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Major research project: The influence of experience and reasoning on delusion formation

Paul Tabraham

University College London

North Thames Regional Health Authority

Doctorate in Clinical Psychology

CONTENTS

ABSTRACT

This study tested two theoretical models of delusion formation. The first suggests that most delusions are caused by the application of normal reasoning to abnormal experiences (Maher, 1974; 1988; 1992). The second suggests that many delusions are caused by an information-processing bias that results in both abnormal reasoning and abnormal experiences (Garety & Hemsley, 1994). The first model predicts that people with delusions, who demonstrate a "jump-to-conclusions" bias, will experience less perceptual anomalies (e.g. hallucinations) than those who do not. The second model predicts that people with delusions, who demonstrate a "jump-to-conclusions" bias, will experience more perceptual anomalies than those who do not. The second model also predicts that the "jump-to-conclusions" bias will be associated with a failure to make use of past regularities when processing new stimuli and a deficiency in the meta-cognitive skill of reality discrimination.

The presence of a "jump-to-conclusions" bias in fifty adults with delusions was assessed by their performance on a probabilistic inference task The performance of the 22 participants who demonstrated the bias, was compared with the performance of the 28 participants, in whom the bias was absent, on three computer-based tasks and two structured interviews, which sought to measure perceptual anomalies, reality discrimination and the use of past regularities in processing new stimuli.

Results indicated that people with delusions, who demonstrate a "jump-to-conclusions" bias, experienced less hallucinations than those who do not, thus supporting Maher's model. Experiences of voices commenting, olfactory hallucinations, visual hallucinations and general auditory hallucinations were more common in participants without a "jump-to-conclusions" bias. The "jump-to-conclusions" bias was not associated with a failure to make use of past regularities when processing new stimuli nor with a deficiency in the meta-cognitive skill of reality discrimination, thus contradicting Garety & Hemsley's model. A deficiency in auditory reality discrimination was associated with the experience of voices commenting. A deficiency in visual reality discrimination was associated with a failure to make use of past regularities when processing new stimuli although this information-processing bias was not observed in the sample as a whole.

It was concluded that there is considerable variation between individuals in the factors that result in delusions. Despite contradicting some specific predictions of Garety & Hemsley's (1994) model, the findings are consistent with a multi-factorial model of delusion formation. The relationship between these factors would be demonstrated more clearly by the identification of these factors in case studies of individuals with delusions, than by the identification of differences between groups of people with and without delusions. The mechanisms that connect these factors to psychotic phenomena would be elucidated by case studies that specify patients' experiences and cognitive biases in more detail than studies of heterogeneous groups.

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INTRODUCTION

Overview

This study tested two theoretical models of delusion formation. The first suggests that most delusions are caused by the application of normal reasoning to abnormal experiences (Maher, 1974; 1988; 1992). The second suggests that many delusions are caused by an information-processing bias that results in both abnormal reasoning and abnormal experiences (Garety & Hemsley, 1994). The first model predicts that people with delusions, who demonstrate a reasoning bias, will experience less perceptual anomalies (e.g. hallucinations) than those who do not. The second model predicts that people with delusions, who demonstrate a reasoning bias, will experience more perceptual anomalies than those who do not. Individuals with delusions, with and without a reasoning bias were compared in order to determine which of the two models was the most accurate.

Single Symptom Approach

Historically, psychiatry has dominated the study of psychotic phenomena. As a branch of medicine, psychiatric research has traditionally taken syndromes in which delusions sometimes occur (e.g. schizophrenia, bipolar affective disorder) as its objects of study. However, Persons (1986) has argued that the study of individual symptoms, rather than syndromes, has at least six advantages:

1. Avoidance of misclassification of subjects.

2. The study of important phenomena which are often ignored.
3. Facilitation of theoretical development.
4. Isolation of single elements of pathology for study.
5. Recognition of the continuity of clinical phenomena with normal phenomena.
6. Improvements in diagnostic classification.

This study applied the single-symptom approach to delusions. However, because delusions are commonly identified among people with a diagnosis of schizophrenia, literature on this syndrome was also considered.

Definitions of Delusion

The term "delusion" is used in everyday language to refer to false beliefs. The Oxford English Dictionary defines a delusion as:

"A fixed false opinion with regard to objective things, especially as a form of mental derangement." (Oxford English Dictionary).

Delusions are associated with a number of medical conditions (Maher, 1984). The term is used clinically to describe a category of beliefs that are assumed to be products of pathological processes.

Psychiatric Definition

The psychiatric classification system currently used in UK, ICD-10 (World Health

Organisation (WHO), 1992), contains no definition of delusion. The US system, the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV; American Psychiatric Association (APA), 1994), defines a delusion as:

"A false personal belief based on incorrect inference about external reality and firmly sustained in spite of what almost everyone else believes and in spite of what constitutes incontrovertible and obvious proof or evidence to the contrary. The belief is not one ordinarily accepted by the person's subculture (i.e. it is not an article of religious faith). When a false belief involves a value judgment, it is regarded as a delusion only when the judgment is so extreme as to defy credibility. Delusional conviction occurs on a continuum and can sometimes be inferred from an individual's behaviour. It is often difficult to distinguish between a delusion and an overvalued idea (in which case the individual has an unreasonable belief or idea but does not hold it as firmly as is the case with a delusion)." (DSM IV, p.765).

This definition contains only minor revisions to the definition used in both DSM-III (APA, 1980) and DSM-IIIR (APA, 1987). The DSM-III/-IIIR definition included examples of delusions involving extreme value judgments and spelt out the distinction between a delusion and a hallucination and between a delusion and an over-valued idea. The DSM-III/-IIIR definition does not state that delusions are held with absolute conviction but the potential for variation in conviction is clarified in DSM-IV. However, DSM-IV does not contain any information about the reason for changes.

