary mixed between-within subjects repeated measures analysis of variance was carried out to test for any effect of order on anxiety or PSI scores. A significant main effect of order was found for both anxiety scores, $F\ (1,32) = 7.41$ ($p<.01$) and PSI scores, $F\ (1,32) = 5.07$ ($p<.05$), with participants who experienced seclusion first reporting higher anxiety and PSI scores throughout the experiment. There were no interactions between order and group, indicating that these order effects are not dependent on degree of hallucination proneness.

3.4.2 Baseline Group Comparisons

It was hypothesised that the high scoring group would score significantly higher on measures of psychotic-like symptoms under normal baseline conditions. The high and low scoring groups did differ significantly in PSI scores at baseline ($F(1,34)=6.145$, $p<.001$), with the high scoring group reporting a greater number of psychosis-like experiences (see Table 1 for descriptives). Baseline trait and state anxiety scores were significantly correlated ($r=.74$, $p<.001$). Significant differences in trait anxiety ($F(1,34)=20.23$, $p<.001$) and state anxiety ($F(1,34)=7.91$, $p<.01$) were found between the high and low hallucination prone groups at baseline, with the high hallucination prone group reporting higher levels of trait anxiety ($x=47.78$, $SD=12.95$ compared to 31.89, $SD=7.55$) and state anxiety ($x=42.28$, SD

=11.83 compared to 32.50, SE=8.82). Although not specifically hypothesised all the above findings are in the expected direction.

3.4.3 Psychosis-like experiences across groups and conditions

It was hypothesised that whilst both groups would experience a significant increase in psychosis-like symptoms from baseline in near-total sensory deprivation, the increase would be significantly greater for the high scoring group. Results of a mixed between-within subjects repeated measures analysis of variance demonstrated a significant main effect of group for PSI scores, ($F(1,34)=31.31$, $p<.001$) (see Table 1 for descriptives). This indicates that the high hallucination prone group experienced a significantly greater number of psychosis-like symptoms overall throughout the experiment, independent of condition (see Figure 1).

There was also a main effect of condition for PSI scores ($F(1,83)=12.524$, $p<.001$) (see Table 1 for descriptives). Planned contrasts revealed that PSI scores were significantly higher in deprivation than at baseline ($F(1,34)=17.86$, $p<.001$) and PSI scores were significantly higher in deprivation than in seclusion, $F(1,34)=14.05$, $p<.001$). There was no significant difference in PSI scores between seclusion and baseline. There was no interaction effect detected between group and condition, suggesting that both high and low scoring groups responded in a similar way to the experimental conditions.

Table 1. Mean Questionnaire Scores for High and Low Hallucination-Prone Groups by Condition

Mean Questionnaire Scores (Standard Deviations)	**High Scorers (n = 18)**			**Low Scorers (n = 18)**		
Revised Hallucinations Scale	54.94 (5.25)			26.22 (1.77)		
	Baseline	**Seclusion**	**Deprivation**	**Baseline**	**Seclusion**	**Deprivation**
Trait Anxiety	47.78 (12.95)	-	-	31.89 (7.55)	-	-
State Anxiety	42.28 (11.83)	36.33 (11.67)	38.89 (14.46)	32.50 (8.82)	33.17 (6.72)	36.17 (8.92)
PSI	37.00 (16.24)	36.83 (19.50)	49.28 (18.98)	13.83 (8.62)	19.89 (7.65)	27.11 (11.00)

Note: Trait anxiety was measured once only, at baseline.

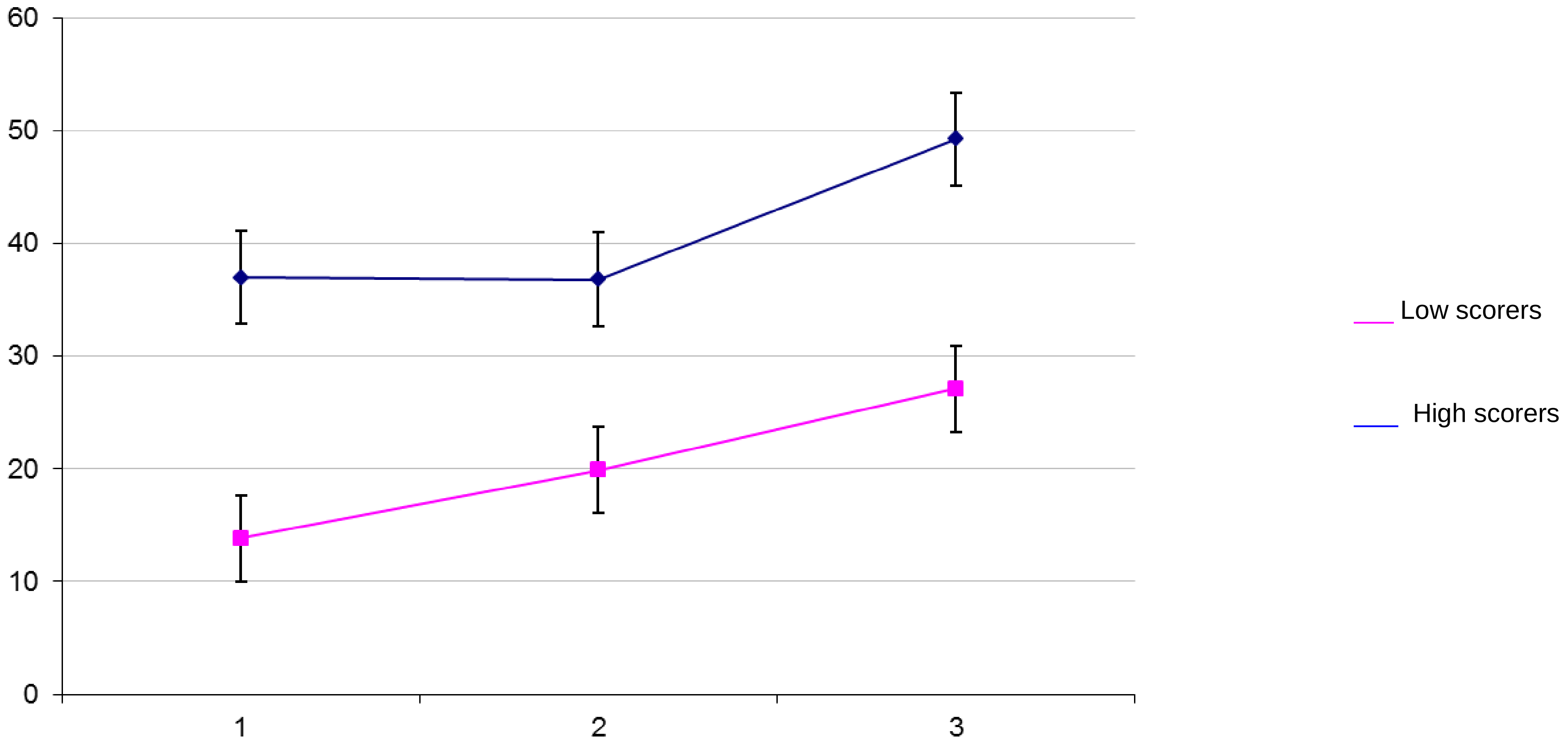

Figure 2. PSI scores in high and low hallucination-prone groups by condition

Table 2. Mean PSI Subscale Scores for High and Low Hallucination-Prone Groups by Condition

	High Scorers (n = 18)			Low Scorers (n = 18)		
PSI Subscale	**Mean Scores (Standard Deviations)**			**Mean Scores (Standard Deviations)**		
	Baseline	**Seclusion**	**Deprivation**	**Baseline**	**Seclusion**	**Deprivation**
Delusory Thinking	4.83 (3.37)	4.94 (3.47)	5.50 (4.57)	2.17 (1.50)	1.78 (2.05)	2.22 (1.80)
Perceptual Distortions	3.33 (3.09)	5.78 (4.57)	10.78 (5.83)	1.17 (1.38)	2.06 (1.70)	4.89 (3.25)
Cognitive Disorganisation	9.94 (5.10)	8.78 (4.92)	11.78 (5.66)	3.33 (2.95)	4.56 (3.57)	5.72 (3.71)
Anhedonia	9.17 (5.62)	8.06 (3.65)	10.56 (4.22)	3.67 (2.40)	6.83 (2.31)	8.72 (3.53)
Mania	5.89 (2.45)	6.17 (3.01)	7.28 (3.43)	2.78 (1.73)	3.89 (1.18)	4.50 (1.86)
Paranoia	3.83 (2.94)	3.11 (3.45)	3.39 (3.13)	0.72 (1.27)	0.78 (1.31)	1.06 (1.55)

A further mixed between-within subjects repeated measures analysis of variance examining the PSI subscales of Delusional Thinking, Perceptual Distortion, Cognitive Disorganisation, Anhedonia, Mania, and Paranoia was conducted to investigate any difference in particular types of psychosis-like experiences reported across the different conditions. Consistent with hypotheses, there was a significant main effect of condition for Perceptual Distortions ($F(2,68)=34.15$, $p<.001$), Anhedonia ($F(2,68)=10.76$, $p<.001$), Mania ($F(2,68)=6.53$, $p<.01$), and Cognitive Disorganisation ($F(2,68)=3.22$, $p<.05$). Planned contrasts indicated that perceptual distortions and anhedonia scores were significantly higher in seclusion than at baseline, and further increased during deprivation. Mania and Cognitive Disorganisation were also significantly higher during deprivation than at baseline, but did not increase significantly in seclusion (see Table 2). A significant interaction between group and condition was found for the Perceptual Distortions subscale ($F(2,68)=3.63$,$p<.05$),with high scorers showing a greater increase in these symptoms in deprivation than low scorers. A significant interaction between group and condition was also found for the Anhedonia subscale ($F(2,68)=5.31$, $p<.01$), with low scorers showing a more marked increase in anhedonic symptoms in deprivation than high scorers (see Table 2).

3.4.4 State and Trait Anxiety across groups and conditions

Results of a mixed between-within subjects repeated measures analysis of variance demonstrated a significant main effect of group for state anxiety scores ($F(1,34)=4.21$, $p<.05$) (see Table 1 for descriptives). This indicates that the high hallucination prone group experienced higher state anxiety than the low hallucination prone group. There was no effect of condition for state anxiety, suggesting that anxiety did not differ between baseline, seclusion, and deprivation conditions (see Figure 3). Thus state anxiety is unlikely to account for the differences in psychosis-like experiences between conditions. Trait anxiety differed between experimental groups, but did not correlate with PSI scores in any condition. Consequently trait anxiety was not considered as a covariate for analysis of variance for PSI scores.

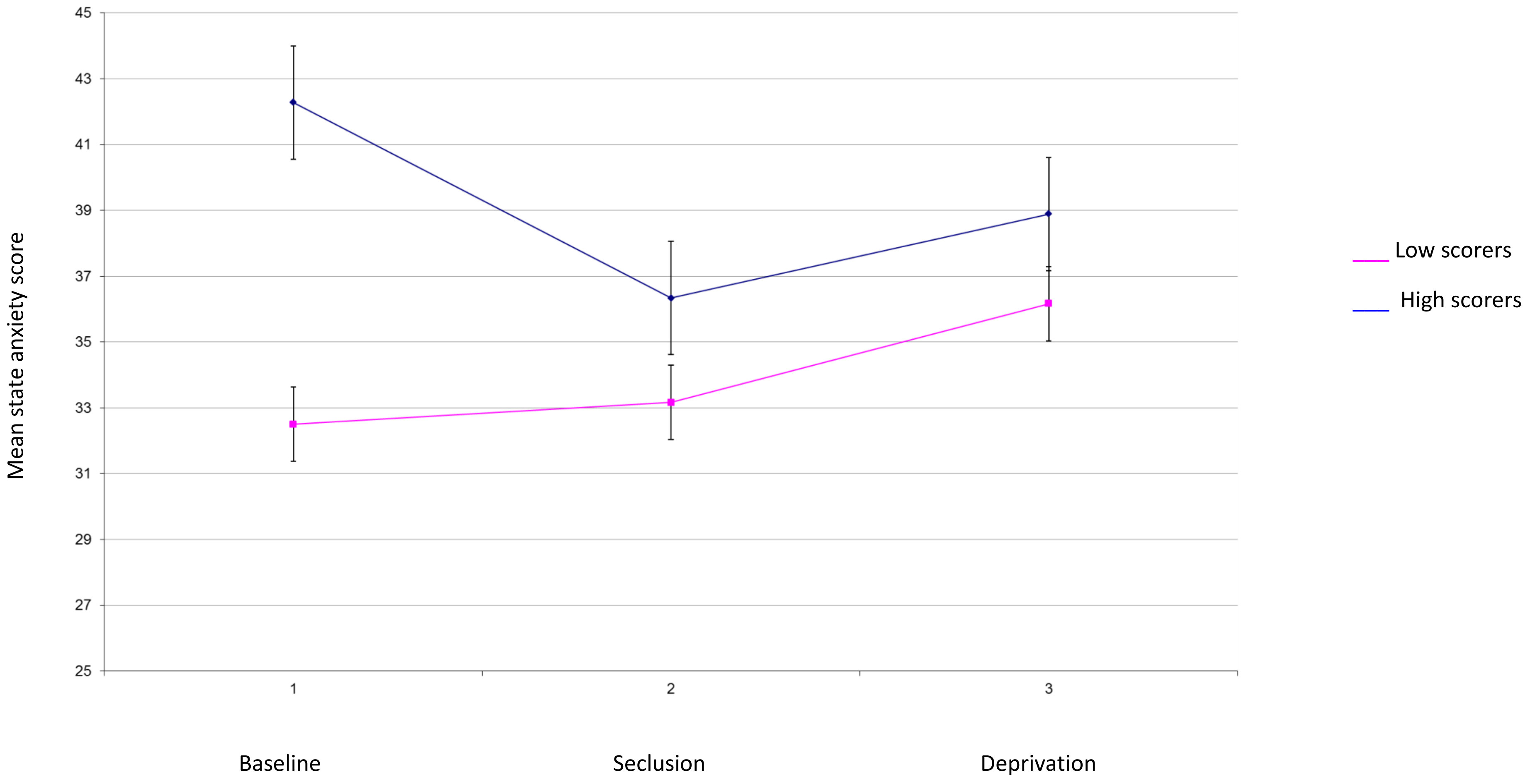

Figure 3. State anxiety scores in high and low hallucination-prone groups by condition.

3.5 Discussion

Consistent with hypotheses, hallucination proneness was associated with greater psychosis-like symptoms under all conditions. In addition, both high and low scoring groups experienced a significant increase in psychosis-like symptoms in sensory deprivation conditions. Sensory deprivation was found to produce a significant increase on four subscales of the Psychotomimetic States Inventory: Perceptual Distortions, Anhedonia, Mania, and Cognitive Disorganisation. Findings with respect to perceptual distortions and anhedonia were highly marked and were consistent with the first pilot study (Mason and Brady, 2009). However unlike the previous study, paranoia did not appear to increase significantly. As the current study is larger and so better powered, and utilised a longer time period, it is likely to provide a more sensitive profile of the psychotic-like symptoms provoked by deprivation. In the current study, an interaction effect between condition and group was only seen for the Perceptual Distortion subscale clearly validating the RHS and suggesting a state-trait interaction.

Also of interest, but not predicted, was that low scorers experienced a significantly greater increase in anhedonic symptoms during deprivation as compared to baseline measurement. Previously this finding had only been seen in high scorers. This could be due to boredom effects in the low scoring group (related to the longer time duration), who otherwise reported few psychosis-like experiences during deprivation.

The potential role of state and trait anxiety was explored. Consistent with the previous literature (Allen et al., 2005) trait and state anxiety distinguished the high hallucination-prone from the low hallucination-prone groups at baseline. However, trait anxiety did not predict changes in PSI scores, nor did state anxiety differ across condition in either group. Therefore the increase in psychosis-like symptoms seen in both groups during deprivation cannot be readily attributed to increased anxiety.

3.5.1 Limitations

The ‘secluded office’ condition attempted to provide a closer analogue to sensory deprivation (in duration at least) than the baseline but this was not highly successful. While, on many indices these two conditions appeared highly similar there were significant order effects across both groups; with participants who experienced seclusion first reporting more psychosis-like experiences throughout the experiment. It is possible that participants who experienced seclusion first responded to the perceived demand characteristics of the experiment, endorsing more items on the PSI measure in this first condition. Counter-balancing was incorporated into the experimental design in an attempt to moderate any order effects, but demand characteristics may still have had some impact, particularly on the seclusion data. As a consequence, the baseline condition is very probably the more stable one against which to compare the experimental deprivation condition.

Chapter 4

Cognitive appraisals of Psychosis-like Experiences

4.1 Introduction

The following chapter focuses on the importance of cognitive appraisals in the development of psychosis. The rationale for the study of cognitive appraisals across the psychosis spectrum is first outlined, concluding with a discussion of the AANEX questionnaires (Brett et al. 2007), which represent one method for collecting data on appraisal styles. A further aspect of the sensory deprivation pilot study described earlier in chapter 3 is then presented, which details the collection and analysis of data on the cognitive appraisal styles of the high and low schizotypy groups. The results are then discussed, and the limitations of the pilot methodology are reflected on, together with suggestions for further improvements.

4.1.1 Cognitive Models of Psychosis

In their cognitive model of the positive symptoms of psychosis, Garety, Kuipers, Fowler, Freeman and Bebbington (2001) suggest that psychosocial vulnerabilities, such as experiencing adverse environments, life events, deprivation, severe childhood trauma and social adversity, may play a role in the development of psychosis. They suggest that these experiences may create an enduring cognitive vulnerability, developing negative schematic models which may fuel anomalous experiences, external attributions and low self-esteem.

Garety et al. (2001) make clear that the basic cognitive disturbance that leads to anomalous conscious experiences is not sufficient to trigger psychosis. It is during the search for an explanation as to the cause of these anomalous experiences (which are not only unusual but also highly emotionally charged) that true psychosis develops. Garety et al. (2001)

maintain that the cognitive appraisal processes an individual adopts to make sense of their anomalous experiences are the critical factor that determines whether an individual develops psychosis. If a person is able to reject the hypothesis that the unusual experiences they are having are caused by an external agency (known as the externality hypothesis) they can be protected from developing full-blown psychosis. It is only when the individual appraises their experiences as externally caused and personally significant that true psychosis has developed, and the anomalous experiences can be formally identified as hallucinations (with associated delusions). Therefore cognitive appraisal styles represent an important target for both research and psychological therapy aimed at alleviating the distress associated with psychosis.

Appraisals are not the only cognitive processes thought to be relevant to the development and maintenance of positive psychotic symptoms. Garety et al. (1997) also identified several 'cognitive biases' that are thought to contribute most significantly to the development of psychosis. These are: a 'jumping to conclusions' data gathering bias, an externalising attributional style, and poor social understanding or limited 'theory of mind'. The social isolation often associated with onset of psychosis can also help maintain these cognitive biases, as a psychotic individuals beliefs are not being contradicted or challenged by others. In fact, regardless of the degree of social isolation experienced, lack of willingness to consider alternatives to delusional beliefs is in itself associated with poorer outcome (Garety et al. 1997).

The sensory deprivation protocol piloted in chapter 3 demonstrated it was effective in generating PLE's in the majority, if not all, participants. Given the importance of cognitive appraisals styles in demarcating the boundary between anomalous experiences and clinical psychosis, this chapter now goes on to consider data collected during the pilot study regarding appraisal styles in participants who experienced anomalous experiences during their time in sensory deprivation. In order to establish whether participants appraisal styles reflected typical appraisal and cognitive/emotional response styles of people experiencing genuine ‘spontaneous’ anomalous experiences that had not been experimentally ‘induced’, the appraisal styles were compared with existing data from a clinical group (schizophrenia spectrum disorders) and a non-clinical group with anomalous experiences sometimes termed ‘no-need-for-care’ (Lovatt et al., 2010). It was hypothesised that participants’ appraisal styles would be similar to the no-need-for-care group, and less similar to the clinical group.

4.1.2 The study of appraisal styles across the psychotic continuum

Appraisals and the continuum of psychotic experiences have been studied in depth by Brett et al (2007). They developed a new measure, the Appraisals of Anomalous Experiences Interview (AANEX), to assess anomalous experiences and individuals’ responses to them, including their appraisals. They compared a clinical sample of individuals with schizophrenia spectrum disorders with otherwise healthy individuals from the general population reporting a range of psychotic-like experiences. It was found that the clinical sample appraised their experiences as more negative, more dangerous, more likely to be external and personally caused, and made more paranoid/conspiracy interpretations. In contrast the non-clinical sample made more psychological, spiritual and normalising appraisals, were less distressed by their anomalous experiences, and felt they had greater controllability over them. These findings provide some support for cognitive models of psychosis, since the two groups could be differentiated by their appraisals, but they also suggest that the relationships between the anomalous experiences and their appraisals are complex.

The first section of the measure (the AANEX inventory) includes items reflecting Schneiderian first-rank symptoms and anomalies of perception, cognition, affect, and ‘individuation’ (sense of distinction between self and others), as well as some ‘paranormal’ experiences. The inventory generates two sets of scores: lifetime (not collected in this study), and state. For state scores, items are rated between 0 and 2 (absent, marginal, and present).

The second section (the AANEX-CAR) is a structured interview that assesses appraisals, context, and responses pertaining to any anomalous experiences endorsed from the inventory. It can also be used independently from the inventory to explore anomalies elicited with other clinical instruments (in this instance, the Psychotomimetic States Inventory). The format is flexible, and different sub-sections can be used to assess current anomalous experiences, lifetime anomalous experiences, and also changes in interpretation and response style over time. Assessing a person's current style of appraising and responding takes approximately 10-15 minutes.

4.2 Sensory Deprivation Pilot Study Part 2 – Cognitive Appraisal Styles

A full description on the pilot study methodology can be found in chapter 3. The following discusses the procedure for collection, analysis, and interpretation of data on cognitive appraisal styles.

4.2.1 Procedure

After completion of the 25 minute seclusion and sensory deprivation conditions, participants were moved to an ante-room where they were immediately asked to complete questionnaires referring to the time that they had spent in seclusion/sensory deprivation. These included the AANEX Inventory (state items only); State-Trait Anxiety Inventory (state items only); Psychotomimetic States Inventory. For participants who reported clear anomalous experiences, the AANEX CAR interview was also administered to gather data on appraisal and responding styles.

4.3 Results

4.3.1 Preliminary Statistical Analyses

All statistical analyses were conducted using SPSS 17.0. Data were checked for normality before analysis using descriptive statistics and histograms with normal distribution curves.