In a book detailing their investigations into the psychology of delusional reasoning, Garety and Hemsley (1994) use, as a starting point for their discussion of modern definitions, one provided in a textbook of psychiatry:

"A delusion is an abnormal belief. Delusions arise from disturbed judgments in which the experience of reality becomes a source of new and false meanings. Delusions usually have attributed to them the following characteristics:

1. They are held with absolute conviction.
2. They are experienced as self-evident truths usually of great personal significance.
3. They are not amenable to reason or modifiable by experience.
4. Their content is often fantastic or at best inherently unlikely.
5. The beliefs are not shared by those of a common social or cultural background." (Mullen, 1979, p. 36).

The results of their own, and others' research, provide compelling empirical evidence that challenges the validity of ascribing these characteristics to delusions (see "Criticisms of Current Definitions" section).

Delusions can be divided into subtypes in at least two ways. The "Heidelburg approach" (Arthur, 1964) to delusions, espoused by phenomenologists such as Jaspers, Gruhle, Schneider and Mayer-Gross, made a distinction between primary and secondary delusions. The former are described as intrinsically unexplainable; an incorrect symbolic meaning is given to a correctly perceived stimulus. The latter are conceived as responses to disturbance in social or affective experience.

As well as the distinction between primary and secondary delusions, they are also often categorised according to their content. DSM-IV lists some more common types:

"**Bizarre** A delusion that involves a phenomenon that a person's culture would regard as totally implausible.

Delusional jealousy The delusion that ones sexual partner is unfaithful.

Erotomanic A delusion that another person, usually of higher status, is in love with the individual.

Grandiose A delusion of inflated worth, power, knowledge, identity, or special relationship to a deity or famous person.

Of being controlled A delusion in which feelings, impulses, thoughts, or actions are experienced as being under the control of some external force rather than being under one's own control.

Of reference A delusion whose theme is that events, objects, or other persons in one's immediate environment have a particular and unusual significance. These delusions are usually of a negative or pejorative nature, but also may be grandiose in content. This differs from an *idea of reference*, in which the false belief is not as firmly held nor as fully organized into a true belief.

Persecutory A delusion in which the central theme is that one (or someone to whom one is close) is being attacked, harassed, cheated, persecuted, or conspired against.

Somatic A delusion whose main content pertains to the to the appearance or functioning of one's body.

Thought broadcasting The delusion that one's thoughts are being broadcast out loud so that they can be perceived by others.

Thought insertion The delusion that certain of one's thoughts are not one's own, but rather are inserted into one's mind." (DSM-IV, p. 765-766)

As an atheoretical document, DSM-IV makes no claims about the mechanisms that might result in these types of delusions. In particular, it is silent about the possibility that different types of delusions might have different causes. Because many theoretical models of delusions have been proposed in the context of theoretical models of schizophrenia, they have often attempted to explain all delusions, and indeed all symptoms of schizophrenia, with a single pathological mechanism (e.g. Frith, 1979; Hemsley, 1996). This approach ignores the fact that few, if any, individuals hold all different types of delusion let alone all symptoms of schizophrenia.

It might be hypothesised that groups of delusion types have common features and might be expected to share common aetiologies and hence cluster in individuals. Delusions of control, thought insertion, reference and thought broadcasting explain perceptual experience in an immediate, automatic way; whereas persecutory and grandiose delusions seem to represent the conclusion of a conscious reasoning process that gives meaning to experience. This distinction resonates with the distinction, made by some philosophers, between "initial" and "derived" beliefs (Jones, 1999).

The question of whether types of psychotic symptoms cluster in individuals, and have independent causes, has been obscured by research being conducted in the context of diagnostic groups. Liddle (1987) used factor analysis to identify three syndromes within schizophrenia: psychomotor poverty, disorganisation and reality distortion. Williams (1996) identified four clusters of symptoms within a group of people with a diagnosis of schizophrenia: psychomotor poverty, disorganisation, reality distortion, and episodic (latent expression of positive symptoms). Unfortunately, both of these studies assume that schizophrenia is a meaningful construct, so people with psychotic symptoms whose frequency, duration or co-existence with affective symptoms cause them to receive different diagnoses were excluded. Also, the analyses were not fine-grained enough to identify clusters of delusion types.

Psychological Definition

As will be demonstrated in the next section, strict criteria to define delusions have received cogent criticism. Oltmanns (1988) suggests a definition of delusions should incorporate a list of defining characteristics, none of which is necessary or sufficient:

- The balance of evidence for and against the belief is such that other people consider it completely incredible.
- The belief is not shared by others.
- The belief is held with firm conviction. The person's statements or behaviours are unresponsive to the presentation of evidence contrary to the belief.
- The person is preoccupied by (emotionally committed to) the belief and finds it difficult to avoid thinking or talking about it.
- The belief involves personal reference rather than unconventional religious, scientific or political conviction.
- The belief is a source of subjective distress or interferes with the person's social or occupational functioning.

- The person does not report subjective efforts to resist the belief (in contrast to patients with obsessional ideas).

Garety & Hemsley (1994) found that, on the basis of empirical evidence, this was the most accurate definition, if also the most open-ended.

Criticisms of Current Definitions

The DSM-IV definition implies that:

1. The putative pathology most likely lies in a process of incorrect inference.
2. Any belief may be categorically classed as either true or false.
3. There are reliable criteria by which to judge the truth or falsity of a belief.
4. There are clear criteria for correct and incorrect inference.
5. There are reliable bases upon which to assess the degree to which the available counterevidence is sufficient to disconfirm a belief (Maher, 1992).

In clinical practice, the presence of delusions is inferred on the basis of common sense. If the belief expressed seems implausible then it is deemed to be false. Seldom is there an attempt on the part of clinicians to gather evidence with which to judge the truth or falsity of the belief. Paradoxically, this results in a situation whereby the process of inference that leads to a belief being assigned to the category "delusion" is actually less rational than the process of inference that leads to the delusion's formation, since it relies upon intuition rather than empiricism.

The second, third and fifth implications raise epistemological questions. If beliefs are considered to be equivalent to scientific hypotheses, then there are criteria with which to judge falsity but not truth. However, non-delusional beliefs are often unfalsifiable and therefore, unscientific. Questions of truth and falsity are best left to the discipline of philosophy. The first and fourth implications raise questions concerning processes of inference or reasoning and may be addressed by psychology. Indeed, the influence of reasoning on delusion formation and maintenance is a key issue addressed by this research.

Chadwick *et al.* (1996) provide a critique of the DSM-IIIR definition of delusions. The criterion of falsity is criticised firstly on the basis that delusions need not be false. A man who believes his wife to be unfaithful may have a delusion, even if the belief is true, if he reached this conclusion on the basis of spurious evidence (Brockington, 1991). Secondly, decisions about the truth or falsity of propositions are difficult to make even when a wealth of evidence is available. The task of making such decisions reliably on the basis of an interview is too much to ask of clinicians. Moor and Tucker (1979) claim that false beliefs are found in all people. They disagree with Chadwick *et al.* (1996) in that they believe that falsity is a necessary characteristic of a delusion, even if it is not sufficient grounds upon which to label a belief as delusional.

The factors that determine whether a belief is labelled delusional include more than an assessment of validity. For example, members of minority religions may hold a number of beliefs that are unusual. A belief in the existence of sentient, metaphysical beings, which are able to influence the physical world, is not necessarily a delusion. It will certainly never be labelled delusional if it is never talked about or acted upon. If an individual holding such a belief successfully publishes a book about it or runs workshops to teach others to communicate with these beings, the belief is not delusional. If he or she finds this belief frightening rather than comforting and seeks to prevent the influence of such spirits by wearing tin foil, the belief is likely to be labelled delusional. This indicates that it is not simply the content of a belief that makes it delusional but also the response of the individual to that content. Factors such as education, intelligence, social status and wealth may influence the likelihood that unusual beliefs are expressed in a way that is acceptable to friends, family, employers and government agencies, and consequently, the likelihood of the individuals holding those unusual beliefs coming into contact with mental health services.

The issue of "incorrect inference" amongst people with delusions is addressed more fully in a later section. Suffice it to say that biases in attributional style (Bentall *et al.*, 1994) and probabilistic reasoning (Garety, 1991) have been identified amongst people with delusions. However, the former apply only to delusions of persecution and the latter apply only to about 50% of people tested. Additionally, these biases have only been demonstrated on experimental tasks that result in the participants forming "conclusions" but not "beliefs", delusional or otherwise.

Chadwick *et al.* (1996), along with other commentators (e.g. Garety & Freeman, 1999) take the criterion, "firmly sustained" to indicate total and unwavering conviction. This is curious in that they also state that the DSM-IV definition allows for varying conviction (which it does) even though this definition also retains the criterion, "firmly sustained". Likewise, they state that the DSM-IV definition does not make any direct assertions about unmodifiability, yet the only implication that delusions are unmodifiable in DSM-IIIR is the criterion "firmly sustained in spite of what almost everyone else believes and in spite of what constitutes incontrovertible and obvious proof or evidence to the contrary", which is retained in DSM-IV. Perhaps the confusion lies in a difference between definitions in diagnostic manuals and criteria used to identify delusions in practice. This may explain Garety & Hemsley's (1994) decision to cite Mullen's (1979) definition.

Many delusions are held with strong or total certainty but so are many non-delusional political, religious and moral beliefs. Also, Brett-Jones *et al.*, (1987) showed that conviction in delusions could vary dramatically. The characteristic of unmodifiability or incorrigibility has also been challenged on empirical grounds. The application of cognitive-behavioural therapy (CBT) to delusions (Alford & Beck, 1994; Chadwick and Lowe, 1990; Chadwick *et al.*, 1994) has shown that, in the context of a sound therapeutic relationship, the presentation of contradictory evidence can modify delusions.

Finally, the DSM-IV definition implies that bizarreness is characteristic of delusions by stressing the fact that they are held "in spite of what everyone else believes" and are not "ordinarily accepted by the person's subculture". Attempts to measure bizarreness have proved unreliable (Kendler *et al.*, 1983) and Harper (1992) makes the point that the acceptability of beliefs changes across time and culture. For example, a belief that women have equal value to men and should, therefore, be allowed to own property and participate in public life would have seemed absurd in Britain until the end of the nineteenth century but self-evident in Northern Sumatra during the same period. Moor and Tucker (1979) note that defining delusions on the basis of deviancy, legitimises the use of psychiatry to repress dissenting minorities.

The assumption that delusions are qualitatively different to non-delusional beliefs has also been criticised (Strauss, 1969). It has been argued that delusional beliefs can best be distinguished from non-delusional beliefs by quantitative differences in a number of characteristics such as: conviction, maintenance factors, related affect, action, preoccupation, systematisation and insight (Buchanan *et al.*, 1993). Empirical studies of dimensions of delusions generally compare delusions with each other rather than contrast them with non-delusional beliefs. However, Jones & Watson (1997) compared delusions with three other types of belief: non-delusional beliefs of people with delusions, religious beliefs of people without delusions and overvalued ideas of people with anorexia nervosa, on a number of dimensions derived from clinical and philosophical literature (see "Identification and Measurement of Delusions" section).