4.3.2 AANEX Inventory Scores across Groups and Conditions

Results of a mixed between-within subjects repeated measures analysis of variance demonstrated a significant main effect of group for AANEX inventory scores, ($F(1,34)=24.27$, $p<.001$) (see Table 1 for descriptives). This indicates that the high hallucination prone group experienced a significantly greater number of psychosis-like symptoms overall throughout the experiment, independent of condition.

There was also a main effect of condition for AANEX inventory scores ($F(1,83)=145.14$, $p<.001$) (see Table 1 for descriptives). Planned contrasts revealed that AANEX inventory scores were significantly higher in deprivation than at baseline ($F(1,34)=9.90$, $p<.001$) and were significantly higher in deprivation than in seclusion, $F(1,34)=9.85$, $p<.001$). There was also a significant difference in AANEX inventory scores between seclusion and baseline, $F(1,34) = 3.79$, $p<.001$. An interaction effect was detected between group and condition, suggesting that the high scoring group experienced a larger increase in AANEX inventory scores in sensory deprivation than the low scoring group.

Table 1. Mean ANNEX Inventory Scores for High and Low Hallucination-Prone Groups by Condition

Mean Questionnaire Scores (Standard Deviations)	**High Scorers (n = 18)**			**Low Scorers (n = 18)**		
Revised Hallucinations Scale	54.94 (5.25)			26.22 (1.77)		
	Baseline	**Seclusion**	**Deprivation**	**Baseline**	**Seclusion**	**Deprivation**
AANEX	11.91 (11.34)	13.41 (10.72)	28.05 (12.19)	1.83 (2.62)	3.33 (3.63)	8.39 (4.85)

4.3.3 AANEX CAR

AANEX CAR semi-structured interviews were administered to all participants who reported clearly identifiable psychosis-like experiences in seclusion or deprivation. Interviews were indicated for 11 out of 18 participants in the high scoring group, and 4 out of 18 participants in the low scoring group. Consistent with PSI results, the hallucination prone group reported a greater number of psychosis-like experiences than the non-prone group (chi sq.=4.11, p< .005).

The types of experiences participants reported were varied, including hearing noises such as insects buzzing and whistling (n=2); hearing music (n=2); seeing shapes and coloured lights (n=4); visual hallucinations such as seeing faces and animals (n=2); out-of-body experiences or the experience of watching events through another's eyes (n=3); disorientation such as feelings of falling, the room spinning, and the walls closing in (n=2).

Audio recordings of participants' descriptions of their experiences were collected as part of the AANEX-CAR interviews, and transcriptions can be found in table 2. As the majority of these descriptions referred to sensory disturbances, the nature of these experiences were categorised according to the spatial characteristics of the sensory phenomena described (ranging from simple percepts to the feeling of immersion in a complex multisensory environment), and the presence of absence of exploratory behaviour (participant interactions with their perceptions through their degree of attention or focus, or through moving their body to explore the qualities of the perception). These categorises were drawn from Lloyd et al.'s (2012) qualitative study of sensory deprivation, a full description of which is presented within the literature review in chapter 2. Basic and more complex sensory phenomena were reported by both high and low scoring groups. However, the presence of exploratory behaviour was able to distinguish the high scoring group (8 out of 11 accounts) from the low scoring group (0 out of 4 accounts). There were also two participant descriptions of psychosis like experiences that could not be categorised as sensory phenomena, with one participant in the low scoring group reporting paranoid ideation, and one participant in the high scoring group reporting a delusional belief not accompanied by any hallucinations.

All ANNEX CAR interviews were indicated following experiences in deprivation. Interviews were scored according to the procedure described by Brett et al (2007), and ratings derived for appraisal dimensions, appraisal categories, emotional response, cognitive and behavioural response, perceived social understanding, and perceived controllability.

In order to establish whether AANEX CAR scores reflected typical appraisal and cognitive/emotional response styles of people experiencing genuine symptoms that had not been experimentally 'induced', the scores were compared with existing data from a clinical group (schizophrenia spectrum disorders) and a non-clinical group with anomalous experiences (Lovatt et al., 2010: see table 3). Due to the small number of low scoring participants with AANEX CAR scores, the RHS groups were combined). Experiences under sensory deprivation were similar to those seen in the non-clinical group and differed from the clinical group in being appraised as less dangerous, less external, less due to others, and less anxiety provoking/negative emotionally; and as having a greater sense of agency, and more likely to have a psychological cause. However, the sensory deprivation group's appraisals differed from the non-clinical group in not being as positively valenced; not as spiritual in meaning; or positive emotionally. In these latter respects they did not differ significantly from the clinical group.

Table 2. Audio Transcripts of Participant Descriptions of Psychosis Like Experiences

Group	Description of Psychosis Like Experiences	Spatial characteristics		Exploratory behaviour
		Basic	Complex	
Low	I heard music… music playing in my head. Just like… I think it was a song that just played on my i-pod before I came here. It would come and go kind of thing.	χ	✓	✓
Low	At first it was just darkness and me waving my hand in fron of my face to see if I could see it. Then after a while I saw just like white blobs. Then it started morphong into pictures I've drawn recently, like swans and clowns and things. And then after that I didn't really know what was going on. There were lots of dots and shapes flying around, but it felt like I was watching a film. It seemed like there was some sort of a story line but I didn't know what it was… maybe subconsciously I knew. At one point I blinked and there was a flash. As though my eyes were a camera and I had just taken a picture.	✓	✓	χ
Low	I could see shapes standing out in the dark. I felt scared and just closed my eyes. And	✓	χ	χ

	then I opened it [sic] and when I would get scared I just closed them again.			
Low	I was bothered by the idea that people were watching me. Maybe there were hidden cameras.	N/A	N/A	N/A
High	"I started seeing lights and shadows that became hills and a church far away. I felt liberated and like I wanted to fly and reach those places. I saw the face of Homer Simpson. His face was in a house. Then I saw circles being formed made of light. Then I started seeing waves, like the waves of the sea. It was like I was on a boat watching the waves reaching the beach. I would try to focus on them. To make sense of them… to know more about them. But then they just disappeared.	χ	✓	✓
High	I saw what looked like a cat, as if someone was shining a light onto it with a torch. I wasn't sure whether it was me shining the torch on it, but I felt out of control. Then it turned into the car crash. I felt like I was tapping into parts of my mind that I keep hidden. When I saw the car crash I thought it must be in there, like some kind of trauma. I was trying to work out why the cat would turn into the car… trying to rationalise it.	χ	✓	✓

High	I heard a song I know from a Korean drama. At first I didn't really notice, but then I noticed it was in the background of my thoughts. I started to concentrate on it, and the more I was 'in it', it got stronger. At one point I thought I had said something, but then I wasn't sure whether I had just thought it or actually said it.	χ	✓	✓
High	I felt like the sound was… like mosquito sound [sic]. When you shut the door it was really scary. Suddenly I heard sound like mosquito sound [sic].	χ	✓	χ
High	I felt like something was missing inside. Caused by the unusual scenario… caused by the light. I wasn't in control of what I was seeing, it was out of my hands. Yet, I must have generated them myself.	✓	χ	χ
High	I felt like the room was spinning for about 5 minutes. At first it felt like a roller coaster, it was quite random. Then after a while it was just left to right and got faster and faster. I tried to close my eyes but that didn't work. So then I tried to focus on changing the direction.	χ	✓	✓
High	I felt like I had some sort of mental connection… like I knew what they [other people]	N/A	N/A	N/A

	were thinking about. All of a sudden a thought would just randomly pop into my head and I would just know.			
High	I heard little noises that came from different angles in the room. They came across as quite piercing actually. Almost as though someone was whistling. I found myself recalling a football match, but I was watching from the side, I wasn't actually playing. I remember that game and I was actually playing, but it was like I was watching from the side like a spectator. As a spectator I felt fairly critical of my performance, which is quite interesting. Everything I saw was me making a mistake.	✓	✓	✓
High	I heard a noise and actually thought someone had opened the door. I was like… what was that? And I just kept on staring.	χ	✓	✓
High	I saw what I thought was a computer screen, but lying on its side giving out lines of light. I had the sensation that the walls were a lot closer than I thought they were… I could sense them right next to my head. I moved my feet and opened my legs to check the wall wasn't either side of me.	χ	✓	✓

High	I felt like I was outside of my body. It was like I was in a dream because I couldn’t really see or hear. I felt like I was living in another world. I was doing some things… like washing my face. I felt like I was lying in my bed about to get up, and I was like ‘next I am going to wash my face’.	χ	✓	✓

Table 3. Appraisals under sensory deprivation compared with Lovatt et al. groups

AANEX-CAR Items	**Sensory Deprivation Group (n=15) mean (SD)**	**Clinical Group (n=29) mean (SD)**	**Non-clinical Group (n=290 Mean (SD)**	***F* test**	***Post hoc* comparisons (Scheffe)**
APPRAISAL DIMENSIONS					
Valence	2.93 (1.24)	2.52 (1.25)	4.19 (1.04)	14.23**	NC > C = SD
Dangerousness	2.66 (1.74)	3.81 (1.18)	2.74 (1.10)	5.85**	C > NC = SD
Externality	2.00 (1.10)	3.44 (1.25)	2.33 (0.92)	10.61**	C > NC = SD
Agency	4.47 (0.72)	3.85 (1.20)	2.44 (1.15)	19.46**	C > NC = SD
APPRAISAL CATEGORIES					
Biological	0.07 (0.26)	0.48 (0.80)	0.44 (0.80)	n.s	-
Psychological/normalising	2.00 (0.00)	0.44 (0.75)	1.44 (0.75)	29.90**	C > NC = SD
Spiritual	0.33 (0.70)	0.67 (0.78)	1.33 (0.88)	8.54**	NC > C = SD
Other people	0.07 (0.25)	1.11 (0.93)	0.74 (0.26)	23.03**	C >NC = SD
EMOTIONAL RESPONSE					
Neutral arousal	2.33 (1.19)	2.59 (1.25)	2.70 (1.07)	n.s	-
Negative emotional response	2.12 (1.54)	3.70 (1.07)	2.00 (0.92)	17.09**	C > NC = SD
Positive emotional response	2.07 (1.24)	2.19 (0.92)	3.15 (1.13)	7.05**	NC > C = SD
Self-rated anxiety	2.53 (1.31)	3.96 (1.02)	1.96 (1.06)	22.69**	C > NC = SD
Self-rated excitement	2.27 (1.34)	2.48 (1.48)	3.03 (1.45)	n.s	-

NC, non-clinical group; C, clinical group; SD, sensory deprivation group ** $p<0.01$

4.4 Discussion

The majority of hallucination prone individuals (11 of 19) reported clear anomalous experiences sufficient for AANEX CAR interview, in contrast with a minority of non-prone (4 of 19). AANEX CAR data showed the appraisal and cognitive/emotional response styles of participants were broadly consistent with those of non-clinical individuals with anomalous experiences. Participants strongly believed that the causes of their experiences were psychological in nature and that they had some agency within them. The unusual environmental context may have made them more likely to interpret their experiences in terms of internal mental processes. Anxiety, dangerousness and a negative emotional response were at the low levels seen in non-clinical individuals, and unlike the symptomatic experiences of those with psychotic disorders. However, non-clinical individuals with repeated anomalous experiences have often been shown to develop positively valenced appraisals with, for some, strong spiritual meanings. This did not prove the case, in general, for those in sensory deprivation. 'Naturally' occurring – and reoccurring – anomalous experiences are plausibly more likely to develop idiosyncratic and personally highly meaningful appraisals than those perceived as 'artificially' created by laboratory conditions.

The qualitative descriptions of participants' experiences in sensory deprivation demonstrate that the high schizotypy group tended to experience more complex perceptual disturbances than the low schizotypy group. However, it was the presence of exploratory behaviours in the high schizotypy group that distinguished these participants' descriptions from those in the low schizotypy group. This is suggestive that exploratory behaviour (presumably reflecting a strong sense that the perceptual experience is not self, but externally generated) is key in distinguishing hallucinations from illusions and other sensory disturbances. However, even if the experiences of many of the high schizotypy participants are to be considered 'true' hallucinations, it is important to note that they differed significantly from the auditory hallucinations classically associated with clinical psychosis. There were no accounts that referred to hearing voices (only music), and visual hallucinations and out of body experiences were more commonly reported.

4.4.1 Limitations

Though the appraisal data goes some way to detailing the similarities with clinical and non-clinical psychotic experiences there is some way to go before concluding the phenomena seen in sensory deprivation are comparable. There were issues with the validity of the AANEX-inventory, as it was originally designed and validated as a researcher-led interview, and in the current study it was used as a self-administered questionnaire to facilitate collection of baseline data online. AANEX-CAR interviews necessitated asking further questions about questionnaire items participants endorsed probing psychosis-like experiences, and during this process it became apparent that there were significant cultural differences involved in the interpretation of items probing PLE's. In particular, participants from India were noted to endorse high levels of psychosis-like symptoms on questionnaires, however following discussion it became apparent that they had interpreted the questions in ways that were not expected, and they were not describing genuine psychosis-like experiences. For example, the AANEX inventory item "You felt that you could read other people's minds" was endorsed, but participants were describing a sense of closeness and intuition in friendships rather than genuine mind reading. This was not problematic following seclusion and deprivation, because participant's questionnaire responses were discussed with them and amended accordingly. However, participant's baseline data was submitted online, and therefore responses could not be discussed and verified. For this reason, it is imperative that future studies collecting ANNEX inventory data do so using the original researcher-led interview format.

One of the main suggestions for the direction of future research to emerge from the literature review in chapter 2 addresses the need for established criteria to distinguish true hallucinations from illusions and other non-voluntary perceptions. The categorisation of participant's descriptions of psychosis like experiences using Lloyd et al.'s (2012) themes found that these could be usefully applied to the pilot data, but in the current format they are somewhat limited. Future research could consider how these themes can be developed further, potentially in the form of a quantitative measure that would allow the nature of anomalous experiences to be more formally evaluated.

Chapter 5

Hallucination proneness

5.1 Introduction

Chapters 3 and 4 have discussed the development and piloting of a sensory deprivation paradigm that was successful in inducing PLEs in many, if not all participants. Critical to understanding the group differences that were observed in susceptibility to PLE's in sensory deprivation is the concept of hallucination proneness. This chapter discusses hallucination proneness in further detail, covering its links with the associated construct of schizotypy, and the various options available for self-report measurement. One such measure, the Revised Hallucinations Scale (RHS, Morrison et al. 2002) is then the focus of the remainder of the chapter. The proposed factor structures of the RHS are discussed, alongside the difficulties that have been encountered replicating these structures. This is then followed by an empirical study that uses Exploratory Structural Equation Modelling (ESEM) techniques to identify an alternative factor structure for the RHS.

5.1.1 The concept of hallucination proneness

It has been suggested that psychotic symptoms such as hallucinations and delusions exist on a continuum that ranges from normality to clinical psychosis (van Os et al 2009). In support of the continuum theory is the fact that during their lifetime, 5% - 15% of the general population may have the experience of hearing voices without an objective basis (Tien, 1991; Johns et al., 2004). In addition, a recent review and meta-analysis of the literature on PLE's (Linscott and Van Os 2013) found that nearly all demographic and experiential risk factors for psychosis were also able to predict greater risk of PLE's (such as hallucinations) in the general population.

Focusing on the general population, the propensity for an individual to experience hallucinations may be defined as 'hallucination proneness' (Morrison et al. 2002). Until recently is has been believed that the factors underlying hallucination proneness included personality traits (Laroi et al. 2005) and meta-cognitive beliefs (i.e. beliefs about one's own thoughts) (Varese and Bentall, 2011). However, more recent evidence has found very limited empirical support for the once widely accepted relationship with meta-cognitions once methodological limitations of research have been taken into account.

Research utilising the Five Factor Model of Personality (Goldberg, 1993) has shown openness to experience (involving active imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, and intellectual curiosity) and neuroticism (the tendency to experience negative emotions such as anger, anxiety or depression) are associated with hallucination-proneness (Laroi et al. 2005). Laroi et al (2005) have gone on to characterise this relationship further. In their study comparing hallucinatory experiences in young and elderly participants, openness was found to operate as a pre-disposing factor, whereas neuroticism seemed to be operating as a precipitating factor, particularly for younger participants (of the age when clinical psychosis would be most likely to develop).

Morrison, Haddock and Tarrier's (1995) once widely accepted metacognitive model of hallucinations purports misattribution to an external source is influence by metacognitive beliefs. The model proposes that hallucinations result from attempts to reduce the negative arousal that results from the experience of intrusive thoughts. Specifically, it is argued that hallucination-prone individuals hold certain metacognitive beliefs about the importance of thought consistency and the need to control thoughts. When intrusive thoughts are experienced, the inconsistency between these metacognitive beliefs and the experience of uncontrollable mental events leads to the attribution of these thoughts to an external source.

However, more recently Varese and Bentall (2011) have reviewed the considerable amount of literature that has been published on the metacognitive model, and reported a meta-analysis on the results of 10 clinical and 15 non-clinical studies. They concluded that there is limited empirical support for the metacognitive account of hallucinatory experiences. It was noted that the studies on non-clinical groups did offer support for the existence of robust relationships between hallucination proneness and metacognitive beliefs. However, these studies were found to have methodological limitations which may have led to inflated estimates and no such relationships were able to be drawn from the clinical study results. Varese and Bentall (2011) concluded that greater endorsement of dysfunctional metacognitive beliefs in hallucination prone individuals might conceivably be regarded as a consequence of hallucinatory experience, rather than an underlying aetiological factor.

5.1.2 The Relationship between Hallucination Proneness and Schizotypy

Within the general population, the rather broader set of traits under the rubric of psychosis proneness, or schizotypy, (Claridge 1972) have become of increasing interest in recent years as researchers seek to understand the commonalities and differences between unusual experiences in the general population and the clustering of symptoms in people diagnosed with schizophrenia. Though the exact number and nature of its factorial structure is disputed, the most consistent finding is that of so-called 'positive' schizotypy analogous to positive psychotic symptoms (the disposition to have unusual perceptual and other cognitive experiences, such as hallucinations, magical or superstitious belief and interpretation of events). Other traits generally identified include cognitive disorganization (a tendency for thoughts to become derailed, disorganised or tangential), 'negative' schizotypy (a tendency to introversion, lack of pleasure and affect), and impulsive, non-conformist/ asocial behaviour. The most parsimonious way of viewing hallucination proneness, and one substantiated by empirical evidence, is that it forms a part of 'positive' schizotypy. It should be noted, however, that the various schizotypal traits, regardless of the exact measurement tool, are not unrelated (or 'orthogonal' in factorial terms). Rather, they tend to correlate to some extent so that hallucination proneness may well also be associated, albeit more weakly, with a wider range of schizotypal features. Indeed, this is the basic premise for using the RHS (a short questionnaire measuring hallucination proneness, Morrison et al., 2002) as a screening tool to identify highly schizotypal individuals. The pilot study presented in chapter 3 also confirmed that hallucination proneness scores were significantly correlated with degree of psychosis-like exeriences, both at baseline and under sensory deprivation conditions.

5.1.3 Measures of Hallucination Proneness in the General Population

Auditory hallucinations are probably the most prominent and common positive symptoms of psychosis, but also occur frequently in the absence of disorder (Linscott and van Os, 2013) as well as in sub-clinical forms with some but not all of the phenomenological features. With this in mind, researchers have been interested in designing measures of predisposition towards hallucinations for use in the general population, perhaps most often as part of thw wider rubic of schizotypy/psychosis proneness. A commonly used example is the Oxford and Liverpool Inventory of Feelings and Experiences (O-LIFE, Mason et al. 1995) that is based on a factor analysis of a wide range of psychosis-proneness scales (Claridge et al., (1996). The Unusual Experiences subscale taps into the experience of anomalous perceptions, including but not limited to hallucinatory experiences. There are also a number of measures grounded in clinical psychiatry that aim to measure 'sub-clinical psychotic symptoms in the general population, including The Peters Delusions Inventory (PDI, Peters et al. 1999) that measures delusional ideation, and The Magical Ideation Scale (Eckblad and Chapman, 1983) that covers a range of beliefs and experiences from first-rank symptoms of schizophrenia and ideas of reference to popular paranormal and conspiracy theory themes. There are also measures that focus more specifically on the perceptual and hallucinatory experiences associated with psychosis. The Perceptual Aberration Scale (Chapman et al. 1978) measures the level of body-image aberration, with items based on experiences of somatic distortions and hallucinations. There is also The Cardiff Anomalous Perceptions Scale (CAPS; Bell et al. 2006), a measure of perceptual anomalies with subscales for distress, intrusiveness, and frequency of anomalous experiences. While the above scales have items relevant to hallucination proneness it is not their specific focus.

The most frequently used questionnaire measures specifically aimed at tapping hallucination proneness within general population samples are versions of the Launay and Slade (1981) Hallucination Scale. The Launay Slade Hallucination Scale (the LSHS), is the original 12-item questionnaire scale to measure hallucinatory predisposition. It was designed to capture the full range of hallucination proneness, containing items specifically focused on clinical symptoms of auditory and visual hallucinations, plus additional items tapping areas that represent sub-clinical forms of over hallucinatory experience (for example, intrusive thoughts and vivid daydreams). A revised version of this scale, the Revised LSHS (Morrison et al. 2000) was subsequently published, and is a 16-item questionnaire containing 4 additional items specifically tapping predisposition to visual hallucinations (the original LSHS only contains one item of this kind), and uses a potentially more sensitive 4-point scale to measure frequency (1=never, 2=sometimes, 3=often, 4=almost always) rather than a forced true/false response.

The Revised LSHS then underwent a further revision to produce the Revised Hallucination Scale (the RHS, Morrison et al. 2002), a 24-item questionnaire containing 8 additional items that tap sub-clinical forms of overt hallucinatory phenomena in greater detail (including items measuring predisposition to visual hallucinations, predisposition to auditory hallucinations, vividness of imagery, and daydreaming. It retains the revised 4-point scale scoring method. The RHS has subsequently become an extensively used measure of hallucination proneness in experimental and correlational studies drawing on the general population.