One is left in the rather uncomfortable position of being unable to define delusions from first principles. In some ways the Oxford English Dictionary's definition sums up the problem, in that delusions are false beliefs associated with "mental derangement" and also clinical phenomena whose presence indicates "mental derangement". So the definition is circular; a belief is called a delusion because it is held by a person who is "mentally deranged" and a person is "mentally deranged" because they have a delusion. There are examples of non-delusional beliefs that have many, if not all, of Oltmann's defining characteristics. However, those beliefs are never classified as delusions because their holders do not transgress societal or legal conventions. Consequently, they do not come into contact with agencies that are responsible for the identification and eradication of "mental derangement" in general and delusions in particular.

Despite these problems with definition, the beliefs of interest to clinicians are those that present clinically. For this reason, the most pragmatic solution is to defer the responsibility for identifying delusions to the discipline that specialises in the identification of signs and symptoms indicative of mental illness, psychiatry. In practice, psychological research into delusions relies upon psychiatric tools of measurement to assess their presence and severity (e.g. Dudley *et al.*, 1997; Garety *et al.*, 1991; Peters *et al.*, 1999; Pickup & Frith, 2001).

Identification and Measurement of Delusions

Problems in the definition of delusions lead to problems in their reliable identification. Beliefs whose content is similar to that found in common types of delusions (i.e. persecution, grandiose, alien control etc.) are more likely to be described as delusions. The Schedule for the Assessment of Positive Symptoms (SAPS; Andreason, 1984) contains a semi-structured interview that probes for delusions of persecution, of jealousy, of sin and guilt (whose severity is assessed on the basis of consistency, influence on behaviour, preoccupation and bizarreness), of reference, of mind reading, of thought broadcasting, of thought insertion, of thought withdrawal, grandiose delusions, religious delusions and somatic delusions (whose severity is assessed on the basis of frequency, influence on behaviour, and pervasiveness).

There is no sure way to assess the validity of beliefs on the basis of an interview.

However, many of the beliefs falling into the categories above are assumed to be false because they describe phenomena for which there is no scientific evidence (i.e. mind reading, thought broadcasting, thought insertion, thought withdrawal). Similarly, religious and grandiose delusions often contain elements of non-scientific phenomena. There may be clear evidence that some somatic delusions are false but, if the belief concerns the internal functioning of the body, there may not be evidence available. Somatic delusions may be bizarre (e.g. a belief that there is a snake inside one's head) or quite reasonable (e.g. a belief that one is HIV positive). In the latter case the truth or falsity of the belief cannot be inferred without reference to further evidence.

Beliefs about sin and guilt may be categorised as delusions on the basis that they derive from value judgments that defy credibility. However, the delusion may refer to an act that the individual believes that he or she performed, but the assessor has no way of knowing whether or not the act was performed by the individual. Likewise, beliefs about a partner being unfaithful are difficult to disprove and can only be assessed on the basis of the evidence that individuals have used to reach this conclusion. Delusions of reference are often unlikely (e.g. a belief that the news presenter was addressing one individual exclusively) but this is not always the case (e.g. a belief that one is being talked about by other people). Lastly, beliefs about being harassed or monitored present problems for assessment in that they are often possible (e.g. "racists are breaking my windows") and difficult to disprove (e.g. "people at work are spreading rumours that I am homosexual"). Persecutory delusions may contain implausible or highly unlikely elements (e.g. "the CIA is using satellites to watch me") and the evidence from which this conclusion was derived may indicate that the belief is not reasonable but occasionally the individual may be being monitored by a less sinister agency (e.g. a private detective hired by a suspicious partner) and mistake this for a more powerful organisation.

As was described above, the fact that a belief is false is not sufficient for it to be classified as delusional. Garety & Hemsley (1994) measured a number of dimensions of delusional beliefs: conviction, preoccupation, interference, resistance, dismissibility, absurdity, self-evidentness, reassurance seeking, worry, unhappiness and pervasiveness. Of these dimensions they found that only conviction received no self-rated low scores and there was still considerable variation. These ratings were specific to one delusion and not compared to non-delusional beliefs. Jones & Watson (1997) compared delusions with non-delusional beliefs of people with delusions, with religious beliefs of people without delusions and overvalued ideas of people with anorexia nervosa on 12 dimensions: conviction, influence on behaviour, influence on cognition, truthfulness, importance, frequency, cultural acceptability, imagination, speed, perception, thought and affect. Amongst other things, they found that delusions differ from the religious beliefs of people without delusions, on dimensions of frequency (of consideration), (role of) imagination, speed (at which the belief is formed) and (role of) perception.

The multi-dimensional nature of delusions raises questions for theoretical models of delusion formation, which have concentrated on the mechanism by which false beliefs are formed. As Moor & Tucker (1979) point out, a belief must be more than false for it to be categorised as a delusion. It may be that extreme values of any number of dimensions of belief lead to those beliefs being labelled delusional and that independent psychological processes influence these dimensions. It is also possible that delusional beliefs might arise through the combined effect of several different psychological processes.

Theoretical Models of Delusion Formation and Maintenance

Theoretical models of delusion formation and maintenance have been proposed by Maher (1974; 1988; 1992), by Bentall *et al.* (1994), by Frith (1992) and by Garety & Hemsley (1994) (see Garety & Freeman, 1999 for a review).

Maher's Model of Delusion Formation and Maintenance

Maher's theoretical model of delusion formation denies that delusions arise from an incorrect process of inference; a fact assumed by current psychiatric definitions (e.g. DSM-IV). In his most recent formulation of the theory (1992, p.262) he proposed that "the origin of delusions lies *most often* in the nature of conscious experience of the patient, rather than the inferential processes that are brought to bear on that experience." (italics added). He makes no predictions about how often inferential processes might be involved but the statement implies that he believes them to influence delusion formation in less than 50% of all people with delusions or less than 50% of all delusions. These are not the same because one person can, and often does, have more than one delusion and it is theoretically possible that the aetiologies of two delusions within one individual differ.