5.1.4 *Difficulties Identifying the Factor Structure of the RHS*

Considerable attention has focussed on the underlying psychometric structure of hallucination proneness items in one or other forms emerging from the original Launay-Slade work. Morrison et al. (2002) used principal components analysis to analyse RHS data from 132 participants in the original study. They identified a three-factor structure consisting of a 9-item subscale assessing vividness of imagination and daydreaming (α = .88), a 7-item subscale assessing tendency towards experiencing visual disturbances and hallucinations (α = .80) and a 4-item subscale measuring tendency towards experiencing auditory hallucinations (α = .62). However, subsequent attempts to validate this three-factor structure have had mixed success. Reasons for this may relate to the original sample: n = 132 might simply be too small for a sufficiently powered, and hence valid, factor analysis. General recommendations for minimum sample size are frequently cited to be in excess of 250 (Cattell, 1978), or of around ten times the items – in this case 240. Furthermore, of the three published studies attempting to confirm the RHS factor structure, none use the questionnaire in the original English form, instead reporting on translations of the questionnaire into Polish (Gaweda and Kokoszka, 2011), Portuguese (Paixao and Moreira, 2008) or Spanish (Cangas et al., 2011). Therefore it is difficult to discern whether the inability to replicate the factor structure is due to the original structure failing to generalise to a different population, or due to the questionnaire translation process failing to achieve conceptual and cross-cultural equivalence.

Notwithstanding these linguistic issues, Cangas et al's (2011) paper reports a confirmatory factor analysis 'of the RHS', however on closer reading the scale they are reporting on is actually the 12 item Revised Launay Slade Hallucination Scale (Revised LSHS, Morrison et al. 2000), and the terminology has unfortunately become confused for the 24-item RHS (Morrison et al. 2002). Paixao and Moreira (2008) report finding a 3 factor structure similar to the original RHS, albeit the proportion of the total variance explained by each of the factors differed substantially. However, Gaweda and Kokoszka (2011) report finding a four factor structure: 1) imagery vividness; 2) auditory and visual perceptual anomalies; 3) experience of dissociation; 4) auditory hallucinatory like experiences; and concluded the factor structure of Polish versions of the RHS is comparable to the original, with the addition of a new subscale that may represent the experience of dissociation.

5.1.5 Limitations in Confirmatory Factor Analysis Techniques and the development of Exploratory Structural Equation Modelling

Another explanation for the difficulty replicating the RHS factor structure may lie in limitations inherent in CFA techniques. Some of the theoretical assumptions of CFA make it less suitable for modelling constructs such as hallucination proneness – the original EFA showed the three RHS factors to be significantly correlated and several items loaded significantly onto more than one factor (Morrison et al. 2002). Therefore the CFA assumption that items have factorial complexity of one (i.e. no cross-loadings of items) is not met, and therefore inappropriate use of CFA may result in overestimation or underestimation of the number of factors extracted. An example of how this can be problematic can be seen from another area of psychology, the measurement of personality. Inter-factor correlation is common in the Five Factor Model of personality (FFM). The literature underpinning the FFM is extensive and robust (Chamorro-Premuzic and Furnham, 2010), and yet the leading psychometric measure of the FFM, the NEO Personality Inventory Revised (NEO-PI-R) has failed to be confirmed by CFA when judged by traditionally accepted psychometric standards (Church and Burke, 1994; McCrae et al 1996). This would strongly suggest that alternative approaches to deriving underlying factor structures are likely to be more appropriate where cross-loading of items is common as here.

The recent development of Exploratory Structural Equation Modeling (ESEM) is arguably more appropriate for modelling data with high inter-factorial correlations. This is because in ESEM the assumption that items have factorial complexity of one is relaxed. There are also further advantages, including the availability of standard errors for parameter estimates in an exploratory setting, and an assessment of fit using goodness-of-fit indices available in traditional structural equation modelling frameworks (Asparouhov and Muthen, 2009; Marsh et al., 2010).

5.2 Empirical Study to Establish a Factor Structure for the RHS using ESEM

An empirical study was conducted in order to establish whether an ESEM factor structure supports the original proposed structure of the RHS, and whether it fits the data better than a competing CFA model. A large sample (n = 562) of RHS respondents drawn from a student population was analysed, who completed the questionnaire in the original English form.

5.2.1 Method

5.2.1.1 Participants

Participant data was taken from two separate data-sets. In the first data-set (n=562) participants had completed an online survey, comprising the RHS plus some additional psychometric measures. In the second data-set (n=160) participants had completed only the RHS, also online. In both data-sets participants' ages ranged from 18 to 65 years, and the majority were students educated to undergraduate level. The data-sets were also similar in terms of gender split (57% and 58% female in the first and second data-sets respectively) and in terms of mean age (23 years, SD 6 years for both data-sets).

5.2.1.2 Measures

The Revised Hallucinations Scale (RHS), (Morrison et al. 2002) is a 24-item questionnaire based on the Launay-Slade Hallucination Scale (Launay and Slade, 1981) measuring predisposition to experience hallucinations. It uses a revised scoring method which allows participants to respond on a 4-point scale (1 = never to 4 = almost always). The scale has been shown to have good reliability and predictive validity, and moderately stable internal consistency over a period of 4-6 weeks (Morrison et al. 2002).

5.2.1.3 Analysis

SPSS 22.0 was used for data cleaning. All structural equation modelling was carried out using Mplus 7.3 (Muthen and Muthen, 1998 – 2015). Model tests were based on the covariance matrix with MLM estimation to address issues related to non-normality of the data. Oblique Geomin rotation was selected due to strong theoretical grounds for supposing the underlying factors should be related (Launay and Slade, 1981; Morrison et al. 2000; Morrison et al. 2002).

Initially a confirmatory factor analysis (CFA) was conducted on the first sample of RHS data (n= 562) to examine whether the original factor structure for the RHS (Morrison et al. 2002) could be replicated. Since this was not the case, a principal components analysis (PCA) was run using SPSS 22.0 in order to explore alternative possible factor structures. A new factor structure was proposed, and validated by conducting a CFA on a separate second data-set (n=160). A further CFA of the new proposed structure was also conducted on the original data-set (for comparative purposes only). As this model proved a good fit, an Exploratory SEM Analysis was also conducted on this data-set. CFA and ESEM models were first fitted to males and females separately, prior to examining measurement equivalence in order to demonstrate if survey items measured constructs similarly across populations.

Multiple fit indices in addition to the model chi-square are reported, because chi-square's sensitivity to sample size can lead to rejection of theoretically appropriate models (e.g. Byrne, 1998). Root mean square error of approximation (RMSEA; Steiger, 1990), and standardised root mean square residual (SRMR) were assessed as indicators of model absolute fit (that is, a model's ability to reproduce the covariance matrix). RMSEA values below .10 indicate a good fit to the data and values below .05 very good fit (Steiger, 1990). SRMR values less than .08 indicate good fit to the data (Hu and Bentler, 1999). The comparative fit index (CFI; Bentler, 1990) and Tucker-Lewis index (TLI) were assessed as indicators of comparative fit (whether the model under consideration is better than the null model). CFI and TFI values exceeding .95 indicate good fit to the data (Hu and Bentler, 1999).

5.2.2 Results

Confirmatory factor analysis (CFA) of the first sample (n= 562) examined whether the original factor structure (Morrison et al. 2002) could be replicated. Fit indices for the original three factor CFA model are presented in table 1.

The model showed reasonable absolute fit with the data (RMSEA ≤ .08, SRMR ≤ .08). However, the comparative fit indices did not show the model to be superior to the baseline model in terms of ability to provide good fit to the data with CFI and TLI values far below the .95 threshold. Because of this, we did not proceed further interpreting the factor structure of this model as it was not appropriate for the data.

Table 1. Fit Indices for the Original Three Factor CFA model

Model						
	X^2	df	CFI	TLI	RMSEA	SRMR
Three Factors (oblique)	1053.27	167	0.78	0.75	0.08	0.07

5.2.2.1 Principal Components Analysis

Since Morrison et al.'s (2002) original factor structure was not replicated, a principal components analysis (PCA) explored alternative possible factor structures. The suitability of PCA was assessed prior to analysis. Questionnaire item 9 was removed from the analysis as it did not correlate well with other items. In addition, item 9 was found to have very low variance, in keeping with the findings of Morrison et al. (2002) who also eliminated this item. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.90, and Bartlett's test of sphericity was statistically significant (p .000) indicating that the data was likely factorisable.

PCA revealed five components that had eigenvalues greater than one and which explained 32.24%, 8.00%, 5.99%, 5.37%, and 4.62% of the total variance respectively. Visual inspection of the scree plot indicated that four components should be retained (Cattell, 1966). In addition, the first four components all explained in excess of 5% of the total variance. As such, four components were retained.

The four-component solution explained 51.62% of the total variance. A direct oblimin rotation was chosen due to the proposed underlying factor relations. Items were required to load above 0.4 on a factor to contribute to it, and in order to identify distinct subscales, if an item loaded over 0.4 on both factors, it only contributed to the factor it loaded highest on (if there was a difference of less than 0.1 in the loadings, such items were allocated to the subscale with which the item content was judged most consistent). After the application of these criteria, the interpretation of the data was consistent with a new four factor structure. Factor 1 consisted of a 10-item subscale interpreted as representing Morrison et al's (2002) original Vividness of Imagination/Daydreaming factor. Factor 2 consisted of a 7-item subscale interpreted as representing Auditory and Visual Anomalous Experiences (a combination of Morrison et al's (2002) original Visual Hallucination and Auditory Hallucination factors. Factor 3 consisted of a two-item subscale interpreted as representing Fantasy (not present in the original factor structure) and Factor 4 consisted of Dissociation (also not present in the original). The factor structure matrix is shown in Table 2. Table 3 presents correlations between the factors.

5.2.2.2 Confirmatory Factor Analysis of Proposed Four Factor Structure

In order to provide further evidence to support the proposed new four factor structure, a CFA was conducted on an unrelated set of RHS data collected as part of a separate study (n=160). Fit indices for the new four factor CFA model are presented in Table 4.

The model showed good absolute fit with the data (RMSEA 0.06, SRMR 0.06). The comparative fit indices showed the model to be superior to the baseline model in terms of ability to provide good fit to the data with CFI and TLI values approaching the .95 threshold. Standardised parameter estimates for the model are presented in Table 5.

Table 5 shows the CFA model parameters were all significant ($p \leq .001$) and explained substantial amounts of item variance (R^2 = .12 to .83). The model provides good support for the a priori PCA four factor structure obtained from the previous data-set. In fact, the loadings are an exact replication of this structure.

Table 6 presents the disattenuated correlations between the factors. All four factors were shown to be significantly correlated with one another.

Table 2: Factor Structure Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
1. I daydream about being someone else.	.059	-.024	**.849**	-.012
2. I hear a voice speaking my thoughts aloud.	**.571**	.122	.038	.133
3. A passing thought will seem so real that it frightens me.	.200	.287	.177	-.200
4. I imagine myself off in far distant places.	**.442**	-.136	.407	-.123
5. I fantasise about being someone else.	-.074	.150	**.847**	-.022
6. In my daydreams I can hear the sound of a tune almost as clearly as if I were actually listening to it.	**.796**	.023	-.166	-.016
7. I hear the telephone ring and find that I am mistaken.	-.034	**.706**	.042	.031
8. I hear people call my name and find that nobody has done so.	-.060	**.745**	.055	.086
9. I have heard the voice of God speaking to me.				
10. The people in my daydreams seem so true to life that I think they are real.	.302	**.410**	.139	.077

11. No matter how much I try to concentrate on my work unrelated thoughts always creep into my mind.	**.356**	.130	.146	-.108
12. I can see thing strongly in my daydreams.	**.767**	-.089	.143	-.086
13. I can hear music when it is not being played.	**.643**	.104	-.158	-.099
14. I have seen a person's face in front of me when no one was there.	.187	**.454**	-.028	-.103
15. I can see the people in my daydreams very clearly.	**.733**	.028	.142	.087
16. My thoughts seem as real as actual events in my life.	**.427**	.207	.095	-.174
17. I have a vivid imaginary life.	**.565**	-.093	.222	-.144
18. I have had the experience of hearing a person's voice and then found that there was no one there.	.138	**.638**	-.044	-.061
19. When I look at things they look unreal to me.	.017	-.046	-.010	**-.853**
20. I see shadows and shapes when there is nothing there.	.108	**.450**	-.136	-.241
21. I have been troubled by hearing voices in my head.	-.133	**.412**	.088	-.287
22. When I look at myself in the mirror I look different.	.035	.100	.084	**-.633**

23. The sounds I hear in my daydreams are generally clear and distinct.	**.778**	-.040	-.060	-.066
24. When I look at things they appear strange to me.	.021	-.011	-.015	**-.868**

Table 3. Inter-factor Correlations

	1	2	3	4
Vividness of Imagination/Daydreaming	1.00			
Auditory and Visual Anomalous Experiences	.37	1.00		
Fantasy	.34	.22	1.000	
Dissociation	-.38	-.40	-.228	1.000

Table 4. Fit Indices for the New Proposed Four Factor CFA model

Model	X^2	df	CFI	TLI	RMSEA	SRMR
Male	340.59	183	0.87	0.85	0.06	0.07
Female	375.55	183	0.90	0.89	0.06	0.06
Baseline	326.81	203	0.91	0.89	0.06	0.06

Table 5. Standardised Parameter Estimates for the Proposed Four Factor Model

RHS Item	Factor 1:Vividness of Imagination/Daydreaming	Factor 2: Auditory and Visual Anomalous Experiences	Factor 3: Fantasy	Factor 4: Dissociation	R^2
1			.91**		.83
2	.53**				.28
4	.59**				.35
5			.86**		.74
6	.71**				.50
7		.61**			.37
8		.64**			.40
10		.67**			.44
11	.68**				.46
12	.80**				.64
13	.59**				.34
14		.47**			.22
15	.77**				.59

16	.70**				.49
17	.77**				.60
18		.73**			.53
19				.80**	.63
20		.51**			.26
21		.35**			.12
22				.59**	.35
23	.72**				.52
24				.83**	.69

** p ≤.001

Table 6. Inter-factor Correlations

	1	2	3	4
Factor 1: Vividness of Imagination/Daydreaming	1.00			
Factor 2: Auditory and Visual Anomalous Experiences	0.85**	1.00		
Factor 3: Fantasy	0.68**	0.56**	1.00	
Factor 4: Dissociation	0.64**	0.69**	0.48**	1.00

**P < .001

5.2.2.3 Exploratory SEM Analysis

Exploratory SEM Analysis was conducted on the original (N= 562) data set. Results from ESEM analyses are presented in Table 7. A further CFA was also conducted on this data-set for comparative purposes (see Table 8). Note this CFA was not used to validate the proposed PCA factor structure (a separate data-set has been presented above for this purpose). Results indicated an improvement in fit for the male-only and female-only models to what are considered acceptable levels by conventional standards (Males CFI .89 and Females CFI .93; Males SRMR .04 and Females SRMR .04). The improved model fit observed using ESEM is likely due to relaxation of CFA conditions where each item is only allowed to load on its target factor and has zero loadings on every other factor. Given the significant inter-factor correlations identified from the CFA analysis, it is highly probable that many items may load onto multiple factors.

Table 7. Fit Indices for the ESEM model.

Model						
	X^2	df	CFI	TLI	RMSEA	SRMR
Male	315.29	167	0.89	0.84	0.06	0.04
Female	341.00	167	0.93	0.89	0.06	0.04
Single group	470.26	186	0.92	0.88	0.05	0.03
Baseline	572.28	264	0.93	0.88	0.06	0.04
Metric	5112.30	506	0.88	0.86	0.07	0.13

Table 8. Fit Indices for New Proposed 4 Factor CFA model

Model	X^2	df	CFI	TLI	RMSEA	SRMR
Four Factors (oblique)	515.33	183	0.89	0.88	0.06	0.05

5.2.2.4 Measurement Equivalence Results

The two-group baseline model with no invariance constraints provides a good fit to the data (CFI = .93, TLI = .88, RMSEA = .06, SRMR = .04). In fact, these fit statistics are approximately the same as those based on the total group ESEM model. These results support the configural invariance of the RHS: suggesting that the same ESEM model is able to fit data from male and female groups when no additional invariance constraints are imposed.

The metric model constrains factor loading to be invariant across the two groups. Because the number of freely estimated factor loadings in the ESEM model is very high, a totally invariant model is much more parsimonious than a zero-invariance model: The number of freely estimated parameters drops from 240 to 132. Nevertheless, the metric model still provided an adequate fit to the data, as shown by the fit indices that control for parsimony (TLI = .86, RMSEA = .07) approaching acceptable levels. Taken in conjunction with the baseline model findings, the metric model provides further support for the invariance of the factor loadings across male and female groups.

5.2.2.5 Interpretation of Exploratory SEM Factors.

Due to the relaxation of the assumption that items have zero loadings on all factors other than the target factor under the ESEM approach, it is possible that the pattern of factor loadings does not support the a-priori factor structure: therefore patterns of factor loadings were examined. For a factor the be considered a component of the a-priori factor model, all, or at least the majority, of the items that measure the factor were expected to have their highest loadings on it, and all these loadings were expected to be statistically significant. From examination of the factor loadings (see Table 9) it was clear that Factor 1 represents the Fantasy domain described by others. For both males and females, all the loadings of the a-priori fantasy items were significant on Factor 1, and all a-priori items have their highest loadings on this factor. Factor 2 similarly represents Vividness of Imagination/Daydreaming. For both males and females, all the loadings on the a-priori Vividness of

Imagination/Daydreaming items were significant on Factor 2, and all a-priori items had their highest loading on this factor, with the exception of item 11 which, for males, had marginally larger loadings on Factor 3 than Factor 2. Factor 3 represents Auditory and Visual Anomalous Experiences. For both males and females, all the loadings on the a-priori Anomalous Experiences items were significant, and all a-priori items had their highest loading on this factor with the exceptions of items 2 and 10. Item 2, for males, had marginally larger loadings on Factor 4 than Factor 3. Item 10, for females, has marginally larger loadings on Factor 2 than Factor 3. Factor 4 represents Dissociation, as all a priori items were significant with the highest loadings on this factor in both males and females. In summary, the ESEM solutions for males and females revealed clear support for the a-priori four factor model. In addition, cross-loading for certain items, most notably items 10, 11, and 20, demonstrates that traditional CFA approaches are likely to prove inadequate if the strongest fit to the factor model is desired, and ESEM approaches may be more appropriate in this context.

Table 9: Loading Parameter Estimates and Significance Values from Standardised ESEM Model

	Male				**Female**			
	1	2	3	4	1	2	3	4
Item								
1	0.76**	0.08	-0.02	-0.00**	0.57**	0.14	-0.02	0.00
2	0.06	0.37**	0.23*	-0.17	0.03	0.43**	0.08	-0.00
3	0.03	0.22	0.34**	0.05	0.12	0.10	0.19**	0.13*
4	0.22*	0.46**	0.00	-0.00	0.20	0.41**	-0.09	0.13
5	0.76**	-0.00	0.13	0.01**	0.66**	-0.02	0.13	-0.01
6	-0.14	0.66**	0.04	0.05	-0.05	0.65**	0.17	-0.11
7	0.16	-0.05	0.50**	0.08	-0.01	-0.01	0.34**	0.03
8	0.17	-0.02	0.49**	-0.03	-0.03	-0.05	0.38**	0.02
10	-0.03	0.33*	0.43**	-0.21	0.07	0.18**	0.17*	0.04
11	0.07	0.21*	0.25*	0.05	0.06	0.34**	0.09	0.09
12	0.05	0.77**	-0.13	0.09	0.03	0.83**	-0.05	0.04
13	-0.09	0.39*	0.21	0.16	-0.02	0.44**	0.17	-0.06

14	-0.12	0.22	0.36*	0.08	0.03	0.05	0.18**	0.01
15	0.08	0.74**	-0.02	-0.15	0.01	0.69**	0.04	-0.04
16	-0.01	0.39**	0.23	0.17	0.10	0.30**	0.25**	0.03
17	0.23**	0.43**	-0.01	0.16	0.02	0.64**	-0.03	0.07
18	0.01	0.10	0.62**	0.00	0.00	0.03	0.34**	0.01
19	-0.05	0.01	0.05	0.77	0.00	0.01	-0.01	0.44**
20	-0.01	0.00	0.29**	0.34	-0.04	0.06	0.32**	-0.00
21	0.05	0.08	0.44*	0.09	0.02	-0.03	0.11*	0.08*
22	0.09	0.04	0.16	0.46	0.04	0.05	0.15	0.26**
23	-0.02	0.65**	0.10	-0.04	-0.07	0.56**	0.01	0.05
24	0.04	0.03	-0.02	0.83	-0.04	0.01	0.03	0.47**

* p ≤.05 ** p ≤.01

5.2.3 Discussion

Although the RHS has become an extensively used measure of hallucination proneness in experimental and correlational studies drawing on the general population, it has proved challenging to identify its underlying factor structure. Attempts to validate the original proposed three-factor structure using CFA have yielded varied results and it has not been possible to show a good model fit. The current research highlights that CFA may not be the most appropriate technique for deriving underlying factor structure for a construct such as hallucination proneness – CFA makes unrealistic assumptions that there are no cross-loadings of items onto the factors, when in fact several items have been shown to load significantly onto more than one factor (Morrison et al. 2002). Using a large sample size (n=562) we derived a new four-factor PCA solution that we were able to validate with good model fit using both CFA and ESEM techniques. Importantly, we showed that the ESEM model (where the assumption that items have factorial complexity of one is relaxed) resulted in an improvement in model fit over a CFA model. Furthermore, tests of measurement equivalence showed the ESEM model was able to provide a good fit to the data for both male and female groups. We also showed that the factors retain their a priori interpretations when modelled using ESEM.

The four factor model has some commonality with the original three factor model proposed by Morrison et al. (2002) with the vividness of imagination and daydreaming factor being retained, and the tendency towards visual hallucinations and tendency towards auditory hallucinations factors also being represented, albeit collapsed into one new factor ‘auditory and visual anomalous experiences’. We then propose two new factors: Fantasy and Dissociation. Notably, this has some similarity to a proposed factor structure for the Polish version of the RHS (Gaweda and Kokoszka, 2011) that also identified a new subscale interpreted as representing dissociative experiences.

Within clinical samples, it has been proposed that the relationship between experiencing certain life events (commonly trauma) and the development of psychotic symptoms could be accounted for by dissociative processes (e.g. Moskowitz and Corstens, 2007; Moskowitz et al., 2009;

Varese et al., 2012). Within the general population there is also evidence to suggest that dissociation mediates the relationship between inner speech and auditory hallucination proneness (Alderson-Day et al., 2014), with certain characteristics of inner speech (evaluative and other people) developing into hallucinations via a dissociative stage. Both of these findings strengthen the argument for dissociation being one important underlying factor in vulnerability to hallucinations.

There has been debate as to the nature of the relationship between fantasy proneness and vulnerability to hallucinations, with early research suggesting that fantasy prone individuals have a tendency to make false reports of hallucinatory experiences during experimental paradigms (Merckelbach and van de Ven (2001). However it is now becoming clearer that fantasy proneness is closely associated with hallucination proneness, and fantasy proneness is likely a mediator in the process by which highly prone individuals experience hallucinations (Daniel and Mason, 2015), possibly by driving a specific response bias reflecting impaired reality testing which in turn leads to hallucinations (Bentall, 1990). The identification of fantasy as one underlying factor in the RHS lends further support to the argument that fantasy proneness plays an important role in the genesis of hallucinations in predisposed individuals.

A possible limitation of the study that should be mentioned when interpreting the findings is that participants came from a student sample with a relatively narrow age-range of individuals being represented. Whilst it was possible to report that our four factor model showed good fit for both male and female groups, the fit for a wider age range has yet to be established. For future versions of the RHS, the continuing inclusion of item 9 “I have heard the voice of God speaking to me” should also be re-considered as this item was not found to correlate well with other items. Item 9 also had very low variance, and therefore we argue that the validity of the questionnaire would be improved without the inclusion of this item.

Chapter 6

The Contribution of Individual Differences to Psychosis-Like Experiences

The previous chapters have discussed the sensory deprivation protocol and presented data from an initial pilot study detailing the effectiveness of this method in inducing psychosis-like experiences. Furthermore, the use of the RHS as an effective selection tool for identifying individuals most prone to these experiences has been demonstrated, and potential modifications based on a new alternative factor structure have been discussed. This chapter now turns to the role that individual differences besides hallucination proneness/schizotypy may play in reports of PLE's.

6.1 Introduction

From the context of hallucinations and other psychosis-like experiences being widely viewed as signs of 'illness' and a deviation from 'normal', it is understandable that many find the fact that 28% of the general population may have PLE's during their lifetime (US National Comorbidity Survey 1996) a shocking statistic that is difficult to accept. These experiences may include hallucinations, passivity phenomena, and overvalued or delusional ideas. Other experiences phenomenologically more distal to psychosis, such as belief in having had 'psychic' or paranormal experiences, (eg. telepathy, ESP, telekinesis, 'out-of-body' experiences), synaesthesia, lucid dreaming and hynopompic/hypnagogic states, occur even more widely in the population.

Critics of these figures have argued that some individuals may have a tendency to endorse items on questionnaires enquiring about PLE's, even if they have not actually experienced them. Merckelbach and van de Van (2001) tested this hypothesis by using a white noise paradigm to investigate whether reports of hallucinatory experiences were associated with a heightened sensitivity to demand characteristics, suggestibility, and fantasy proneness. Results showed that reports of hallucinations were actually best predicted by fantasy proneness rather than hallucinatory disposition, calling into question the validity of conclusions drawn from previous research that show a significant proportion of the normal population may have hallucinatory experiences. They suggest that hallucination proneness in the normal population is closely associated with fantasy proneness, and it is fantasy proneness that leads participants to endorse odd experiences (even if they have not actually experienced them).

However, an alternative interpretation of Merckelbach et al's (2001) findings is that fantasy proneness mediates the process by which highly prone individuals experience hallucinations. In this vein, Bentall (1990) has suggested that fantasy proneness drives a specific response bias reflecting impaired reality testing, which in turn leads to reports of hallucinations. Clearly this issue requires further study, as fantasy proneness has not routinely been measured in non-clinical studies of hallucinations.

Evidence in support of the normal population experiencing true hallucinatory experiences during ambiguous auditory paradigms (as opposed to merely endorsing them) comes from experimental studies that have examined similarities between clinical groups with a diagnosis of psychosis and high hallucination prone individuals from within the normal population. In accordance with a continuum model of psychosis (Van Os et al. 2000) the rate that individuals from the normal population report hearing hallucinations in random noise has been shown to be progressively greater across groups with increasing familial risk for psychosis (Galdos et al. 2011). Individuals from the normal population reporting hallucinations during ambiguous auditory tasks have also been shown to mirror clinical populations in terms of psychosis risk factors, including being younger in age, and more likely to be male than female (Barkus et al, 2011).

Whilst there is mounting evidence to suggest that experimentally induced hallucinations are not purely the product of demand characteristics and fantasy proneness, a number of studies that have measured these variables report they are associated with increased likelihood of anomalous experiences. As these studies are correlational in design, it is not possible to implicate these factors in the causality of hallucinations. In particular, it remains unclear whether fantasy-proneness is associated with increased reports of hallucinations through direct causality, or whether this trait is associated with high schizotypy, and it is schizotypal tendencies that drive the experience of hallucinations. Studies that have directly compared high and low schizotypal groups have not generally incorporated measures of fantasy proneness, and there is a need for a study to do so.

6.2 Empirical Study: The Contribution of anxiety, suggestibility, and fantasy proneness to reports of PLE's

The following study aimed to establish, with greater clarity, the effects of brief sensory deprivation (using the anechoic chamber protocol) on individuals who vary in their degree of hallucination proneness (schizotypy). The initial design of Mason and Brady's (2009) study was modified in order to address some of the methodological limitations discussed above, and also to answer some additional research questions. Key modifications included measuring state and trait anxiety before and during the experiment, and incorporating additional measures into the design, including suggestibility, and fantasy proneness. A one-way microphone was also used to monitor participants rather than using a panic-button in an attempt to reduce potential demand characteristics.

6.2.1 Aims and Hypotheses

The presence of PLEs was evaluated under normal baseline conditions, and in sensory deprivation conditions produced by using an anechoic chamber. A group of participants who rated highly for hallucination proneness was compared against a group who rated low for such traits. It was hypothesised that:

1. Sensory deprivation would be associated with greater PLEs when compared to baseline after controlling for anxiety, suggestibility, and fantasy proneness.
2. The high hallucination prone group would report greater PLEs than the low prone group when under sensory deprivation, after controlling for anxiety, suggestibility, and fantasy proneness.
3. Both Hallucination proneness (High/Low group membership) and fantasy proneness will predict the increase in PLEs reported in sensory deprivation.

6.2.2 Method

6.2.2.1 Participants

Participants between the ages of 18 and 65 years were recruited via a university-wide email sent out to all students and staff. Exclusion criteria included a history of a major psychiatric or neurological disorder, or current recreational drug use (defined as during the last three months). The email invited participants to complete a 126 item online questionnaire, comprising a brief fantasy proneness measure (The Creative Experiences Questionnaire, (Merckelbach et al. 2001); The Marlow-Crowne Social Desirability Scale (MC-13) Short-form, (Strahan and Gerbasi, 1972); A brief measure of hallucination proneness (The Revised Hallucinations Scale (RHS), Morrison et al. 2002).

562 participants from a wide range of ethnic backgrounds returned completed questionnaires. Initially, only the RHS scores were examined, and the highest 10% of scorers and lowest 20% of scorers were identified from the sample. The top decile is frequently chosen as it may represent a ‘taxon’ group that possesses a true risk of developing future psychosis (Korfine and Lenzenweger, 1995). A rather wider low hallucination prone group was chosen so as not to contain only individuals with extreme scores of this kind who may perhaps represent an unsuitable reference group. This resulted in the high RHS group containing individuals with scores ≥ 52 ($n = 60$)

and the low group containing individuals with scores ≤ 31 (n = 131). Both groups were then formed into randomised lists using an online randomisation tool (www.random.org), and participants were invited to take-part in list-wise order. 35 participants in the high scoring group and 29 in the low scoring group were invited to participate in the experiment. Of these, 24 high scorers (13 males, 11 females, mean age = 21.25 years, SD = 3.38, mean score = 58.17, SD = 6.51) and 22 low scorers (7 males, 15 females, mean age = 28.23 years, SD = 9.10 , mean score = 27.77, SD = 1.82) attended and took part. Informed consent was obtained, and the study was ethically approved according to university regulations.

6.2.2.2 Power Analysis

Very little is known about the effects of sensory deprivation on people who rate highly for hallucination proneness, and so it was challenging to accurately estimate effect sizes from existing literature. The most similar study to date (Mason and Brady, 2009) reported large effect sizes for increases in perceptual distortions (partial eta squared = 0.56) and anhedonia (partial eta squared = 0.58) measured using the Psychotomimetic States Inventory (Mason et al. 2008) immediately after 15 minutes of sensory deprivation. The power calculation for the current study was based on the smallest of these effect sizes reported by Mason and Brady: partial eta squared = 0.56. This is a conservative estimate for current purposes since participants in the current study spent a longer length of time in sensory deprivation (25 minutes) presumably providing greater opportunity for perceptual distortions to arise. Power calculations suggested that a minimum total sample of N= 36 (i.e. 18 per group) would provide statistical power for a between-within participants repeated measures ANOVA design that exceeded 80% (β= .80), with α= .05.

6.2.2.3 Measures

Gudjonsson Suggestibility Scale (Short version) (GSS, Gudjonsson, 1984): The test consists of a short narrative read to the person, immediately followed by twenty questions about what they have heard. Fifteen questions are loaded with suggestion, whereas five are not. The person is requested to answer the questions as accurately as they can. 'Yield' suggestibility is a measure of how much participants give in or yield to the 15 suggestive questions. After giving their answers they are then told that there are errors in their answers and must answer the questions a second time. 'Shift' suggestibility is a measure of how much participants' responses can be shifted by pressured instructions. Several studies have supported the scales' criterion-related validity [46-48]. As the current study was concerned with the impact of potentially suggestive questions contained in questionnaires surveying perceptual distortions, 'Yield' suggestibility was used as the measure best reflecting this tendency.

The Creative Experiences Questionnaire (Merckelbach 2001): A self-report measure of fantasy proneness consisting of 25 yes/no items. The scale has been shown to have good test-retest stability (r = 0.95) and adequate internal consistency over a six week period (Chronbach's alpha = 0.72). The scale has also been shown to have good construct validity against an earlier measure of fantasy proneness (the Inventory of Childhood Memories and Imaginings, Wilson and Barber 1981; Spielberger et al 1983).

The Revised Hallucinations Scale (RHS), [43]: This is a 24-item questionnaire based on the Launay-Slade Hallucination Scale (Launay and Slade, 1981) measuring a predisposition to experience hallucinations. It uses a revised scoring method which allows participants to respond on a 4-point scale (1 = never to 4 = almost always). The scale has been shown to have good reliability and predictive validity, and moderately stable internal consistency over a period of 4-6 weeks (Brewin et al. 2013). Given the new alternative 4 factor structure proposed in Chapter 5, analysis of RHS data included overall scores, and also individual factor scores.

The Psychotomimetic States Inventory (PSI, Morrison et al. 2002): This is a 48 item questionnaire measuring psychosis-like experiences. Items are rated on a 4-point scale (from 0 = never to 3 = strongly), with some items being reverse scored. The Psychotomimetic States Inventory has sub-scales of Delusory Thinking, Perceptual Distortions, Cognitive Disorganization, Anhedonia, Mania and Paranoia. It was originally developed for use in drug studies, and it was used here because there are currently no validated measures available specifically for studying the effects of sensory deprivation. Despite the limitations of using a non-validated measure, the PSI has produced meaningful results in the previous pilot study of sensory deprivation, and therefore it was included in the current study to further validate the measure in this context.

The State-Trait Anxiety Inventory (STAI, Spielberger et al. 1983): A pair of two 20-item questionnaires that measure the temporary condition of state anxiety, and the more longstanding quality of trait anxiety. Items are rated of a 4-point scale. The STAI has been shown to have good construct validity with multiple other assessment tools (Smeets et al. 1996). It has also been shown to have good test-retest reliability (.54 correlation for state, and .86 correlation for trait anxiety (Spielberger et al. 1970).

6.2.2.4 Equipment

An anechoic chamber was used to produce the deprivation condition. The anechoic chamber is constructed as a room within a room (for further details of the construction see http://www.langsci.ucl.ac.uk/resource/anechoicroom.html). The outer walls are 330mm thick and the inner room is formed of metallic acoustic panels mounted on a floating floor which is then lined with large glass fibre wedges. This results in a very low noise environment in which the sound pressure due to outside levels is below the threshold of human hearing. It is also possible to remove all sources of light from the room, and thus create an environment with near complete deprivation of sight and sound.

6.2.2.5 Procedure

On arrival at the testing facility, participants were given a short briefing by the experimenter, in a calm and reassuring tone. Participants were informed that they would “experience what it is like to spend a short period of time (less than half an hour) in sensory deprivation” and that this would “involve being alone in a room with zero light and sound”. Due to the ethical need to inform participants about any potential negative aspects of taking part, they were also briefed that “since people do not normally experience sensory deprivation in their day-to-day lives, there was a small risk they would find the experience stressful or that they may have some unusual sensory experiences.” No other information was given about the research hypotheses in order to avoid influencing participants’ responses.

Participants initially completed the trait anxiety measure of the STAI. Participants were then given a demonstration of the anechoic chamber so that they could familiarise themselves with the environment. They were then asked to sit in silence in the anechoic chamber in a padded armchair in the middle of the room. Participants were informed that they would be spending approximately 25 minutes in the chamber in complete silence and darkness. It was explained that a microphone was present in the chamber so that participants could be heard by the experimenter outside should they become distressed. This was a one-way set-up, and they could not converse with the experimenter. Participants were informed that if they wished to terminate the experiment at any point they should remain seated and tell the experimenter, who would immediately restore light and communication.

No participants chose to terminate the experiment early. After completion of 25 minutes within the chamber, participants were moved to an ante-room where they were immediately asked to complete questionnaires referring to the time that they had spent in the anechoic chamber: The State-Trait Anxiety Inventory (state items only); The Psychotomimetic States Inventory. Participants then listened to the narrative and associated questions comprising the Gudjonsson Suggestibility Scale. This took approximately 20 minutes, and also acted as a distraction task to allow any effects of the sensory deprivation to dissipate. Participants finally completed a second version of the Psychotomimetic States Inventory, referring to their current baseline state, and the State-Trait Anxiety Inventory (state items only) referring to how they were feeling at that moment in time.

Following completion of the experiment, participants were de-briefed, and received a nominal fee for their time in taking part .

6.2.3 Results

6.2.3.1 Overview of statistical treatment

All statistical analyses were conducted using SPSS 22.0. Data were checked for normality before analysis using descriptive statistics and histograms with normal distribution curves. All self-report scores were normally distributed, meeting parametric assumptions. A marked difference in gender distribution between the two groups was noted (with the high scoring group (n= 24) consisting of 13 males, 11 females, and the low scoring group (n= 22) consisting of 7 males, 15 females). Following baseline comparisons of the groups using MANOVA, a repeated measures ANCOVA was conducted to test hypotheses relating to changes in psychotic-like experiences across conditions taking covariates into account. Gender was included as a covariate in order to control for the effect an uneven gender distribution may otherwise have had on between-group results. Unfortunately, trait anxiety had to be excluded as a covariate in this analysis due to a significant interaction effect, violating the assumption of homogeneity of regression slopes. Subsequently, in order to test the hypothesis that both hallucination proneness and fantasy proneness predict the increase in PLEs reported in sensory deprivation, a stepwise regression was run to determine the impact of Group and the additional covariates on PSI scores in sensory deprivation. Finally, state anxiety was investigated using a repeated measures ANOVA.

6.2.3.2 Baseline Group Comparisons

It was hypothesised that the high hallucination prone group would score significantly more highly on the PSI under normal baseline conditions. MANOVA showed the high and low hallucination prone groups differed on all baseline measures, with the high scoring group reporting a greater number of psychotic-like experiences consistent with the first hypothesis (see Table 1 for descriptives). Although relationships with anxiety, suggestibility and fantasy proneness were not hypothesised, all the above findings are in the expected direction.

Table 1. Mean Questionnaire Scores for High and Low Hallucination Prone Groups at Baseline

Mean Scores (Standard Deviations)	**High Scorers (n = 24)**	**Low Scorers (n = 22)**	**F**	**Sig.**
Revised Hallucinations Scale	58.17 (1.33)	27.77 (1.82)	446.38	<.001
RHS Factor 1 (Vividness of Imagination/Daydreaming	28.96 (4.24)	12.18 (1.22)	319.98	<.001
RHS Factor 2 (Auditory and Visual Anomalous Experiences)	13.63 (3.17)	7.82 (1.00)	67.34	<.001
RHS Factor 3 (Fantasy)	5.50 (1.84)	2.55 (0.74)	49.28	<.001

RHS Factor 4 (Dissociation)	6.50	3.14	52.62	<.001
	(2.15)	(0.35)		
Psychotomimetic State Inventory	43.04	17.55	34.80	<.001
	(17.20)	(11.20)		
Trait Anxiety (STAI)	45.92	36.36	9.22	<.01
	(12.13)	(8.78)		
Baseline State Anxiety (STAI)	40.21	31.14	9.12	<.01
	(11.42)	(8.62)		
Suggestibility (MISS)	58.46	40.55	17.17	<.001
	(18.99)	(7.39)		
Suggestibility (GSS Yield)	4.46	2.18	9.18	<.01
	(2.83)	(2.20)		

Schizotypy (OLIFE)	19.17	6.91	56.92	<.001
	(6.46)	(4.22)		
Fantasy Proneness	14.08	4.95	84.72	<.001
	(3.89)	(2.66)		

Baseline suggestibility was measured using the yield sub-score of the Gudjonsson Suggestibility Scale as this specifically focuses on the impact of suggestive questions, the type of suggestibility likely to have had most potential impact on participant responses to questionnaires during this study. A significant difference in suggestibility was found between the high and low hallucination prone groups ($F(1,45) = 9.18$, $p < .01$), with the high hallucination prone group being more suggestible (mean = 4.46, SD = 2.83) than the low hallucination prone group (mean = 2.18, SD = 2.20). Further analysis revealed that the differences in suggestibility between groups could not be attributed to differences in the memory recall component of the suggestibility task ($F(1,45) = 0.42$, $p > .05$), indicative of a true difference in suggestibility between the groups as opposed to reflecting differing recall ability.

Due to the large number of baseline variables that differed significantly between the two groups, correlations were calculated between all baseline variables measured and the dependent variable of interest (PSI) to assess for their relevance as covariates in ANCOVA, using Bonferroni adjusted alpha levels of .003 per test (.05/15). Trait anxiety, baseline state anxiety, deprivation state anxiety, and fantasy proneness were all found to be significantly positively correlated with baseline psychosis-like experience scores. Baseline state anxiety, deprivation state anxiety and fantasy proneness were also found to be significantly positively correlated to sensory deprivation psychosis-like experience scores. Suggestibility was not found to be significantly correlated with psychosis-like experience scores in either condition. Consequently, baseline state anxiety, deprivation state anxiety, and fantasy proneness were considered as covariates for analysis of variance for PSI scores (plus gender as discussed above). As mentioned previously, trait anxiety could not be included in the ANCOVA due to a violation of statistical assumptions.

Table 2. Correlations between Baseline Measures, Anxiety Measures, and PSI scores

	Trait Anxiety	Baseline State Anxiety	Deprivation State Anxiety	Suggestibility	Fantasy Proneness
Baseline PSI	.74 *	.67 *	.51 *	.30	.67 *
Sensory Deprivation PSI	.42	.52 *	.55 *	.30	.51 *

* Correlation is significant at the Bonferroni adjusted alpha level of .003 (2-tailed)

6.2.3.3 ANCOVA: PLEs across Groups and Conditions

It was hypothesised that there would be a significant increase in psychotic-like experiences from baseline in sensory deprivation across both groups. A mixed between-within subjects repeated measures analysis of variance was run, with baseline state anxiety, deprivation state anxiety, fantasy proneness and gender controlled for as covariates. Results demonstrated a significant main effect of condition for PSI scores, $F(1,40) = 7.09$ ($p=.01$) (see Table 3 for descriptives). This indicates that, overall, participants experienced a significantly greater number of psychosis-like symptoms during sensory deprivation than at baseline.

The mixed ANCOVA analysis did not show a significant main effect of group for PSI scores, F (1,40)) = 3.73 ($p=.06$) (see Table 3 for descriptives). This indicates that the high and low hallucination prone groups reported similar levels of psychosis-like symptoms overall throughout the experiment. However, Figure 1, showing mean PSI scores in the high and low hallucination prone groups by condition (unadjusted for covariates), together with the PSI scores in Table 3, depicts the high scoring group having markedly higher PSI scores throughout the experiment. It is therefore likely that adjustment for the relatively large difference in gender distribution between the two groups is responsible for the lack of a significant main effect of group in the analysis.

Table 3. Mean Anxiety and PSI Scores for High and Low Hallucination Prone Groups by Condition

	High Scorers (n = 24)		Low Scorers (n = 22)	
Revised Hallucinations Scale	58.17		27.77	
	(1.33)		(1.82)	
	Baseline	**Deprivation**	**Baseline**	**Deprivation**
State Anxiety				
	40.21	40.08	31.14	33.36
	(11.42)	(12.06)	(8.62)	(10.08)
PSI	43.04	53.92	17.55	29.59
	(17.20)	(17.88)	(11.20)	(12.71)

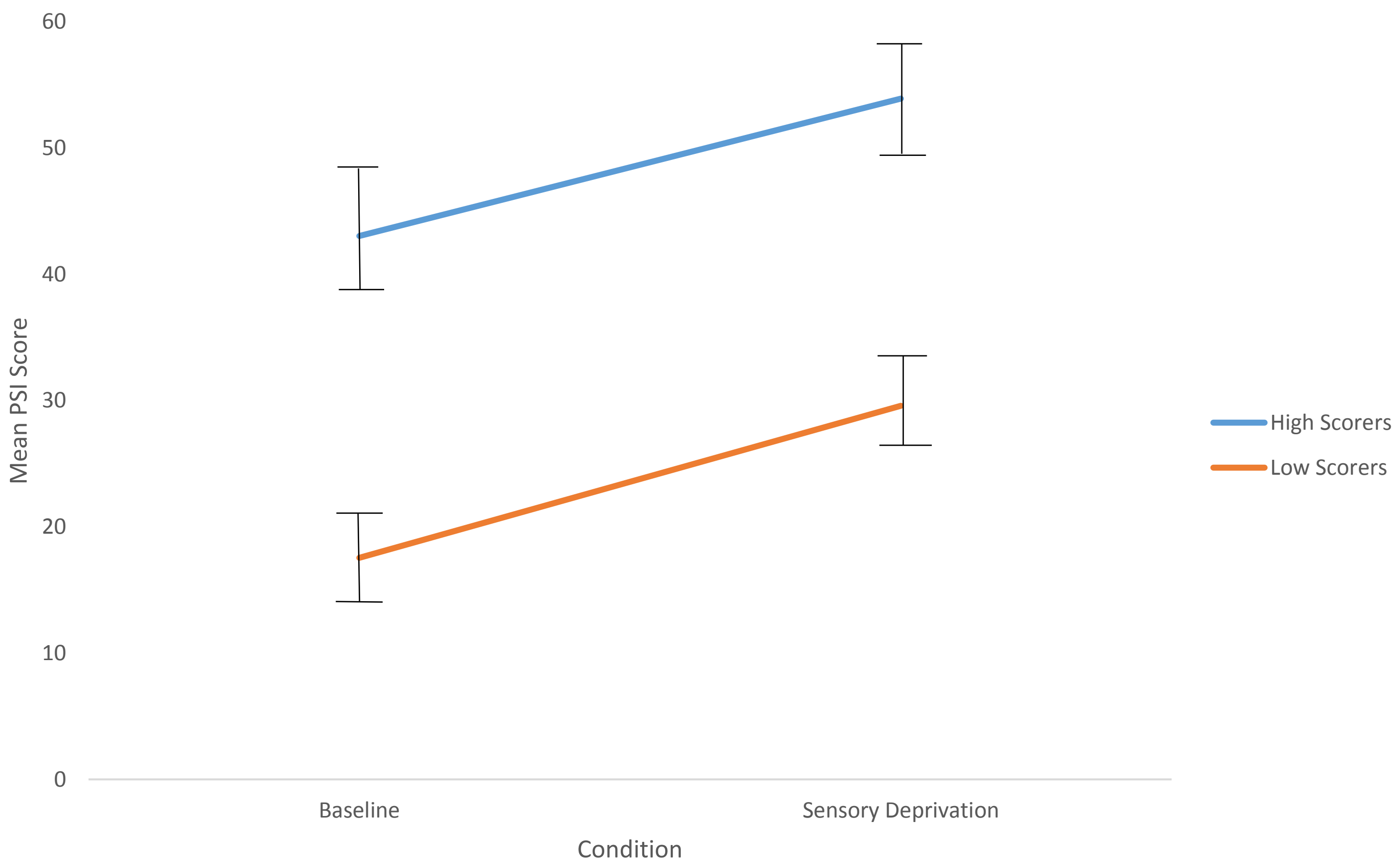

Figure 1. Mean PSI scores in high and low hallucination prone groups by condition.