In Maher's opinion, most delusions are normal beliefs, which explain abnormal (or anomalous) experience (i.e. perception is abnormal but inference is normal). They are delusional (i.e. unshared, held with high conviction, distressing, an influence on behaviour, etc.) because they explain anomalous experience (i.e. experience that the experiencer believes is real but other people do not believe is real). Maher (1992, p.262-263) states that "[t]he essential elements of the hypothesis are:

- The cognitive processes by which delusions are formed are in no important respect different from those by which normal beliefs are formed.
- Delusions serve the purpose of providing order and meaning for empirical observations. In this respect they resemble scientific theories, and have the same adaptive function.
- As in the sciences, the necessity for a theory arises whenever nature presents us with a puzzle. Puzzles arise when predictable events fail to occur and/or unpredicted events do so in their place, e.g. when observation is discrepant with expectation."

Maher & Ross (1984) delineate a sequence of processes that are involved in the formation of all new beliefs, delusional and non-delusional:

Initial observation. Not all observations lead to new beliefs; only those observations that are not expected, that is, observations that are not predicted by an individual's stored knowledge of regularities in the world. Beliefs predict that certain causes reliably result in certain effects. Beliefs are internal representations of these cause and effect relationships, usually encoded in language. Events whose character, timing or location is unexpected, present a puzzle to the individual. The current internal representations of cause and effect relationships are inadequate to explain the observation and must be modified or replaced. Maher likens this to the first stage in the process that results in the creation of a scientific theory.

Experience of puzzlement. The experience of the unexpected evokes a state of puzzlement, curiosity, confusion or surprise. Maher hypothesises that humans are motivated to terminate this state. This does not seem unreasonable although it is likely that some individuals are more curious than others. The relationship between this trait curiosity and state curiosity is unknown. Some individuals may have a high threshold of curiosity whereby they would only be motivated to modify or replace beliefs after frequent unexpected observations. Tolerance of this apparently aversive state might also vary between individuals. The Need for Closure Scale (Kruglanski *et al.*, 1993) measures a construct related to curiosity and tolerance of ambiguity. Using this scale, Colbert (1999) found that students scoring high on the Peters *et al.* Delusions Inventory (PDI: Peters *et al.*, 1999) demonstrated a greater need for closure than students scoring low on the PDI.

The state of puzzlement motivates the individual to check the unexpected observation and, if it is confirmed, to examine other aspects of the environment that may be related to it. The observer begins to form a hypothesis or hypotheses about the observation and its relationship to other environmental events.

Additional observations. The state of puzzlement stimulates a search for additional observations. If the observations are consistent with the hypothesis it gains increasing empirical support.

Explanatory insight. At a certain point the hypothesis has gathered enough empirical support to be accepted as an explanation for the previously unexpected observation. Maher & Ross (1984) compare this to the development of scientific theories and provides examples of this "eureka effect".

Process of confirmation. Once a hypothesis has become a belief it has the power to influence cognition and behaviour, and therefore, perception and affect. The phenomenon of confirmation bias has been demonstrated by research into human reasoning (Kahneman *et al.*, 1982). Existing beliefs influence cognition, behaviour, perception and affect in such a way as to maintain those beliefs. This is achieved by selectively attending to confirmatory observations, minimising the importance of disconfirmatory observations and selectively recalling and rehearsing memories of confirmatory observations.

Experimental Evidence Consistent with Maher's Model

The most compelling evidence for Maher's model is a failure to demonstrate systematic differences in reasoning between people with delusions and people without delusions (but see "Experimental Evidence Consistent with Garety & Hemsley's Model" section). Von Domarus (1944) suggested that delusions were a result of defective logical reasoning, the defect being the assumption of the identity of the subject on the basis of identical predicates. An example of the error would be: "Jesus was persecuted; I am persecuted; therefore, I am Jesus." However, empirical research demonstrated that normal subjects showed similar defects in deductive reasoning (Nims, 1959 cited in Maher & Ross, 1984; Williams, 1964). The strength of the model lies not in the evidence for it but in the lack of evidence against it. It provides a plausible mechanism by which delusions might result from a non-pathological process of reasoning, which explains pathological experience. There is no reason to posit a defect in two processes when a defect in one will explain observations.

Empirical evidence for the theory comes from single case studies of people with delusions, which demonstrate that the patients' delusions were rational interpretations of experience. For example, Southard (1912) describes a man who believed that his stomach was full and he was unable to eat. At autopsy he was found to have an obstruction in his colon. He also describes a woman who complained of bees in her head. She was found to have a medical condition that softened her skull bones resulting in increased pressure on the brain and probable mechanical stimulation of receptor areas.

The wide range of neurological, metabolic and neurotoxic disorders with which delusions are associated (Maher & Ross, 1984) suggest that a degree of physiological disturbance often precedes psychological disturbance. Researchers have demonstrated the possibility of generating irrational beliefs in participants under hypnotically induced sensory impairment (Zimbardo *et al.*, 1981), sensory deprivation (Jones, 1966) and undiagnosed hearing loss (Cooper *et al.*, 1976; Cooper *et al.*, 1974).

Nielsen (1963) conducted an experiment in which participants, with no history of mental illness, were required to use a joystick to track a visual target. After several legitimate trials an optical illusion gave the impression that the participant's hand continued to control the joystick, whereas in fact, the hand they saw was false. This false hand moved at the same time as the participants' but failed to track the visual target accurately. Of the 28 participants, only two explained their poor performance as due to an artificial hand controlling the joystick. Some guessed that an optical illusion had been involved but others suggested that their hand had been taken over by an outside force, that their hand had become autonomous from their brain, that they had been hypnotised, that it had been done by magic or even that it was due to the participant's sexual orientation.

These studies certainly demonstrate that anomalous perceptual experiences do cause some people to generate explanations that are not valid objectively. Their explanatory power may be sufficient to make them resistant to change, especially in the absence of more compelling explanations. However, there is evidently variation between individuals in the way that they account for similar experiences.

Criticisms of Maher's Model

Winters & Neale (1983) criticise Maher's model on the grounds that an association between hearing loss and the presence of delusions does not mean that the former causes the latter. Potentially, delusions could cause hearing loss, both could result from a third factor or another unknown factor might be necessary to mediate the effects of hearing loss. Maher (1988) accepts the criticism but the fact that he is able to propose a plausible mechanism by which hearing loss might cause delusions makes this explanation of the data most appealing (see Einhorn & Hogarth, 1986).

A second theoretical criticism is the question why people with delusions reject "natural" explanations for their experience. This assumes that most people reject implausible explanations in favour of reasonable, empirically testable ones and are willing to accept alternative explanations in the light of observations inconsistent with their original explanation. Maher (1988) counters this criticism by pointing out that people are in fact reluctant to change their beliefs, even when they are presented with evidence that contradicts them, that delusions often explain experience better than natural explanations, which require the experiencer to trust other people's senses more than their own, and that only a minority of human explanations are "natural". In order to illustrate this last point Maher refers to an article that provides many examples of the fantastic beliefs of professionals from Western cultural backgrounds (Roszak, 1981).

Garety & Freeman's (1999) review of cognitive approaches to delusions states that Maher's hypothesis "does not provide a complete account of all delusions" (implying that it does provide a complete account of an unknown proportion of delusions) for three reasons:

1. "[S]ome delusions are found to occur in the absence of any anomalous experiences (e.g. Chapman & Chapman, 1988)." This book chapter, by Chapman & Chapman, reports the findings of a study of 162 college students who scored deviantly high on either one or both of the Perceptual Aberration Scale (Chapman *et al.*, 1978) and the Magical Ideation Scale (Eckblad & Chapman, 1983). They found a great deal of variation in the interpretation of experience and that some participants developed aberrant beliefs in response to experiences that would not be considered anomalous by most people (although the assessment of anomaly depends on pre-existing beliefs). None of the participants had received clinical attention at the

time of the first interview but 25 months later, three had received diagnoses of psychotic illnesses, all of whom had reported anomalous experiences at the first interview. The rest did not have clinical delusions, although they did have some unusual beliefs. However, since they were selected on the basis of a questionnaire that measures aberrant perceptions it seems unreasonable to argue that these unusual beliefs developed in the absence of anomalous perceptions.

This study does raise the question, why did some participants form delusional explanations for their experiences whereas others formed natural explanations? Only some of the participants who experienced perceptual anomalies formed delusional explanations for them. This suggests that another factor, additional to the experience of perceptual anomalies, must be present before delusions are formed.

2. "[P]eople with delusions......may display systematic differences in cognitive processes." There is quite a lot of evidence for this (see Garety & Freeman, 1999 for a review), but it only demonstrates that these differences coexist with delusions and might contribute to their maintenance. It does not show that they contributed to delusion formation unless the presence of abnormal cognitive processes is observed to predate the presence of delusions. It may be that holding unusual beliefs causes (rather than, is caused by) unusual cognitive processes. Investigating the influence of cognitive processes on delusion formation would, therefore, require a longitudinal study of a high-risk population. However, the influence of cognitive processes on the maintenance of delusions is an important and clinically relevant question.

Some evidence that reasoning biases predate delusion formation comes from a study by Linney, *et al.* (1998), who found that individuals who did not have clinical delusions, but scored high on the PDI, demonstrated biases in inferential processes similar to those observed in people with delusions, namely: "jump-to-conclusions" style of data gathering and decreased sensitivity to the effects of random variation. The PDI measures levels of preoccupation, distress and conviction in propositions derived from the Present State Examination (Wing *et al.*, 1974). It is not clear whether the absence of clinical delusions amongst this group is due to a lesser degree of bias or to the influence of other factors (e.g. low level of personal investment in the belief or limited influence of the belief on behaviour).

3. "[T]he experience of anomalous percepts ..... may result, in part, from biased cognitive processes in the task of 'reality discrimination'." Reality discrimination is a term used by Bentall (1990) to describe a metacognitive skill that classifies the source of mental events as external (i.e. as perception) or internal (as imagination). Garety & Freeman's (1999) argument is that anomalous perceptions, which Maher proposes as the cause of delusions, may themselves be a result of a biased cognitive process akin to reasoning.

Research into hallucinations has demonstrated a bias amongst people with a diagnosis of schizophrenia who hallucinate and amongst people scoring high on the Launay-Slade Hallucination Scale (LSHS; Launay & Slade, 1981) to attribute mental events to an external source (Bentall & Slade, 1985; Rankin & O'Carroll, 1995; Bentall, *et al.* 1991, Brébion *et al.*, 1998). Whether the cognitive processes measured in these tasks can be described as reasoning is debatable. Reality discrimination is an automatic process whereas reasoning is usually considered to be a controlled evaluation of evidence.

The existence of the diagnostic category, "delusional disorder" (APA, 1994), presents a further challenge to Maher's model. However, the model can cope with the challenge in a number of ways:

1. A diagnosis of delusional disorder can be applied to individuals who have experienced hallucinations provided such experiences are limited to a few brief periods (APA, 1994).
2. Anomalous perceptions include phenomena that are not clinically significant (e.g. hyper-alertness, poor selective attention, etc.). Individuals with delusional disorder may experience subtle perceptual anomalies.
3. A minority of delusions do originate from abnormal reasoning processes. Some individuals with delusional disorder demonstrate biased reasoning processes (Garety *et al.*, 1991).