Further mixed between-within subjects repeated measures ANCOVAs examining the PSI subscales of Delusional Thinking, Perceptual Distortion, Cognitive Disorganisation, Anhedonia, Mania, and Paranoia were conducted, once again controlling for baseline state anxiety, deprivation state anxiety, fantasy proneness, and gender as covariates, to investigate any difference in particular types of PLEs reported. Analysis revealed a significant main effect of condition for Perceptual Distortions, F (1,40) = 9.19, p=.00. Perceptual distortions were significantly higher in sensory deprivation than at baseline. A significant main effect of group was found for the Anhedonia subscale (F(1,40) = 5.46, p=.03, with high scorers showing greater levels of anhedonia throughout the experiment overall. No significant main effects were found for the subscales of Delusional Thinking, Cognitive Disorganisation, or Paranoia (see table 4).

6.2.3.4 Regression: Impact of Group and Covariates on Sensory Deprivation PSI Scores

A post-hoc stepwise regression analysis was run to determine the impact of Group and the individual covariates on PSI scores in sensory deprivation. The 4 individual RHS factors identified in Chapter 5 were also entered into this regression in order to identify if any of these subscales alone were better predictors of sensory deprivation PSI Scores than total RHS scores. This yielded a final two factor model (containing the factors Group and Deprivation State Anxiety) that was able to account for 54% of the variance in deprivation PSI scores (F (2,43) =24.75, p <.001, R^2 = .54), significantly more than that utilising group alone (See Table 5 for full details of both models). The final regression model showed state anxiety levels were a significant predictor of psychosis-like experiences in sensory deprivation. However, group proved to be a more powerful predictor of psychosis-like experiences in sensory deprivation (accounting for 39% of the variance, compared to 15% for the unique contribution of state anxiety alone)

Table 4. Mean PSI Subscale Scores for High and Low Hallucination-Prone Groups by Condition

	High Scorers (n = 18)		Low Scorers (n = 18)	
PSI Subscale	**Mean (SD)**		**Mean (SD)**	
	Baseline	**Deprivation**	**Baseline**	**Deprivation**
Delusory Thinking	4.58 (2.59)	6.00 (3.24)	2.50 (2.39)	1.95 (2.56)
Perceptual Distortions	3.75 (3.37)	12.29 (6.00)	1.14 (1.73)	7.00 (4.47)
Anhedonia	8.25 (4.63)	9.88 (4.24)	3.14 (3.11)	8.18 (4.23)
Mania	7.21 (2.27)	7.83 (3.07)	4.18 (2.24)	4.32 (2.26)
Paranoia	5.42 (4.10)	4.21 (3.36)	1.27 (1.61)	1.41 (2.02)

Table 5: Stepwise Regression Predicting Deprivation PSI Scores from Group, State Anxiety, Fantasy Proneness, and Suggestibility.

Deprivation PSI scores				
	Model 1		**Model 2**	
Variable	**B**	**β**	**B**	**β**
Constant	5.27		-13.06**	
Group	24.32**	.62	19.70**	.50
Deprivation State Anxiety	Excluded		.69**	.40
Fantasy proneness	Excluded		Excluded	
Gender	Excluded		Excluded	
RHS Factor 1 (Vividness of Imagination/Daydreaming)	Excluded		Excluded	
RHS Factor 2 (Auditory and Visual Anomalous Experiences)	Excluded		Excluded	
RHS Factor 3 (Fantasy)	Excluded		Excluded	
RHS Factor 4 (Dissociation)	Excluded		Excluded	
R^2	.39		.54	
F	27.82**		24.75**	
ΔR^2	.39		.15	

ΔF	27.82**	13.67**

Note. N = 46. * p <.05, ** p < .001.

6.2.3.5 ANOVA: State Anxiety across groups and conditions

To test the potential role that changes in anxiety might play in sensory deprivation, a mixed between-within subjects repeated measures ANOVA was conducted for state anxiety. This demonstrated a significant main effect of group for state anxiety scores, $F(1,44) = 7.98$ ($p<.01$) (see Table 3 for descriptives): the high hallucination prone group experienced greater state anxiety than the low hallucination prone group. There was no effect of condition, suggesting that state anxiety did not differ between baseline and sensory deprivation conditions (see Figure 2). Therefore the increased psychosis-like symptoms experienced by both groups in sensory deprivation cannot readily be attributed to increased state anxiety levels.

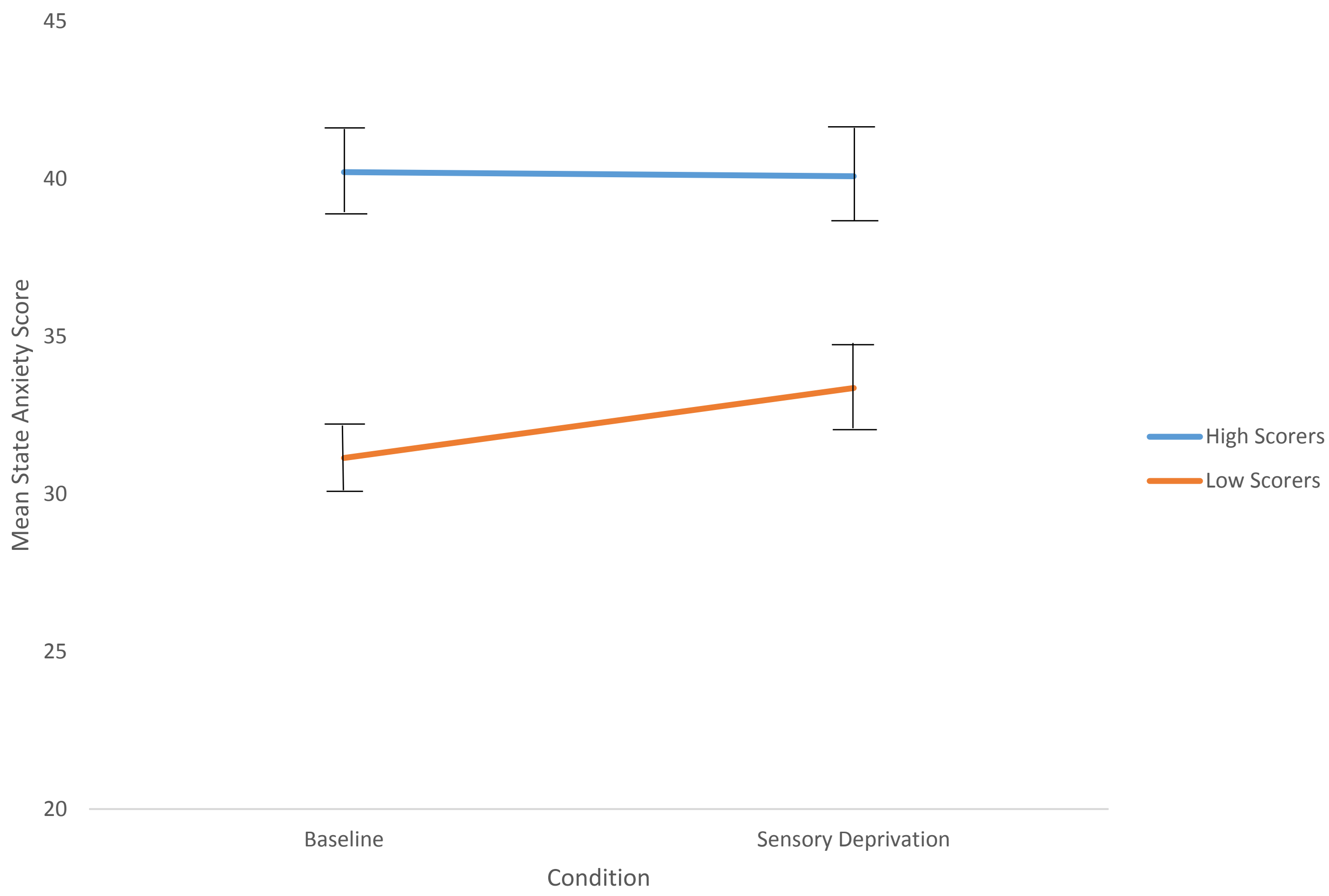

Figure 2. State anxiety scores in high and low hallucination prone groups by condition

6.2.4 Discussion

Consistent with hypotheses, both high and low hallucination prone groups experienced a significant increase in psychosis-like symptoms from baseline in the sensory deprivation environment, and these remained after controlling for state anxiety, suggestibility, and fantasy proneness. As predicted there were marked group differences: the high hallucination prone group reported more psychosis-like experiences at both baseline and in sensory deprivation. These findings are consistent with previous research (Mason and Brady 2009) that, until now, has not taken these potential confounds into account. This provides more substantive evidence that the increase in psychosis-like experiences found in sensory deprivation reflects a genuine aberration in perceptual experience, as opposed to an increased tendency to make reports of psychosis-like experiences driven by individual differences in certain personality traits.

The two groups did, however, exhibit differences on a number of measures at baseline, with the high scoring group reporting greater state/trait anxiety, greater suggestibility and greater fantasy proneness. All of these findings are broadly consistent with existing literature showing anxiety to be linked to hallucination proneness (Allen et al. 2005), and acute anxiety in individuals with clinical psychosis linked to an increase in hallucinatory experiences (Delespaul et al. 2003). Fantasy proneness has also previously been shown to be high in individuals who make hallucinatory reports during auditory experimental paradigms (Merckelbach and van de Ven (2001). However, results of the stepwise regression showed that of the between-group differences found in this study, only state anxiety made a significant contribution to change in PSI scores in sensory deprivation. Fantasy proneness and suggestibility were not found to play a significant role. Taken together, these findings may provide an answer to a question posed in the literature that has previously gone unanswered: Is fantasy proneness responsible for a wide variety of atypical reports (including hallucinatory reports) that are unrelated to genuine experiences, or does this trait reflect impaired reality testing that gives rise to odd and schizophrenia-like experiences (Merckelbach and van de Ven (2001)? The findings of this study support the argument that fantasy proneness (and suggestibility for that matter) are not responsible for hallucinatory reports, and the increased fantasy proneness and suggestibility seen in the high scoring group are likely to reflect other aspects of underlying differences in schizotypal traits (potentially such as impaired reality testing, although this hypothesis remains un-tested in the current study).

The regression model showed state anxiety levels were a significant predictor of psychosis-like experiences in sensory deprivation. However, Group membership proved to be a more powerful predictor of psychosis-like experiences in sensory deprivation (accounting for 39% of the variance, compared to 15% for the unique contribution of state anxiety alone). This finding was corroborated by ANCOVA showing that the main effect of condition remained once state anxiety had been controlled for as a covariate. Although the high hallucination prone group had higher state anxiety scores, state anxiety remained stable across conditions for both groups. Therefore, although state anxiety was shown to be a predictor of psychosis-like experiences in sensory deprivation, it seems unlikely that anxiety is solely responsible for PLE's, indeed it may be a consequence of PLEs as this study was not designed to test the direction of this relationship.

Sensory deprivation was found to produce a significantly greater increase in the hallucination-prone group on the Perceptual Distortions subscale of the Psychotomimetic States Inventory after controlling for anxiety, suggestibility, and fantasy proneness. This finding was highly marked, and consistent with previous studies (Mason and Brady, 2009). However, unlike previous studies, no significant state/trait interactions were found on other PSI scales. These differing findings may be due to methodological differences between the studies, such as length of time in deprivation and statistical control for suggestibility and fantasy proneness.

6.2.4.1 Strengths and Limitations

Despite attempting to address several potential confounds of previous research, there is some way to go before concluding the phenomena seen in sensory deprivation are equivalent to clinical and non-clinical psychotic experiences. The current study is limited by reliance on self-report measures. Biometric approaches such as psychophysiological or neurocognitive indices would clearly strengthen the argument. However, the inclusion of additional measures of state anxiety, suggestibility, and fantasy proneness is a strength of the study, enabling us to conclude that whilst state anxiety does appear to play a role in the genesis of PLE's, fantasy proneness and suggestibility are not implicated. The group design (replicating previous studies) meant that hallucination proneness was not used as a continuous variable and it is possible that the study is better powered to detect a difference in this as opposed to the continuously measured variables. However, without a much larger sample it is not possible to correct for this. In addition, trait anxiety could not be included in the analysis, and therefore it is not currently possible to draw further conclusions regarding the potential role trait anxiety may have in the genesis of PLE's (though we would note that trait and state anxiety correlated very highly indeed).

Whilst attempts were made to control for the differences in gender distribution between the two groups, this made the results more complex to interpret. The greater proportion of males present in the high scoring group (13 males, 11 females), versus the low scoring group (7 males, 15 females) is perhaps not unexpected given that participants were selected for hallucination proneness, a trait synonymous with schizotypy and psychosis-proneness: It has been widely documented that psychosis is more common in males, and with a younger age of onset (for a review see Ochoa et al. 2012).

Recruitment took place on a university campus, and whilst every effort was made to include staff as well as students to sample a broad age range, the majority of participants were students. This limits the ecological validity of the study, although the impact it is likely to have had on the data is uncertain. Schizotypy scores (and hence hallucination proneness) show a tendency to reduce with increasing age (Bora and Arabaci, 2009), and hence an uneven age distribution between groups (as well as gender) could become problematic in a future study sampling the general population. However, other factors such as education level and IQ would be more representative in a general population as opposed to student sample.

6.2.5 Conclusion

Overall the study provides further support for use of sensory deprivation as a non-pharmacological tool for temporarily inducing psychosis-like experiences. Both high and low hallucination prone groups responded to sensory deprivation in a qualitatively similar manner, but with quantitative differences in the frequency of psychosis-like experiences reported, corroborating previous findings. Furthermore, this study provides initial evidence in support of increase in psychosis-like experiences reflecting a genuine aberration in perceptual experience, as opposed to an increased tendency to make reports driven by individual differences in certain personality traits. Increased anxiety, fantasy proneness and suggestibility were characteristics of the high scoring group, but only anxiety was found to be a predictor of psychosis-like experiences in sensory deprivation. However, group differences in hallucination proneness proved to be the most powerful predictor of psychosis-like experiences.

Chapter 7

EEG as a neurophysiological correlate for psychosis like experiences: A pilot study.

7.1 Introduction

This chapter explores the use of electroencephalography (EEG) as a neurophysiological correlate for PLE's during sensory deprivation. It opens with a review of the literature, discussing various approaches that have attempted to collect EEG data during hallucinatory experiences, the findings from these studies, and also discussing potential EEG endophenotypes associated with psychosis. A pilot study is then presented, which attempted a novel protocol for collecting EEG data during sensory deprivation in the anechoic chamber. Results from the pilot study are presented, and the chapter concludes with a critical discussion of the role of EEG correlates for PLE's during sensory deprivation, and the future directions of this research.

7.1.1 EEG Correlates of Hallucinatory Experiences

Although the existing literature reporting on EEG measures during sensory deprivation is sparse, a number of directly relevant (Hayashi et al., 1992; McCreery and Claridge, 1996) and related studies (Putz, 2006) exist.

EEG alpha rhythm is most often discussed within the context of REM sleep research (Johnson et al., 1969). When participants are awakened during high amplitude alpha activity they often report vivid and bizarre dreams (Ogilvie et al. 1982; Tyson et al. 1984). However the finding that visual imagery occurs during abundant alpha activity is reported not only during sleep, but also in daydreams (Kripke and Sonnenschein, 1978). Taken together, these findings suggest high amplitude alpha activity is associated with the occurrence of vivid visual imagery across states of sleep and wakefulness.

Once considered to represent a state of cortical idleness, more modern inhibition hypotheses posit that periods of alpha synchronisation represent active inhibition of either cortical areas related to sensory information processing when attention is internally directed (e.g mental imagery), or to inhibition of non-task relevant cortical areas (Klimesch et al. 1999, Ray and Cole, 1985). An alternative illustration of this concept is to consider alpha synchronisation representative of 'top-down' processing, whereas alpha desynchronization would represent 'bottom-up' processing (Benedek 2011). Therefore in sensory deprivation settings where 'bottom-up' processing is severely disrupted, it follows that increased alpha synchronisation has been observed (Hyashi et el. 1992).

Hayashi, Morikata and Hori (1992) focused on alpha band activity during hallucinations reported during a period of 72 hours in sensory deprivation. Participants were required to press a button with the palm of the hand when they noted hallucinatory experiences occurring. The power spectra were then computed by Fast Fourier Transformation (FFT). The power spectra were then integrated for the alpha band (7.6 – 13.4 Hz) and transformed into amplitude values in microvolts. The amplitude of alpha band activity increased during the 2 minute period before a button press. In addition, peak frequencies of the alpha band EEG were relatively high (10Hz) during the first half of the experiment, but dropped during the second half in which the peak frequency became low (between 8-9Hz). These changes in peak alpha frequency were significantly and inversely correlated with time spent in sensory deprivation. However, participants continued to report hallucinations throughout the duration of the experiment.

McCreery and Claridge (1996) adopted a different approach to utilising EEG in sensory deprivation, borne out of a desire to test Claridge's (1967) dissociation model of psychosis, which posits that the essential feature underlying individual differences in psychoticism/schizotypy is a weakening of homeostatic controls in the nervous system, due to a relative weakness of normal inhibitory mechanisms. One group with a history of out of body experiences (OBE's) and a control group were placed in sensory deprivation conditions created using Ganzfeld field goggles and pink noise. Participants followed a tape of a 20 minute relaxation exercise where they were instructed to imagine themselves floating up to the ceiling and looking down on their physical body. The two EEG variables collected were median frequency of the EEG power spectrum, and coherence function between the two hemispheres. The median frequency of the power spectrum (M50) was used as an index of arousal by comparing its values in the two cerebral hemispheres for each participant. The authors interpreted asymmetries in this measure as evidence of the proposed functional dissociation of arousal systems in individuals high in schizotypy as compared to controls. The coherence function between the two hemispheres was calculated as a measure of the degree of similarity over time between the signals originating from two separate EEG channels (derived from left and right frontal lobes). McCreery and Claridge's (1996) EEG analysis did not break down the EEG data into the different frequency bands, demonstrating the use of EEG as a more global measure of hemispheric arousal. However, they did find strong evidence for dissociation of arousal between the two hemispheres, in particular right hemisphere activation in the OBE group.

More recently Putz et al. (2006) collected data on EEG correlates of multimodal Ganzfeld (MMGF) induced imagery. In MMGF stimulation with homogeneous light and sound induces a state of perceptual deprivation. Although MMGF cannot be considered true sensory deprivation, it is a closely related concept. In this study, seven 'high responders' to Ganzfeld stimulation participated in three 45 minute MMGF sessions with simultaneous EEG recordings, and indicated occurrences of imagery by pressing a button. Relative spectral power changes during the 30 seconds preceding a button press were compared to individual baseline EEG data that was derived from sections of the recording where no imagery was being experienced. Putz et al. (2006) also integrated the normalised FFT-spectra over frequency bands representing alpha through to gamma. Alpha 2 activity (higher frequency alpha in the range 10-12 Hz) was found to be related to the emergence of hallucinatory imagery in the MMGF. Alpha 1 (lower frequency alpha in the range 8-9 Hz) activity was found to decline, however this was attributed to desynchronization related to a shift of attention. Interestingly, beta 2 and beta 3 activity (highest frequency beta above 18 Hz) during the segments directly preceding a button press showed marked oscillations of power, possibly reflecting a shift of cognitive processes from the state of passive observer to judgement of perceived imagery and initialisation and preparation of motor response.

7.1.2 Endophenotypes of Brain Function Associated With Psychosis

Aside from the literature discussed above that focuses on inducing various types of anomalous experiences in healthy individuals, it is also important to consider what EEG data from participants in sensory deprivation might contribute to the debate about how closely highly schizotypal participants experiencing experimentally induced hallucinations relate to individuals with clinical psychosis experiencing naturally occurring hallucinations. Endophenotypes of brain function characterising psychosis (that is, traits that have a genetic influence and that reflect genetic predisposition to developing the disease) have been identified (Bramon et al., 2005; Schulze et al., 2008; Turetsky et al., 2008; Decoster et al. 2012; Shaikh et al., 2013). Because EEG is able to measure ongoing electrical brain activity in vivo non-invasively, it provides a possible basis for detecting the presence of identified endophenotypes associated with psychosis in highly schizotypal individuals who experience hallucinations during sensory deprivation. The majority of these endophenotypes are event-related potentials (brain responses that are the direct result of a specific sensory, cognitive, or motor event), making their study in sensory deprivation setting extremely challenging (for example due to the need to administer computer based tasks to participants). However within the field of quantitative EEG (QEEG) researchers have identified increased slow wave activity in the delta (1-4 Hz) and theta (4-8 Hz) bands (Sponheim et al., 1994; Sponheim et al., 2000; Winterer et al., 2001; Kirino, 2004; Harris et al., 2006; Begic et al., 2011; Hong et al., 2012) and decreased alpha (8-13 Hz) activity (Sponheim et al., 2003; Harris et a;., 2006; Begic et al., 2011) as putative psychosis endophenotypes.