The existing evidence is not sufficient to reject Maher's hypothesis that *most* delusions are caused by anomalous perceptions alone. If Maher's hypothesis is correct, then *most* people with delusions will experience anomalous perceptions (unless the anomalous perceptions have responded to treatment and delusions are maintained by normal cognitive factors). Even Garety & Freeman's (1999) implicit acceptance that *some* delusions are caused by anomalous perceptions alone, warrants further investigation in order to determine the proportion of people with delusions for whom this is the case.

Garety & Hemsley's Model of Delusion Formation and Maintenance

Garety & Hemsley's (1994, p.129) model of delusion formation differs from Maher's model because it suggests that reasoning biases are an important factor in the formation of a large proportion of delusions. It emphasises the influence of multiple processes on belief formation. Biases and deficits in these processes result in the formation of delusional beliefs. The relative influence of these disrupted processes varies from individual to individual; "[i]n some, personality, affect, self-esteem and motivation play a part; in others, abnormalities of perception and judgement are prominent."

The model is probably best represented diagrammatically (see Figure 1). Box 1 represents the prior expectations of the individual. Box 2 represents an event perceived by the individual. Many environmental events are not processed consciously. Information that is expected, unambiguous and affectively neutral will be processed automatically (Dixon, 1982). This is represented in box 3. Information that is unexpected, ambiguous and affectively loaded is more likely to be processed consciously. In recognition of the active nature of perception, the model combines perception and inference in box 4. This is the point at which biased information-processing styles influence the interpretation of experience and their consequences for behaviour. A bias to be unduly influenced by prominent current stimuli over previously learned regularities that has been identified in some people with a

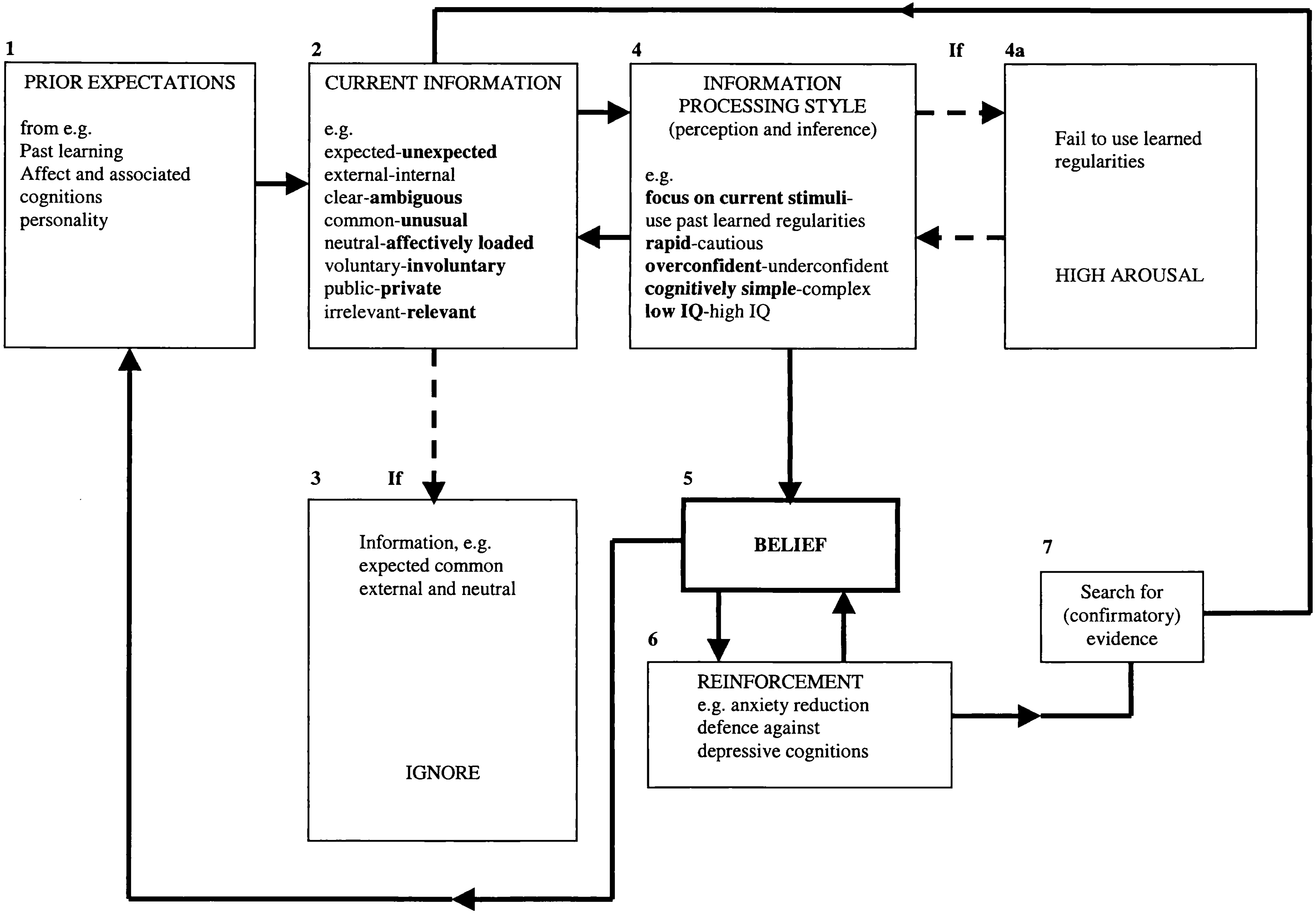


Figure 1. Garety & Hemsley's (1994) model of delusion formation

diagnosis of schizophrenia (see Hemsley, 1996 for a review) means that current information is accorded excessive weight, resulting in invalid inferences. This bias also leads to frequent mismatches between expected and actual events and a consequent increase in arousal level (Gray, 1985). The individual may also be in a state of high arousal for other reasons (e.g. anger, anxiety) but whatever the cause, high arousal causes cognitive processing to become increasingly rapid and shallow (Gray, 1985). This is represented in box 4a.