It is important to note that this evidence has largely been gathered from chronic patients. More recent research (Ranlund et al. 2014) that has considered other groups including first episode patients, individuals with at-risk mental state (ARMS), and relatives of chronic patients has been unable to replicate these QEEG findings outside of a chronic patient group. It is therefore possible that the identified QEEG changes seen in the chronic patients are a reflection of the impact of multiple episodes of psychosis on brain functioning or resulting from the effect of long term medication, as opposed to a true endophenotype of genetic vulnerability. However, there is a lack of additional research to support or refute Ranlund et al.'s QEEG findings in non-chronic groups, and our knowledge of possible QEEG endophenotypes of psychosis remains an incomplete area for further study.

7.1.3 Summary and conclusions

The above discussion of the literature in the fields of EEG during sensory deprivation, and EEG endophenotypes of psychosis yields several important points. A small body of evidence suggests that increased alpha band activity may represent a QEEG correlate of hallucinations experienced during sensory deprivation. However the literature from chronic psychosis patients suggests that over time, alpha activity becomes reduced. This reduction in alpha activity could be explained by other factors, such as disease progression or medication effects. Indeed, antipsychotic drugs have important effects on the EEG and constitute a major potential confounder.

The alterations in beta 2 activity during the segments directly preceding a button press identified by Putz et al. (2006) as reflecting a shift of cognitive processes from the state of passive observer to the initialisation and preparation of a motor response suggests that asking participants to respond with a button press when they notice hallucinatory experiences in sensory deprivation may create confounds in the EEG data. QEEG techniques that compare continuous resting EEG during sensory deprivation and at baseline may be more suitable to investigate the experience of sensory deprivation.

7.2 EEG pilot study

During my PhD studies I have set up a new EEG laboratory in the anechoic chamber located at the UCL Division of Psychology and Language Sciences. The chamber is shielded thus blocking most external electromagnetic radiation. This provides optimal conditions for EEG experiments and in this case also allowed for the desired sensory deprivation conditions. For several months I was involved in the procurement and the setting up and preliminary testing of the equipment. I subsequently collected pilot EEG data for 9 participants.

The existing research suggests that incorporating quantitative EEG measures into the existing sensory deprivation paradigm could yield neurophysiological markers to investigate the neural basis of self-reported psychosis like experiences (PLE) during sensory deprivation. The study design was such that an intergroup QEEG comparison would be possible at baseline, and also so that intragroup comparisons could be made between QEEG collected at baseline and under sensory deprivation conditions.

7.2.1 Aims

Conduct a feasibility pilot, collecting EEG data at baseline (normal resting conditions), and during sensory deprivation.

7.2.2 Hypotheses

1. Participants in the high hallucination prone group will show greater self-report of PLEs, and heightened cortical excitability under sensory deprivation.

2. Participants in the high hallucination prone group will show increased alpha activity during sensory deprivation (compared to resting conditions), but participants in the low schizotypy group will not show this increased activity.

3. Alpha activity levels will be similar across high and low hallucination prone groups under resting conditions.

7.2.3 Method

7.2.3.1 Measures

The Revised Hallucinations Scale (RHS: Morrison et al., 2002): This is a 24-item questionnaire based on the Launay-Slade Hallucination Scale (Launay and Slade, 1981) measuring a predisposition to experience hallucinations. It uses a revised scoring method which allows participants to respond on a 4-point scale (1 = never to 4 = almost always). The scale has been shown to have good reliability and predictive validity, and moderately stable internal consistency over a period of 4-6 weeks (Morrison et al., 2002).

The Psychotomimetic States Inventory (PSI: Mason et al., 2008): This is a 48 item questionnaire measuring psychosis-like experiences. Items are rated on a 4-point scale (from 0 = never to 3 = strongly), with some items being reverse scored. The Psychotomimetic States Inventory has sub-scales of Delusory Thinking, Perceptual Distortions, Cognitive Disorganization, Anhedonia, Mania and Paranoia. Originally developed for use in drug studies, it has produced meaningful results in a previous preliminary study of sensory deprivation (Mason and Brady, 2009).

The Cortical Hyperexcitability Index (Chi: Braithwaite et al. submitted): a 27-item measure of signs of visually driven cortical hyperexcitability associated with aberrant visual experience (Braithwaite et al., submitted). This has three factors (i) heightened visual irritability; (ii) negative visual hallucinations; and (iii) positive visual hallucinations.

7.2.3.2 Participants

Participants (n = 9) between the ages of 18 and 65 years were recruited from a database of individuals who had previously returned an online version of the Revised Hallucination Scale (RHS), but who had not yet participated in the previous sensory deprivation studies. Exclusion criteria included a personal or family history of psychotic disorder, or current use of any recreational or therapeutic drugs potentially affecting the central nervous system during the last three months). Participants were also excluded if they had ever received a diagnosis of neurological disorder, moderate to severe head injury, or alcohol/substance dependence in the last 12 months. From this database, 27 low scorers and 15 high scorers were invited to participate as these conformed to the upper and lower 20th percentiles, according to questionnaire norms. Of these, 5 low scorers (2 males, 3 females, mean age = 24.4 SD=3.9, mean score = 28.2 SD=1.10) and 4 high scorers (1 males, 3 female, mean age = 22.0 SD = 3.37, mean score = 57.5, SD =9.04) gave informed consent consistent with University ethical approval, and completed the experimental procedure.

7.2.3.3 EEG Procedure

On arrival at the testing facility, participants were given a demonstration of the anechoic chamber in order to familiarise themselves with the environment. Participants were informed that they would spend 15 minutes seated in the chamber in complete silence and darkness; they were instructed to stay quiet and relaxed, keeping eyes open, and avoiding muscular, palpebral or ocular movement. Sensory deprivation EEG recording commenced after these instructions. A microphone was present in the chamber so as to terminate testing if needed, by restoring light and communication. Subsequently, participants completed the psychotomimetic states inventory to record any psychosis like experiences that occurred during the recording.

After a short break, participants underwent a second EEG recording under normal baseline conditions in the anechoic chamber (but with the door open and light on so normal sound and vision were restored). They subsequently completed the psychotomimetic states inventory for a second time. The order of both EEG sessions (sensory deprivation and baseline conditions) were counterbalanced across participants. Following completion of the experiment, participants were debriefed, and received a payment (compliant with university departmental guidelines) for their time in taking part.

7.2.3.4 EEG data acquisition

EEG data was collected using a 40-channel NuAmps amplifier and 40 channel quick cap with sintered silver/silver-chloride electrodes, placed according to the International 10/20 System (Jaspers 1958). Bipolar vertical (above and below the left eye) and horizontal (outer canthi of both eyes) EOG channels were included to monitor eye movements. Linked ear lobes served as reference and FPZ was the ground (Ranlund et al, 2014). The signal was recorded continuously at a sampling rate of 500 Hz with no filtering. Electrode impedance was kept below 5 kΩ.

7.2.3.5 EEG data processing

Off-line signal processing was conducted using Neuroscan 4.3 software (www.neuroscan.com). Data were re-referenced to the average of all active EEG sensors (Bledowski et al. 2004) and filtered with a 0.5-70 Hz band-pass and a 50 Hz notch. Sequential epochs of 2000 msec were created from the continuous EEG files, and baseline corrected as the average of the whole segment activity.

Using Independent Component Analysis (ICA), components clearly corresponding to ocular activity were excluded. Additionally, those epochs with activity exceeding ± 100 µV were automatically rejected (Reinhart et al., 2011). Participant's EEG data was included in the analysis if at least 50% of their epochs per 15 min session (~220 segments) survived this artefact rejection. The resulting epoched waveforms after artefact correction were then averaged per subject and grand-averaged per participant group (high and low schizotypy) and/or condition (sensory deprivation and baseline) separately.

Mean EEG amplitudes (µV) were calculated in the delta (1.95-3.90 Hz), theta (4.39 – 7.32 Hz), alpha (8.30 – 12.70 Hz), and beta (13.2 – 21 Hz) frequency bands using the Fast Fourier Transformation and Hanning window with 10% taper length. These frequency bands are typical of similar research (Boutros et al., 2008), with the additional decision taken not to analyse frequencies above 21 Hz due to accumulating evidence that higher frequencies can be substantially contaminated by scalp electromyogram activity (EMG), even after rejection of large EMG bursts (Whitham et al., 2007; Shackman et al., 2010; Nottage et al., 2013).

7.2.3.6 Statistical Analyses

All statistical analyses were conducted using SPSS 22.0. Although EEG amplitudes tend to be normally distributed, given the small sample size and having observed histograms of our data, the distribution showed a departure from the normal curve and hence non-parametric techniques were used throughout the analysis. EEG and cortical hyperexcitability data was compared between groups using Mann-Whitney U tests. Differences in EEG data between conditions was analysed using Wicoxon Matched-Pairs tests.

7.2.4 Results

7.2.4.1 Psychosis-like experiences across groups and conditions

Studies in previous chapters using larger samples have established a clear pattern of psychosis-like experiences, with both high and low hallucination prone groups experiencing a significant increase in psychosis-like symptoms from baseline in sensory deprivation, with a greater increase for the high hallucination prone group. In order to verify whether the smaller pilot sample recruited in this study also demonstrated this pattern, groups were compared using the Mann-Whitney U Test, and the effect of condition was tested using the Wilcoxon Matched-Pairs Test (see table 1 for descriptives).

The high hallucination prone group experienced a greater number of psychosis-like symptoms overall throughout the experiment (median PSI score = 31 compared to 10 for the low scoring group at baseline, and median PSI score = 54 during sensory deprivation compared to 36 for the low scoring group. Due to the lack of power of this pilot study, and the uncharacteristically large increase in PSI scores during sensory deprivation for the low schizotypy group, the group effect did not reach statistical significance (p= .11) on this occasion. However, the effect of condition for PSI scores remained significant in this pilot sample, with psychosis-like experiences being more prevalent under sensory deprivation conditions (overall median PSI score = 43, compared to 13 at baseline (p= .01).

7.2.4.2 Cortical Hyperexcitability

An Independent Samples Mann-Whitney-U test indicated the high hallucination prone group had significantly elevated levels of cortical hyperexcitability (median = 118) when compared to the low schizotypy group (median = 26, p .016). This was evident across all underlying cortical hyperexcitability sub-factors (heightened visual sensitivity median = 56.5 compared to 21.2, (p= .016); negative aura-type visual aberrations median = 23.0 compared to 3.44, (p= .016); positive aura-type visual aberrations median = 25.5 compared to 2.0, (p= .016)).

Table 1. Median Questionnaire Scores for High and Low Hallucination-Prone Groups by Condition

Median Questionnaire Scores (Range)	**High Schizotypy (n = 4)**		**Low Schizotypy (n = 5)**	
Revised Hallucinations Scale	53.5 (19)		28 (3)	
	Baseline	**Deprivation**	**Baseline**	**Deprivation**
PSI Score	31 (41)	54 (47)	10 (10)	36 (34)

7.2.4.3. Baseline EEG Data

The median baseline EEG amplitudes (µV) for each group, in the four frequency bands, are shown in Table 1. These baseline amplitudes can also be seen compared for both groups in Figure 1. Frequencies for the bands chosen were delta (1.95-3.90 Hz), theta (4.39 – 7.32 Hz), alpha (8.30 – 12.70 Hz), and beta (13.2 – 21 Hz). These frequency bands are typical of similar research (Boutros et al., 2008), with the additional decision taken not to analyse frequencies above 21 Hz due to accumulating evidence that higher frequencies can be substantially contaminated by scalp electromypgram activity (EMG), even after rejection of large EMG bursts (Whitham et al., 2007; Shackman et al., 2010; Nottage et al., 2013). For data-reduction purposes (to minimise type 1 error), only the three midline EEG channels, frontal (FZ), central (CZ), and parietal (PZ), were chosen for statistical analysis (Harris et al., 2006). For each individual recording, amplitudes analysed were the average of these three channels.

7.2.4.4 Group comparison at baseline

An Independent Samples Mann-Whitney U Test indicated that theta band amplitudes were significantly lower in the high hallucination prone group at baseline (median =1.60) than the low s hallucination prone group (median = 2.38, p= .032). Beta band amplitudes were also significantly lower at baseline in the high hallucination prone group (median 0.77) than the low group (median = 2.60, p= .032). Alpha band amplitudes were also lower at baseline in the high hallucination prone group (median = 1.34) than the low group (median 2.53), but this only approached and did not reach significance (p= .06). No between group baseline differences were identified for delta bands.

7.2.4.5 Sensory Deprivation EEG Data

Further Independent Samples Mann-Whitney U Tests indicated no significant difference in frequency band amplitudes between groups under sensory deprivation conditions (see Figure 2).

However, observation of the shifts in frequency band amplitudes between baseline and sensory deprivation conditions showed noticeably different patterns for high and low hallucination prone groups (see Figure 3). The high hallucination prone group showed marked increases in amplitude for theta, alpha, and beta frequency bands, with delta amplitudes remaining more stable across the conditions. Wilcoxon Signed Rank tests showed the increases in theta, alpha, and beta frequency bands approached, but failed to meet statistical significance ($p = .07$). The percentage change in scores from baseline are also presented in Table 3 to better quantify the extent of the increases in sensory deprivation between groups. Within the high hallucination prone group, theta amplitudes increased by 37%, alpha amplitudes by 46%, and theta amplitudes by 203% during sensory deprivation as compared to their baseline.

Table 2

Median (and Range) EEG amplitudes (μV) at baseline and during sensory deprivation, for high and low hallucination prone groups.

	Baseline		Sensory Deprivation	
	High scorers	**Low scorers**	**High scorers**	**Low scorers**
Delta	2.31 (0.90)	2.60 (0.28)	2.41 (1.00)	2.40 (1.14)
Theta	1.60 (0.86)	2.38 (0.67)	2.29 (0.92)	2.42 (1.50)
Alpha	1.34 (1.17)	2.53 (1.97)	2.29 (0.92)	2.44 (1.80)
Beta	0.77 (0.25)	2.60 (1.80)	2.41 (1.00)	2.40 (1.14)

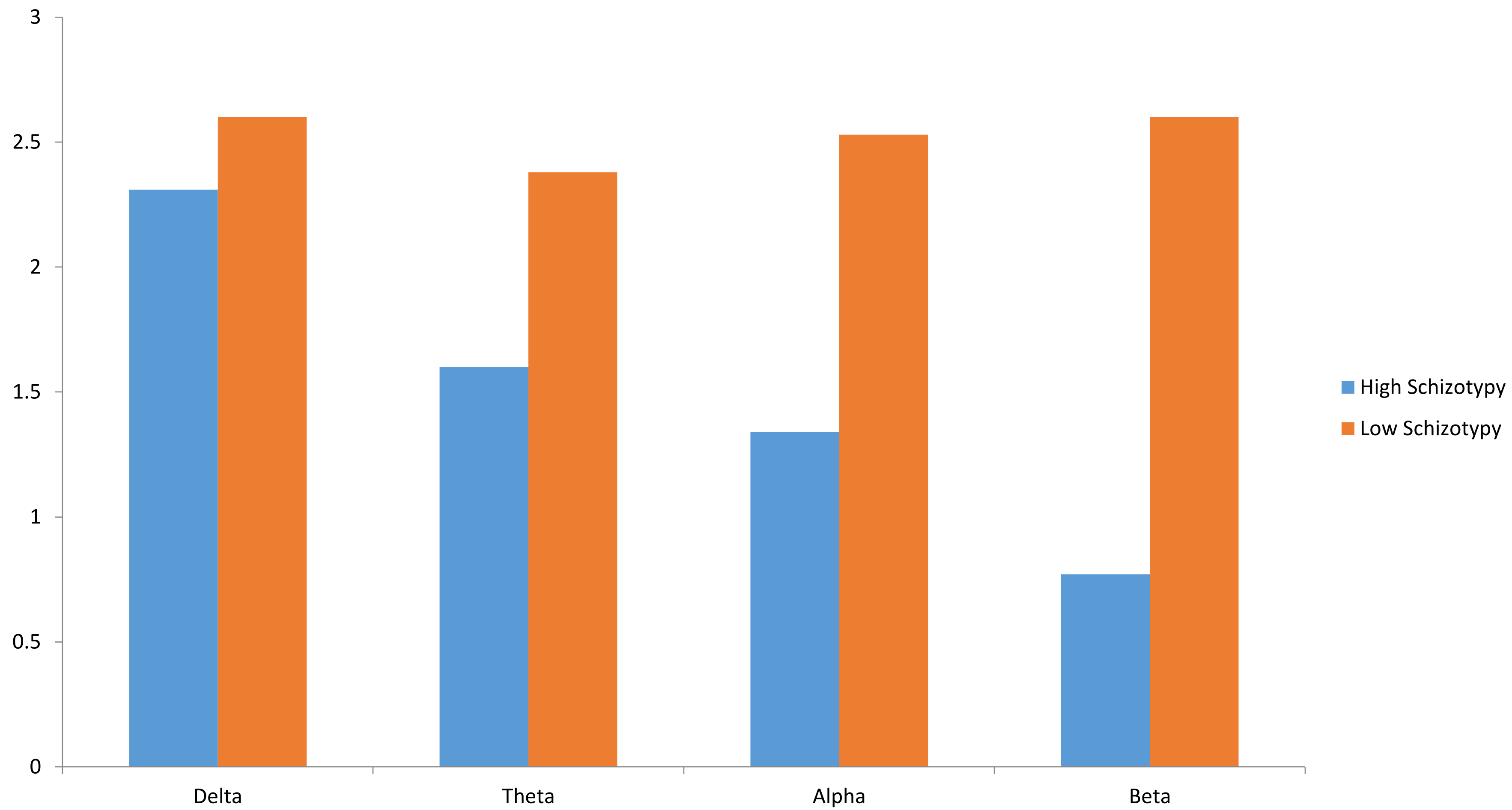

Fig. 1 Bar chart comparing EEG amplitude (µV) for the four frequency bands at baseline for high and low hallucination prone groups

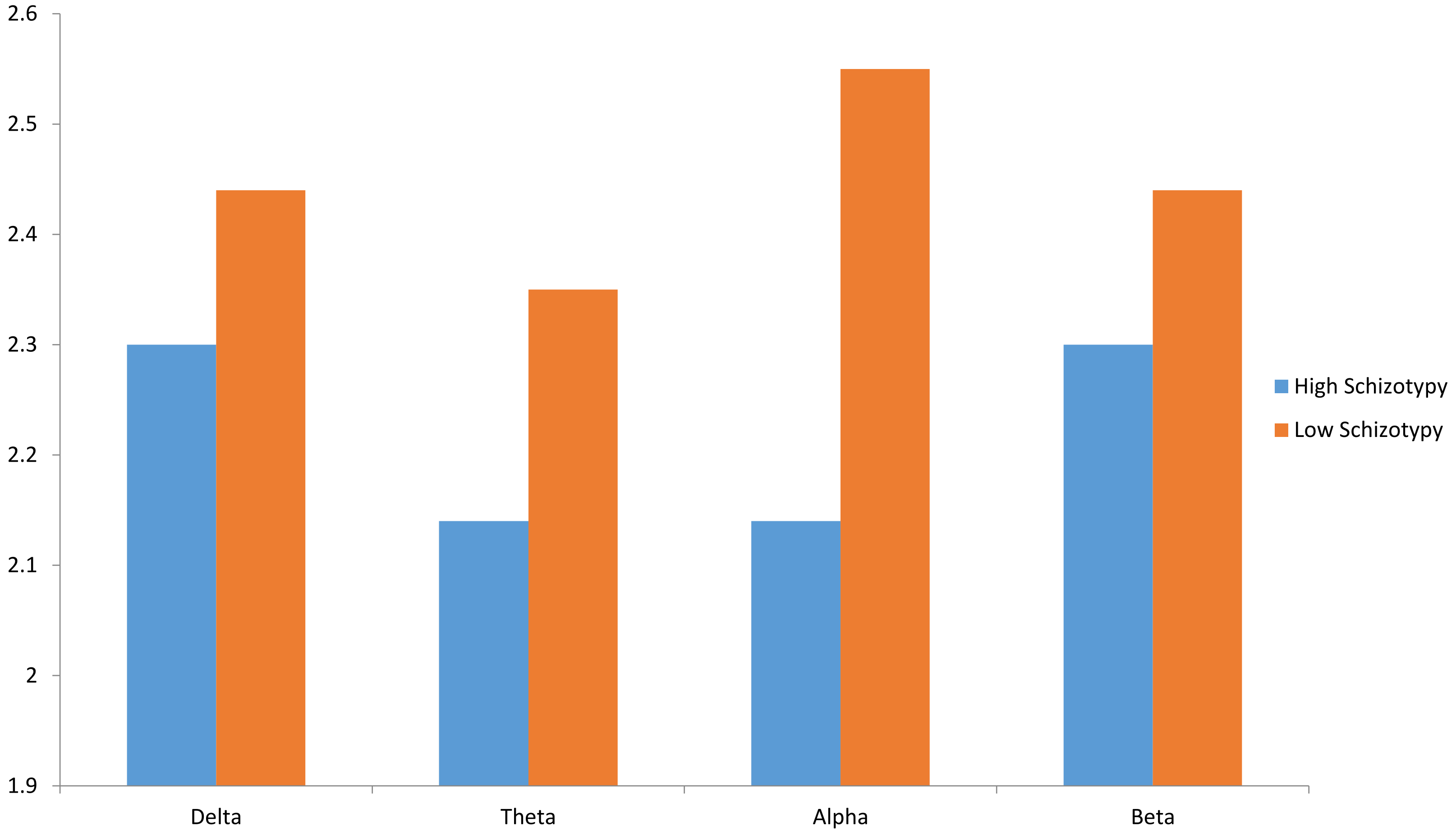

Fig. 2 Bar chart comparing EEG amplitude (µV) for the four frequency bands during sensory deprivation for high and low hallucination prone groups

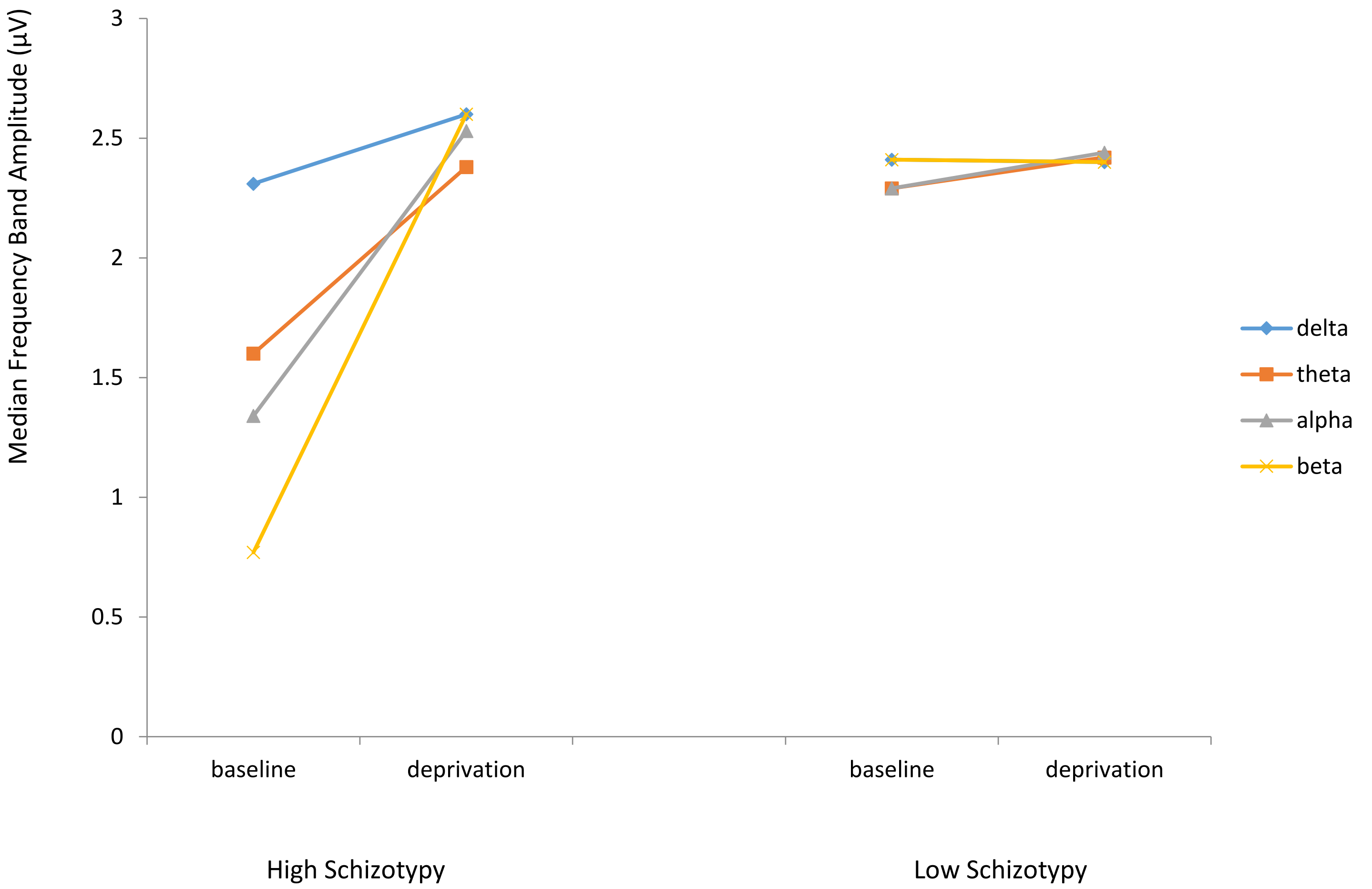

Figure 3. EEG amplitude (µV) for the four frequency bands at baseline and during sensory deprivation, for high and low hallucination prone groups

Table 3. Percentage change in EEG band amplitude from baseline for high and low hallucination prone groups

	Percentage change from baseline (%)	
	High scorers	**Low scorers**
Delta	+7.98	-3.17
Theta	+37.18	+3.07
Alpha	+45.58	+10.87
Beta	+202.63	+10.41

7.2.5 Discussion

Consistent with the findings of larger studies within this thesis, the pilot sample upheld the main features of psychosis like experiences, with the high hallucination prone group showing greater self-reports of PLE's overall, and a more marked increase of PLE's during sensory deprivation than the low hallucination prone group. In this pilot study the main effect of group did not reach statistical significance, and this is likely a reflection of a lack of power from the small sample size. However, a significant effect of condition was detected, with both groups experiencing significantly increased levels of PLE's during sensory deprivation when compared to baseline.

It was hypothesised that participants in the high hallucination prone group would show increased alpha activity during sensory deprivation (compared to resting conditions), whereas participants in the low hallucination prone group would not show this increased activity. Absolute levels of alpha activity were found to be greater in the low hallucination prone group (2.55µV compared to 2.14µV for the high hallucination prone group) under sensory deprivation conditions. However, for this alpha activity to be fully understood it is important that baseline resting levels are taken into consideration. When changes in alpha activity were indexed as a percentage of baseline amplitude, the high hallucination prone group showed a 46% increase in alpha activity during sensory deprivation, compared to just a smaller 11% increase for the low hallucination prone group. Once again, the lack of power is likely responsible for the 46% increase in the high hallucination prone group failing to reach significance.

What was not predicted was the presence of marked increases in theta band amplitude (37%) and beta amplitude (203%) alongside the predicted alpha increases in sensory deprivation for the high hallucination prone group. Once again, the absolute levels of theta and beta amplitudes were broadly similar across the two groups during sensory deprivation, and these reported increases reflect lower resting baseline amplitudes in the high hallucination prone group across theta, alpha, and beta bands.

From this preliminary data, it does not seem possible to differentiate high and low hallucination prone groups solely on the basis of QEEG data under sensory deprivation conditions. However, the pilot findings do indicate that it could be possible to differentiate the two groups at baseline, with the high hallucination prone group showing decreased levels of theta, alpha, and beta activity. It also seems likely that the two groups could be differentiated on the basis of percentage change from baseline across the theta, alpha, and beta bands, whilst delta activity remains relatively stable both between groups and also between baseline and sensory deprivation conditions.

The findings of decreased baseline levels of theta, alpha, and beta activity in the high hallucination prone group concur with the finding that this group also showed significantly elevated levels of cortical hyperexcitability at rest. From the perspective of alpha inhibition theories (Klimesch et al. 1999; Ray and Cole, 1985) the reduced alpha activity seen in the high hallucination prone group may reflect poorer ability to inhibit sensory information processing pathways when attention is internally directed. Under sensory deprivation conditions when the degree of self-focused attention increases, poorer ability to inhibit information processing pathways may be one factor involved in this groups propensity towards hallucinations. Levels of alpha activity did increase substantially (by 46%) in the high hallucination prone group under sensory deprivation conditions, but activity still did not reach the baseline level of the low hallucination prone group. The decreased baseline levels of theta, alpha, and beta activity relative to the low schizotypy group also supports Claridges (1967) weakened inhibitory processing model of psychosis, as low levels of inhibitory activity from these bands are likely neurophysiological correlates of a weakening of homeostatic control over the nervous system.

The profile of qEEG band activity at baseline in the high hallucination prone group, with theta activity dominating over alpha activity, is in keeping with existing research on endophenotypes for psychosis. Researchers have identified increased slow wave activity in theta (4-8 Hz) bands

(Sponheim et al., 1994; Sponheim et al., 2000; Winterer et al., 2001; Kirino, 2004; Harris et al., 2006; Begic et al., 2011; Hong et al., 2012) and decreased alpha (8-13 Hz) activity (Sponheim et al., 2003; Harris et a;., 2006; Begic et al., 2011) as putative psychosis endophenotypes. However, in chronic samples, increased delta (1-4Hz) activity has also been found, which was not evident in this pilot study.

What remains more difficult to understand is the possible reasons why both groups EEG activity became very similar under sensory deprivation conditions. With a larger sample it would be possible to conduct a more refined statistical analysis, comparing the sensory deprivation data of both groups whilst controlling for baseline EEG measures and also baseline PSI scores as covariates using ANCOVA. It is possible that since the difference in group PSI scores was actually greater at baseline than during sensory deprivation, the EEG profiles showed more disparity at baseline. It should also be considered that the lack of difference in EEG profiles during sensory deprivation may indicate that EEG is not able to support participant self-report data as a neurophysiological marker of psychosis like experiences. However, at this stage, further data needs to be collected in order to produce a better powered study, before any real conclusions are able to be drawn.

7.2.5.1 Strengths and Limitations

An important strength of the study design is that a protocol has been designed for collecting resting EEG data during psychosis like experiences that does not require participants to respond with a button-press which affects the EEG, particularly in the beta band. The anechoic chamber is able to reliably induce psychosis like experiences in high hallucination prone individuals so that it is not necessary to ask participants to button-press if such experiences occur. However, the emerging evidence also suggests that the anechoic chamber induces psychosis like experiences in some, but not all, low hallucination prone individuals. In this particular pilot sample, the low schizotypy groups reported fairly high levels of psychosis like experiences during sensory deprivation, adding a further confound to the analysis. Screening potential participants using the RHS is an effective way to predict who is likely to experience psychosis like symptoms, but it is not 100% accurate. Hence, in future studies it could be preferable to exclude data from the sub-set of low hallucination prone participants who go on to experience relatively high levels of psychosis like experiences, in order to have a clearer comparison group for statistical analysis.

Previous studies of sensory deprivation (Hyashi et al. 1997) have divided up the time spent under these conditions into segments, and analysed the EEG data from these segments separately. If a larger sample were to be recruited this would be a preferable strategy as participants have reported a period of adjustment to the sensory deprivation environment that takes a few minutes to settle. EEG data from this phase could be discarded, however this was not possible during this pilot study due to short length of the recordings made. In addition, a further important modification to the protocol could be to continue with the sensory deprivation EEG recording once light and sound have been restored to the chamber. This would enable the length of time that the effects of sensory deprivation persist in the EEG trace to be established, and this could provide useful information as to whether it could be possible to administer cognitive tasks or similar to participants immediately after sensory deprivation whilst maintaining the effects.

7.2.5.2 Clinical Implications

Whilst the small sample size is a major caveat concerning the validity of the findings, it is interesting to consider what the potential clinical implications could be for a psychosis prone group who show dominant theta activity and decreased alpha activity. It is becoming increasingly well understood that practices such as mindfulness meditation can be effective in boosting the power of alpha waves (Mason et al. 1997; Travis 2001; Gaylord et al. 1989; Travis and Wallace 1999), however the literature on the appropriateness of such practices for people with psychosis is mixed, with some claiming that meditation may actually trigger psychotic states in vulnerable individuals (Walsh and

Roche, 1979; Chan-Ob and Boonyanarunthee, 1999; VanderKooi 1997). There is also a growing body of research that has shown the practice of mindfulness meditation to be helpful in reducing symptoms during psychotic episodes (see Khoury et al. 2013 for a meta-analysis). An adequately powered study would need to be conducted in order to comment further on whether EEG data can contribute to the debate over the risks and benefits of meditation in high risk groups. However, if the findings from a larger study were to follow the initial trends seen during this pilot, the question of whether weakened alpha activity in individuals at risk of psychosis can be strengthened through the practice of meditation would represent a question worthy of further research.

Chapter 8

Conclusion

8.1 Overview

In order to advance our understanding of the underlying biological and cognitive changes that drive the pathogenesis of psychosis, there is a pressing need to develop experimental models of psychosis that faithfully mimic the disorder. Conducting research with clinical patients is an important endeavour, however this approach has significant drawbacks and limitations, including ethical concerns regarding the testing of early experimental hypotheses with little evidence for therapeutic benefit, and confounding variables such as hospitalisation, medication effects, illness duration, and cognitive deficits associated with psychosis.

Animal models of psychosis are a valuable tool with which to investigate the neurobiological basis of psychosis, yet their direct relevance to humans can seem remote. Similarly, drug models offer insight into the neurotransmitter systems involved in psychosis, but administering restricted access substances to otherwise healthy participants carries significant ethical and health concerns. Given recent developments in high risk models of psychosis, and evidence that has proved schizotypy to be a useful high risk marker within the general population (see Debbane et al. 2014 for a review), there is a need to consider the potential non-pharmacological methods that could be used to induce psychosis-like experiences in susceptible high hallucination prone individuals in an experimental setting. If successful, this could represent a non-invasive, low-risk approach for studying the pathogenesis of psychosis within the general population.

The literature reviewed in Chapter 2 has pointed towards short term sensory deprivation being one such method. However, to date, our understanding of the complex variables that enter into the situation of sensory deprivation has been very limited, and few researchers have visited this area since the 1960's. Given what we now know about schizotypy and the psychosis spectrum, there is growing evidence to suggest that the study of sensory deprivation is worthy of a fresh look. This thesis has aimed to re-visit the potential for sensory deprivation as an experimental model of psychosis, in the light of post 1960's theoretical developments such as schizotypy and the continuum theory of psychosis. Before the potential utility of sensory deprivation as an authentic experimental analogue for clinical psychosis can be established, it has been essential to address some significant gaps in the existing knowledge base. These key questions included:

1. What non-pharmacological approaches exist for inducing psychosis like experiences in the general population, and how effective are these approaches?
2. Can the Revised Hallucination Scale (Morrison et al. 2002) accurately predict individuals most likely to have psychosis-like experiences in sensory deprivation?
3. What is the factor structure of the RHS (Morrison et al. 2002), and can the original factor structure be replicated?
4. How and why do psychosis-like experiences arise under conditions of sensory deprivation?

8.2 Empirical Findings

8.2.1 What non-pharmacological approaches exist for inducing psychosis like experiences in the general population, and how effective are these approaches?

A systematic review of the literature between 1990 and 2016 (presented in chapter 2) found that a variety of ambiguous auditory environments and perceptually ambiguous visual paradigms have proved successful in inducing hallucinations. The type of hallucinations induced has been shown to be restricted to the sensory modality being manipulated. In sensory deprivation conditions, where several sensory modalities are restricted simultaneously, more complex hallucinations involving tactile, visual and auditory experiences have been reported. Furthermore, evidence was found to suggest that only brief periods of intense deprivation can be effective.

When considering the effectiveness of a technique for inducing psychosis-like experiences, it is also important to consider how closely any symptoms induced mimic those of individuals with clinical psychosis. The Appraisals of Anomalous Experiences interview data presented in Chapter 4 showed the appraisal and cognitive/emotional response styles of participants during sensory deprivation were broadly consistent with those of non-clinical individuals with anomalous experiences. However, anxiety, dangerousness and a negative emotional response were at the low levels seen in non-clinical individuals, and unlike the symptomatic experiences of those with psychotic disorders. It is also important to consider that the psychosis-like experiences reported differed significantly from the auditory hallucinations classically associated with clinical psychosis. There were no accounts that referred to hearing voices (only music), and visual hallucinations and out of body experiences were more commonly reported.

8.2.2 Can the Revised Hallucination Scale (Morrison et al. 2002) accurately predict individuals most likely to have psychosis-like experiences in sensory deprivation?

3 empirical studies presented in this thesis utilised the Revised Hallucination Scale (Morrison et al. 2002) as a means of screening individuals from the general population. The questionnaire was used to select participants with scores in the top and bottom 20th percentiles to form high and low hallucination prone groups in these studies. All studies were consistent in showing that the participants with high RHS scores showed significantly more psychosis-like symptoms overall (at baseline as well as during sensory deprivation), as measured using the Psychotomimetic States Inventory (Mason et al., 2008). Furthermore, whilst high and low scoring participants all experienced significant increases in psychosis-like symptoms during sensory deprivation, the increase was significantly greater for high scoring participants. These findings provide robust evidence in support of the using the RHS as a screening tool for psychosis-proneness.

8.2.3 What is the factor structure of the RHS (Morrison et al. 2002), and can the original factor structure be replicated?

Despite proving to be a reliable tool for selecting hallucination-prone individuals, the validity of the RHS came under scrutiny because various past attempts by others to validate Morrison's original proposed three-factor structure have not met with success. In order to address this issue, a relatively new statistical technique, Exploratory Structural Equation Modelling, was implemented as an adjunct to traditional Confirmatory Factor Analysis. Using this technique it was possible to yield a new four-factor model that was able to be validated with good model fit using both traditional Confirmatory Factor Analysis, and also Exploratory Structural Equation Modelling techniques.

The four factor model has some commonality with the original three factor model proposed by Morrison et al. (2002) with the vividness of imagination and daydreaming factor being retained, and the tendency towards visual hallucinations and tendency towards auditory hallucinations factors also being represented, albeit collapsed into one new factor 'auditory and visual anomalous experiences'. I then propose two new factors: Fantasy and Dissociation. This factor model supports clinical research proposing the relationship between trauma and the development of psychotic symptoms could be accounted for by dissociative processes (e.g. Moskowitz and Corstens, 2007; Moskowitz et al., 2009; Varese et al., 2012). There is also evidence to suggest that both of these new factors may act as mediators for the experience of hallucinations: a dissociative stage has been implicated in the relationship between inner speech developing into hallucinations (Alderson-Day et al. 2014). In addition, Chapter 6 of this thesis draws evidence from a separate study that suggests fantasy proneness is likely a mediator in the process by which highly prone individuals experience hallucinations, possibly by driving a specific response bias reflecting impaired reality testing which in turn leads to hallucinations (Bentall, 1990).

In Chapter 5, the predictive ability of the four individual RHS factors of psychosis-like experiences in sensory deprivation was compared against the predictive ability of total RHS score. No individual factor was found the have superior predictive power than overall total RHS score.

8.2.4 How and why do psychosis-like experiences arise under conditions of sensory deprivation?

The empirical study in chapter six focused on addressing a key debate within the literature concerning whether the psychosis-like experiences reported in sensory deprivation are genuine anomalous experiences, or merely endorsed by certain individuals on self-report questionnaires. Individual differences in suggestibility, fantasy proneness, and anxiety were examined as co-variates, however the main findings still held – both high and low hallucination prone groups experienced a significant increase in psychosis-like symptoms from baseline in sensory deprivation, and the high hallucination prone group reported significantly more psychosis-like experiences at both baseline and in sensory deprivation.

The two groups did exhibit a number of differences at baseline, with the high scoring group reporting greater state/trait anxiety, greater suggestibility, and greater fantasy proneness. However, only state anxiety was found to make a significant contribution to change in PSI scores in sensory deprivation (accounting for 15% of the variance). Fantasy proneness and suggestibility were not implicated (at least, fantasy proneness was not directly implicated, but likely plays a mediating role as discussed above). The most powerful predictor of psychosis-like experiences in sensory deprivation was still found to be group membership, which accounted for 39% of the variance.

Given the above findings provided initial evidence to support the argument that fantasy proneness and suggestibility are not responsible for the hallucinatory reports seen in sensory deprivation, an alternative source of evidence not reliant on self-report was sought to strengthen this argument further. Quantitative EEG data was collected in order to establish whether this approach could provide a robust neurophysiological correlate for psychosis-like experiences.

Notwithstanding the important caveat that only a very small pilot study was conducted, these initial QEEG results could not provide evidence to support the hypothesis that high and low hallucination prone groups can be distinguished on the basis of QEEG data under sensory deprivation. There are however several important methodological reasons why this could have been the case which are discussed in detail in chapter 7, but essentially the small sample size limited the ability to apply appropriate parametric statistical tests capable of controlling for important covariates at baseline. There was evidence to suggest that the two groups differed in their QEEG profiles at baseline, with the high hallucination prone group found to have decreased levels of theta, alpha, and beta activity. On the basis of calculations representing QEEG activity in sensory deprivation as a percentage of baseline activity, clear differences were found between the two groups in sensory deprivation, with the high hallucination prone group showing large shifts towards increased theta, alpha, and beta activity. Without being able to deploy the appropriate tests it was not possible to investigate this further.

Although highly speculative, given the nature of a pilot study, the initial findings point towards the high hallucination prone group being characterised by reduced levels of theta, alpha, and beta activity, with elevated levels of cortical hyperexcitability. Taken together, these reported findings provide evidence in support of weakened inhibitory processing theories of psychosis (Claridge, 1967; Frith, 1992; Hemsley, 1987). Evidence emerging from attentional blink research has suggested that alpha amplitude indicates different brain states, which have a bias either toward external or internal processing. High alpha amplitudes indicate internally oriented brain states, which make it harder for stimuli to be perceived. Low alpha amplitudes indicate externally oriented brain states, which bias the system toward processing information from the sensory channels (Klimesch et al. 1999). The reduced alpha activity seen in the high hallucination prone group may reflect poorer ability to inhibit sensory information processing pathways when attention is internally directed. Under sensory deprivation conditions when the degree of self-focused attention increases, poorer ability to inhibit information processing pathways may be one factor involved in this groups propensity towards hallucinations.

8.3 Thesis Limitations

Throughout the thesis, limitations have been addressed where appropriate, in particular in the discussion sections of the empirical chapters (Chapters 3,4,5,6, and 7), for example limitations such as small sample sizes, innovative techniques, and validity of findings. However it is worth re-iterating some of the wider issues that recur throughout the thesis.

Recruitment took place on a university campus, and whilst every effort was made to include staff as well as students to sample a broad age range, the majority of participants were students. This limits the ecological validity of the thesis, although the impact it is likely to have had on the data is uncertain. Schizotypy scores (and hence hallucination proneness) show a tendency to reduce with increasing age (Bora and Arabaci, 2009), and hence an uneven age distribution between groups could become problematic in a future study sampling the general population.

Factors such as education level and IQ would also be more representative in a general population as opposed to student sample. We know that lower IQ scores are associated with increased risk for developing psychotic disorders (Zammit et al., 2004; Eberhard et al., 2003; Munro et al., 2002), and those with a lower-than-average IQ score have been found to carry a 40% greater risk than subjects with higher than average IQ (Zammit et al., 2004). One theory is that IQ may be an outward marker of subtle cerebral disease that could eventually influence development of psychotic symptoms (Reichenberg, 2010). Another theory is that a higher IQ may bestow protection against psychosis by influencing interpretation of stimuli and events more accurately (Kendler et al., 2015). Therefore studying appraisals of psychosis-like experiences in a higher education sample (and hence presumably with higher than average IQ) may be particularly liable to be non-representative of the general population.

Whilst conducting the appraisals of anomalous experiences research presented in chapter 4 it became apparent that there were significant cultural differences involved in the interpretation of questionnaire items probing PLE's, with participants from some ethnic backgrounds showing a tendency to endorse high levels of psychosis-like symptoms on questionnaires. This was detected during the AANEX interview process, but presumably these cultural differences in interpretation style would also have affected online RHS questionnaires administered during studies throughout the thesis. Although the RHS did prove to be a reliable screening tool for identifying hallucination prone individuals, ideally the questionnaire should have been experimenter administered to reduce these cultural interpretation issues.