Box 5 represents the belief formed as a result of the information gathered and processed. Although it is not clear from the diagram, the model does not suggest that it is usual for new beliefs to form as a result of a single unexpected event. However, when the current information is ambiguous, the effect of any reasoning bias is greater and belief formation as a result of a single experience is more likely. The model does not distinguish between hypotheses or ideas and beliefs. Intuitively, and according to Maher's model, one would assume that several hypotheses might be generated and further information gathered before a belief was granted assent. This search for further information is represented in box 7 and the point is made that it is normal to search for confirmatory evidence. A belief that relieves confusion or aversive affective states (e.g. fear, unhappiness) will be reinforced (box 6). The belief then influences the expectations of the individual (box 1).

The model proposes that some delusions are normal beliefs that explain abnormal experience, as suggested by Maher. However, other delusions are abnormal beliefs that explain normal experience (i.e. input is normal but processing is abnormal). Still other delusions are abnormal beliefs that explain abnormal experience (i.e. input is abnormal and processing is abnormal). The model goes on to state that there are a variety of factors that influence input and processing: personality, affect, self-esteem, motivation, abnormalities of perception, abnormalities of judgement. They state that "different types of delusions are likely to involve different mechanisms." The model does not explain how one might distinguish between these different types of delusions clinically. Therefore, by Garety & Hemsley's own admission, "[s]uch a model assists in making predictions only after a detailed assessment of the individual case."

Experimental Evidence for Reasoning Biases amongst People with Delusions

Garety & Hemsley's (1994) proposition that some delusional beliefs are formed by a process of abnormal reasoning has a long history. The rejection of Von Domarus's (1944) hypothesis described earlier, illustrates a difficulty in the study of reasoning; the identification of a standard against which to compare groups. Prescriptive approaches such as Von Domarus's are problematic because of errors of reasoning identified in individuals without delusions. Comparative approaches have had more success. A number of studies have shown that people with delusions "jump-to-conclusions" on a probabilistic inference task (Huq *et al.*, 1988; Garety *et al.*, 1991; Dudley *et al.*, 1997a; Peters *et al.*, 1997; Fear & Healy, 1997).

A typical example of the task is to present subjects with two jars. Each jar contains 100 coloured beads. In one jar there are 85 red beads and 15 green beads. In other jar there are 15 red beads and 85 green beads. The participant is informed that the jars will be removed from his or her view and that one of the jars will be selected. He or she is then informed that the experimenter will remove beads from the selected jar and show them to him or her one at a time, replacing each bead before the next one is drawn so that there are always one hundred beads in the jar. The participant's task is to decide from which jar the beads are being drawn. In fact the beads are shown to the participant in a pre-determined order.

Garety *et al.* (1991) have demonstrated that a *subgroup* of people with delusions exhibit biased performance on such probabilistic inference tasks. This bias causes some people with delusions to decide to which category (85 red beads: 15 green beads or 15 red beads: 85 green beads) an entity (jar filled with red and green beads) belongs, on the basis of less evidence (beads drawn from the jar) than either that required by Bayes' Theorem or by people without delusions. In speculating about the cause of the "jump-to-conclusions" (JTC) bias, Garety & Hemsley (1994) suggest two options: "a disruption of 'gestalt' perception so that the part is taken to equal the whole (Cutting, 1985)" and "an over-emphasis on present stimuli, neglecting past learning (Hemsley, 1987)." Dudley *et al.* (1997) suggest two additional alternative explanations of the JTC bias: a functional strategy that reduces cognitive demands or an extreme version of the confirmation bias. Clare *et al.* (1993) suggested that the effect could be accounted for by memory problems or impulsivity although these seem unlikely in the light of Dudley *et al.*'s (1997) findings.

Dudley *et al.* (1997) tested the hypotheses that the effect was due to impulsivity or memory problems by changing the basic task in two ways. Firstly, they created a second condition in which the ratio of beads was 60:40 instead of 85:15. They found that participants with delusions requested more beads in the 60:40 condition than the 85:15 condition, indicating that they had taken account of the fact that more evidence was required to reach a conclusion. However, even in the 60:40 condition they requested less beads than participants without delusions. Secondly, they provided participants with a running total of the number of beads of each colour presented so far, to eliminate the influence of memory problems.

Dudley *et al.* (1997) also found that the reasoning of the group of people with delusions did not differ from the reasoning of the group of people without delusions, if the amount of evidence presented was controlled by the experimenter. They presented a group of individuals with delusions and a group of individuals without delusions with, what they were told was, the outcome of a series of coin tosses. Participants were asked to estimate the probability that the coin was biased to heads. Both groups reasoned in the same way; they were unduly influenced by the strength of the evidence (the proportion of heads in the sample) and did not take account of weight (the number of spins). For this reason Dudley *et al.* (1997) suggest that the difference in performance observed in individuals with delusions is more accurately described as a *data-gathering* bias than a reasoning bias.

In a review of eight studies that investigated the performance of individuals with delusions on the "beads" task, Garety & Freeman (1999) found that the seven that measured draws to decision all demonstrated a JTC bias in the group of people with delusions. Some studies used an alternative measure of performance instead of, or in addition to, draws to decision. In these studies, participants were asked to estimate the probability that beads were being drawn from a specified jar after each draw. Neither Garety *et al.* (1991), Fear & Healey (1997) nor Young & Bentall (1997a) found a significant difference between the group of people with delusions and the