The systematic literature review presented in chapter 2 identifies lack of double-blinding techniques as a limitation to many of the studies featured. Although attempts were made to allocate participants to high and low hallucination prone groups in a double-blind fashion throughout the experiments in this thesis, working as a lone researcher made it impossible to maintain blinding due to the need to attend to the administrative tasks of running the studies and checking recruitment levels across groups. This may have affected the results in that as the experimenter I could have implicitly influenced the frequency and types of experiences reported by participants. The predominant use of self-report instruments (besides the AANEX interviews) is likely to have minimised experimenter influence, but nevertheless a truly double-blind protocol would have been superior.

8.4 Theoretical Implications

The empirical studies presented in this thesis rely upon the validity of the theoretical construct of schizotypy, and the assumptions of high-risk models of psychosis that purport that sub-clinical forms of psychotic symptomatology seen in highly schizotypal individuals share the same pathogenesis as clinical psychosis. Whilst high risk models have gained in popularity over recent years, they are by no means universally accepted (see Lawrie et al., 2010, for a critique).

Although a pilot study with a very limited sample size, the findings from the QEEG research in Chapter 7 provide further support for the validity of high-risk models of psychosis. The profile of qEEG band activity at baseline in the high hallucination prone group, with theta activity dominating over alpha activity, is in keeping with existing research on endophenotypes for psychosis. Researchers have identified increased slow wave activity in theta bands (Sponheim et al., 1994; Sponheim et al. 2000; Winterer et al., 2001; Kirino, 2004; Harris et al., 2006; Begic et al., 2011; Hong et al., 2012) and decreased alpha activity (Sponheim et al. 2003; Harris et al. 2006; Begic et al. 2011) as putative psychosis endophenotypes. These findings would suggest that if sub-clinical highly schizotypal samples share the endophenotypes seen in clinical samples, they will also share the same pathogenic processes (albeit at a diminished level).

8.5 Recommendations for Future Research

In its current format, the use of sensory deprivation as an experimental model of psychosis is limited by the requirement for participants to be inactive, in an environment with no light or sound. It is therefore not possible to ask participants to engage in computer based cognitive tasks or take part in other activities that would disrupt the conditions of deprivation. Given that the QEEG data showed clear differences in the high schizotypal group EEG profiles at baseline and under sensory deprivation conditions, it would be possible to design a study to detect how long the effects of sensory deprivation can be seen on QEEG activity before participants return back to a baseline state of functioning. EEG recording could continue once light and sound are restored to the anechoic chamber in order to detect whether there is a ‘window’ during which cognitive tasks could be given to participants. If there did prove to be a period of time whilst the effects of sensory deprivation persist, this would open up many possibilities for areas of future study such as attention tasks, timing and perception tasks, and semantic processing tasks.

8.6 Final Conclusion

This thesis has aimed to establish the potential utility of sensory deprivation as an experimental model of psychosis, given that existing approaches such as animal and drug models have major limitations to their use. The ability for short-term sensory deprivation to successfully induce psychosis-like experiences in highly hallucination prone individuals has been demonstrated and replicated several times throughout the course of this thesis. There is also exciting preliminary evidence to suggest that it may be possible to detect QEEG correlates of psychosis-like experiences, although further data collection is necessary in this area.

What remains more difficult to ascertain is how similar to genuine clinical psychosis the PLE’s induced by sensory deprivation actually are. A number of differences have been identified, some of the most important being that the hallucinations induced by sensory deprivation tend to be predominantly visual and not auditory in nature, and participants show less of tendency to make external attributions for their experiences, maintaining a strong sense of personal agency.

Returning to Garety’s (2001) model of the positive symptoms of psychosis, it is clear that the basic cognitive disturbance that leads to anomalous conscious experiences is not sufficient to trigger psychosis. This happens against a back-drop of psychosocial vulnerabilities that influence how an individual forms an explanation as to the cause of these experiences. It would therefore seem unlikely that it is possible to create an experimental model of psychosis that faithfully mimics not only the basic cognitive disturbance, but also evokes the same external appraisal styles seen in psychosis. The study of appraisals is likely one area in which clinical research comes to the fore.

If it were possible to detect a ‘window’ following exposure to sensory deprivation during which cognitive tasks could be administered to participants, this would represent a low-risk and ethically acceptable way to study the basic cognitive disturbances of psychosis within the normal population. Sensory deprivation certainly has the potential to contribute significantly to our understanding of psychosis, and could work effectively on a stand-alone basis, or also as an adjunct to existing animal and drug models.

Dissemination of Results

<u>Published Book Chapters</u>

Daniel, C. and Mason, O. “Inducing altered states of consciousness”, in Schizotypy: New Dimensions. O. Mason and G. Claridge, Eds., Routledge, London, UK, 2014.

<u>Published Journal Articles</u>

Daniel C, Lovatt, A, Mason OJ . Quasi-psychotic experiences and their cognitive appraisal under short-term sensory deprivation. *Frontiers in Psychiatry* 2014. 5: 106. DOI: 10.3389/fpsyt.2014.00106

Daniel C, and Mason O. Predicting Psychotic-Like Experiences during Sensory Deprivation, *BioMed Research International*, vol. 2015, Article ID 439379, 10 pages, 2015. doi:10.1155/2015/439379

Fonseca-Pedrero E, Ortuño-Sierra J, Sierro G, **Daniel C**, Cella M, Preti A, Mohr C, Mason OJ. The measurement invariance of schizotypy in Europe, *European Psychiatry* 2015 Oct;30(7):837-44. doi: 10.1016/j.eurpsy.2015.07.005

<u>Submitted Journal Articles</u>

Submitted to Biological Psychiatry (co-author): Associations between psychosis endophenotypes across brain functional, structural and cognitive domains.

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Appendices

Appendix A

AANEX Inventory and CAR

Appendix B

State-Trait Anxiety Inventory

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name ______________________________ Date ______________

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	①	②	③	④
22. I feel nervous and restless	①	②	③	④
23. I feel satisfied with myself	①	②	③	④
24. I wish I could be as happy as others seem to be	①	②	③	④
25. I feel like a failure	①	②	③	④
26. I feel rested	①	②	③	④
27. I am "calm, cool, and collected"	①	②	③	④
28. I feel that difficulties are piling up so that I cannot overcome them	①	②	③	④
29. I worry too much over something that really doesn't matter	①	②	③	④
30. I am happy	①	②	③	④
31. I have disturbing thoughts	①	②	③	④
32. I lack self-confidence	①	②	③	④
33. I feel secure	①	②	③	④
34. I make decisions easily	①	②	③	④
35. I feel inadequate	①	②	③	④
36. I am content	①	②	③	④
37. Some unimportant thought runs through my mind and bothers me	①	②	③	④
38. I take disappointments so keenly that I can't put them out of my mind	①	②	③	④
39. I am a steady person	①	②	③	④
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	①	②	③	④

Appendix C

Psychotomimetic States Inventory (PSI)

Please complete the following questions by circling the number that best describes your experience <u>in the past few hours</u>

	Not at all	*Slightly*	*Moderately*	*Strongly*
1. You enjoyed mixing with people	3	2	1	0
2. You hesitated even when you knew what you are going to say	0	1	2	3
3. Your mood went up and down a lot	0	1	2	3
4. You felt that you could predict what was about to happen	0	1	2	3
5. You felt more sensitive to light or the colour or brightness of things	0	1	2	3
6. You felt close to people	3	2	1	0
7. You thought that you were being talked about	0	1	2	3
8. It was more difficult than normal to follow conversations with people	0	1	2	3
9. You felt rather indifferent about things	0	1	2	3
10. Your mind jumped a lot from one thing to another	0	1	2	3
11. You thought people were saying or doing things to annoy you	0	1	2	3
12. You thought other people could read your mind	0	1	2	3
13. You found it more difficult than usual to start doing things	0	1	2	3
14. You were bothered by the idea that people were watching you	0	1	2	3
15. You found activities less enjoyable than usual	0	1	2	3
16. Your mind was so full of ideas that you couldn't concentrate on one thing	0	1	2	3
17. You felt that people had it in for you	0	1	2	3
18. It was fun to do things with other people	3	2	1	0
19. You felt that you had special or magical powers	0	1	2	3
20. Your sense of smell was unusually strong or different	0	1	2	3
21. You wanted to be the centre of attention more than usual	0	1	2	3
22. Your experience of time was unnaturally fast or slow	0	1	2	3
23. You felt that no one understood you	0	1	2	3
24. You felt rather uninvolved with other people	0	1	2	3

Please turn over

	Not at all	Slightly	Moderately	Strongly
25. People could put thoughts into your mind	0	1	2	3
26. You experienced something very special or important	0	1	2	3
27. Your hearing became very sensitive	0	1	2	3
28. You found it difficult to think clearly	0	1	2	3
29. You stopped to think things over before doing them	3	2	1	0
30. Your speech was difficult to understand because your words were all mixed up	0	1	2	3
31. You felt that you might cause something to happen just by thinking about it	0	1	2	3
32. You felt as though your head, limbs or body had somehow changed	0	1	2	3
33. You felt that you deserved to be punished in some way	0	1	2	3
34. When you tried to concentrate many unrelated thoughts popped into your mind	0	1	2	3
35. Your thoughts were sometimes so strong that you could almost hear them	0	1	2	3
36. You saw a person's face in front of you when no one was in fact there	0	1	2	3
37. Your thoughts stopped suddenly, interrupting what you were saying	0	1	2	3
38. You had a vague sense of danger or sudden dread for reasons you didn't understand	0	1	2	3
39. You would have felt uncomfortable if your friends were to touch you	0	1	2	3
40. You felt that you could read other people's minds	0	1	2	3
41. Ideas and insights came to you so fast that you couldn't express them all	0	1	2	3
42. You thought people were laughing about you behind your back	0	1	2	3
43. You had the feeling of gaining or losing energy when people looked at or touched you	0	1	2	3
44. You could sense an evil presence around you, even though you could not see it	0	1	2	3
45. You could see shapes and forms even though they weren't there	0	1	2	3
46. You were easily distracted when doing something or talking to someone	0	1	2	3
47. You were confused by too much happening at the same time	0	1	2	3
48. You believed you were a special person with an important mission	0	1	2	3

Scoring Key

Sum the answers given to the following items for each sub-scale.

Please note that items 1, 6 18 and 29 are reverse scored on the form.

Delusional Thinking (8 items)

4, 12, 19, 25, 26, 31, 35, 40.

Perceptual distortion (10 items)

5, 20, 22, 27, 32, 36, 43, 44, 45.

Cognitive Disorganisation (9 items)

2, 8, 10, 13, 28, 30, 34, 37, 46, 47.

Anhedonia (7 items)

1, 6, 9, 15, 18, 24, 39.

Mania (6 items)

3, 16, 21, 29, 41, 48.

Paranoia (8 items)

7, 11, 14 17, 23, 33, 38, 42.

Appendix D

Revised Hallucinations Scale (RHS)

Below are a number of statements that people have expressed about personal experiences. Please read each item carefully and say how much you **generally agree** with it by **circling** the appropriate number. Please respond to **all the items**, there are no right or wrong answers. Do not spend too much time thinking about each one.

	Never	Sometimes	Often	Almost Always
1. I daydream about being someone else.	1	2	3	4
2. I hear a voice speaking my thoughts aloud.	1	2	3	4
3. A passing thought will seem so real that it frightens me.	1	2	3	4
4. I imagine myself off in far distant places.	1	2	3	4
5. I fantasise about being someone else.	1	2	3	4
6. In my daydreams I can hear the sound of a tune almost as clearly as if I were actually listening to it.	1	2	3	4
7. I hear the telephone ring and find that I am mistaken.	1	2	3	4
8. I hear people call my name and find that nobody has done so.	1	2	3	4
9. I have heard the voice of God speaking to me.	1	2	3	4
10. The people in my daydreams seem so true to life that I think they are real.	1	2	3	4
11. No matter how much I try to concentrate on my work unrelated thoughts always creep into my mind.	1	2	3	4
12. I can see thing strongly in my daydreams.	1	2	3	4
13. I can hear music when it is not being played.	1	2	3	4
14. I have seen a person's face in front of me when no one was there.	1	2	3	4
15. I can see the people in my daydreams very clearly.	1	2	3	4
16. My thoughts seem as real as actual events in my life.	1	2	3	4
17. I have a vivid imaginary life.	1	2	3	4
18. I have had the experience of hearing a person's voice and then found that there was no one there.	1	2	3	4
19. When I look at things they look unreal to me.	1	2	3	4
20. I see shadows and shapes when there is nothing there.	1	2	3	4
21. I have been troubled by hearing voices in my head.	1	2	3	4
22. When I look at myself in the mirror I look different.	1	2	3	4
23. The sounds I hear in my daydreams are generally clear and distinct.	1	2	3	4
24. When I look at things they appear strange to me.	1	2	3	4

Appendix E

Gudjonsson Suggestibility Scale (Short Version)

Appendix F

The Creative Experiences Questionnaire

Appendix G

The Cortical Hyperexcitability Index

Cortical Hyperexcitability Index (CHi)

Jason J Braithwaite

Rachel Marchant

Hayley Dewe

Chie Takahashi

A scale designed to provide an index of cortically mediated visual irritability, discomfort and associated visual distortions.

Version 1 = 27 questions.

Responses = 7-point unipolar Likert-scale, one for Frequency and one for Intensity.

For scoring – subtract '1' from the values given to create a range from 0 – 6. Sum the scores from both scales into an overall CHi index for each question, and then sum all the questions. Maximum possible score = 324.

Participants must complete both scales (frequency / intensity), which are summed to give an overall index of cortical hyperexcitability (CHi) for each participant.

1): Do you ever feel that your vision is more sensitive to external sensory information (e.g., light / patterns) than is usually the case?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

2): Do you ever feel overwhelmed by visual information?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

3): Do you ever feel that your visual perception seems heightened or enhanced?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

4): Have indoor lights ever seemed so bright that they have irritated and bothered your eyes?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

5): Have everyday objects ever looked different to you than their typical appearance (e.g., larger / smaller)?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

6): Have you ever experienced the phenomena of phosphenes (transient flashes / sparkles of light) for no apparent reason?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

7): Do you ever find certain environments to be visually uncomfortable / irritative?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

8): Do you ever see shapes, lights, or colours even though there is nothing really there?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

9): Do you ever find that the appearance of things or people seems to change in a puzzling way, (e.g. distorted shapes or sizes or colours)?

How frequently?

1 2 3 4 5 6 7

Never — All the time

How intense?

1 2 3 4 5 6 7

Not at all — Extremely intense

10): Have you ever seen and been distracted by shadows or movement in your peripheral vision, when nothing was there?

How frequently?

1 2 3 4 5 6 7

Never — All the time

How intense?

1 2 3 4 5 6 7

Not at all — Extremely intense

11): Have you ever felt dizzy / nauseous due to strong light levels or the presence of certain visual patterns?

How frequently?

1 2 3 4 5 6 7

Never — All the time

How intense?

1 2 3 4 5 6 7

Not at all — Extremely intense

12): Do you ever have days when lights or colours seem brighter or more intense than usual?

How frequently?

1 2 3 4 5 6 7

Never — All the time

How intense?

1 2 3 4 5 6 7

Not at all — Extremely intense

13): Have you ever seen an apparition / ghost?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

14): Do you ever experience visual pain / discomfort from looking at certain objects and patterns?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

15): Have you had a headache / migraine that you felt was induced by visual information in your immediate surroundings?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

16): Have you experienced visual distortions (e.g., shimmer, flicker, bending lines, shadows) when you have been tired or fatigued?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

17): Have you ever been aware of a 'flicker' on your computer screen?

How frequently?

1 2 3 4 5 6 7

Never ... All the time

How intense?

1 2 3 4 5 6 7

Not at all ... Extremely intense

18): Does working on a computer for long periods ever irritate / bother your eyes?

How frequently?

1 2 3 4 5 6 7

Never ... All the time

How intense?

1 2 3 4 5 6 7

Not at all ... Extremely intense

19): Have you ever noticed the presence of perceptual distortions in your vision as a result of lack of sleep?

How frequently?

1 2 3 4 5 6 7

Never ... All the time

How intense?

1 2 3 4 5 6 7

Not at all ... Extremely intense

20): Does working / reading under fluorescent lights irritate / bother your eyes?

How frequently?

1 2 3 4 5 6 7

Never ... All the time

How intense?

1 2 3 4 5 6 7

Not at all ... Extremely intense

21): Have you had an out-of-body experience, where you were convinced you experienced the world from a vantage point outside of your physical body?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

22): Do you ever sense the presence of another being, despite being unable to see any evidence ?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

23): Do headlights from oncoming traffic / cars irritate or bother your eyes?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

24): Do you experience visual discomfort / irritation from reading certain letter fonts / styles?

How frequently?

1 2 3 4 5 6 7

Never All the time

How intense?

1 2 3 4 5 6 7

Not at all Extremely intense

25): Have you ever experienced a sudden and unexpected narrowing of your visual field (greying out of peripheral vision / tunnel vision)?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

26): Have you ever experienced sudden and unexpected flashes of moving patterns (e.g., stripes / zigzags) imposed on the visual world?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

27): Have you ever experienced localised / partial alterations in your field of vision, resulting in a diminished, distorted, or transient loss of visual information?

How frequently?

1	2	3	4	5	6	7
Never						All the time

How intense?

1	2	3	4	5	6	7
Not at all						Extremely intense

Total Frequency =__________________

Total Intensity =__________________

Total CHi =__________________

Appendix H

UCL Ethical Approval Letter

UCL RESEARCH ETHICS COMMITTEE
GRADUATE SCHOOL OFFICE

UCL

Dr Oliver Mason
Research Department of Clinical Health and Educational Psychology
UCL

2 December 2013

Dear Dr Mason

Notification of Ethical Approval
Project ID: 5124/001: Sensory deprivation as an experiment model of psychosis

I am pleased to confirm that your study has been approved by the UCL Research Ethics Committee for the duration of the study i.e. **until January 2016.**

Approval is subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the study for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'.

The form identified above can be accessed by logging on to the ethics website homepage: http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Key Responsibilities of the Researcher Following Approval'.

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

   Reporting Non-Serious Adverse Events
   For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

   Reporting Serious Adverse Events
   The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the study you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

With best wishes for the research.

Yours sincerely

[redacted]

Professor John Foreman
Chair of the UCL Research Ethics Committee

Cc:
Christina Daniel, Applicant
John King, Chair of CEHP Ethics Committee

UCL Research Ethics Committee, c/o The Graduate School, North Cloisters, Wilkins Building
University College London Gower Street London WC1E 6BT
Tel: +44 (0)20 7679 7844 Fax: +44 (0)20 7679 7043
ethics@ucl.ac.uk
www.ucl.ac.uk/gradschool

Appendix I

Participant Information Sheets and Consent Forms

Information Sheet for Participation in Research Studies (A)

You will be given a copy of this information sheet.

Title of Project: **The Effects of Short-Term Sensory Deprivation**

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 5124/001

Name Christina Daniel

Work Address Research Department of Clinical, Educational and Health Psychology
University College London
Gower Street
London WC1E 6BT

Contact Details christina.daniel.13@ucl.ac.uk

We would like to invite to participate in this research project.

Details of Study:

This is a study investigating the experiences of people in sensory deprivation. You will have already completed an online questionnaire, and you are being invited to take part in the second part of the experiment. By taking part, you will get the unique opportunity to experience what it is like to spend a short period of time (approximately 25 minutes) in sensory deprivation. This will involve being alone in a room with zero light and sound. The results from this research will help us to understand more about people who experience certain types of mental health difficulties.

- I am recruiting adults aged between 18 and 65 years to take part in this study.
- In order to be able to take part, it is important that you have never experienced a major psychiatric or neurological disorder, and that you have not taken any recreational drugs in the last 3 months.
- You will be asked to complete some additional questionnaires and arrange a time to come to the Department of Language Sciences at UCL to take part in the experiment. This will take approximately 2 - 2.5 hours to complete.
- Because people do not normally experience sensory deprivation in their day-to-day lives, there is a small risk that you may find the experience stressful or you may have some unusual sensory experiences.
- You will be sent a copy of the final report once the study has been completed.
- Your contact details will be stored securely and will not be shared with anyone else except the researcher, who may need them to contact you about the study.
- All data will be anonymised so that you cannot be identified. Audio-taped interviews will be transcribed (written up) and the tape will then be wiped clear.
- All documents will be stored securely for 12 months following completion of the study, after which time they will be destroyed.

Please discuss the information above with others if you wish or ask us if there is anything that is not clear or if you would like more information.

It is up to you to decide whether to take part or not; choosing not to take part will not disadvantage you in any way. If you do decide to take part you are still free to withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.

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Details of Study:

This is a study investigating the experiences of people in sensory deprivation. You will have already completed an online questionnaire, and you are being invited to take part in the second part of the experiment. By taking part, you will get the unique opportunity to experience what it is like to spend a short period of time (approximately 15 minutes) in sensory deprivation. This will involve being alone in a room with zero light and sound. The results from this research will help us to understand more about people who experience certain types of mental health difficulties.

Part of this experiment involves the use of EEG (electroencephalography). The electrical activity produced by your brain can be measured with electrodes that are attached to the scalp surface. Because the signals are very small, it is necessary to clean your skin with alcohol and then use a very small amount of salt water to ensure the electrodes make good contact. The procedure of electrode attachment is painless (though it might occasionally give rise to a slight feeling of discomfort). After the recording session you will not be left with any residue in your hair besides it being a little bit damp in places, which will quickly dry.

The EEG electrodes are connected to a computer that records your brain activity at rest, and while you are in sensory deprivation. You will be asked to sit still during the entire measurement, since movements will interfere with getting accurate data. There will also be some additional questionnaires to complete.

Please expect to spend approximately 2 hours taking part.

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It is up to you to decide whether to take part or not; choosing not to take part will not disadvantage you in any way. If you do decide to take part you are still free to withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.

Informed Consent Form for Participation in Research Studies

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: **The Effects of Short-Term Sensory Deprivation**

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 5124/001

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Participant's Statement

I

- have read the notes written above and the Information Sheet, and understand what the study involves.
- confirm that I have never experienced a major psychiatric or neurological disorder, and that I am not currently using recreational drugs.
- understand that if I decide at any time that I no longer wish to take part in this project, I can notify the researchers involved and withdraw immediately.
- consent to the processing of my personal information for the purposes of this research study.
- understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.
- understand that the information I have submitted will be published as a report and I will be sent a copy. Confidentiality and anonymity will be maintained and it will not be possible to identify me from any publications.
- understand that I am being paid for my assistance in this research and that some of my personal details will be passed to UCL Finance for administration purposes.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study.

Signed: Date: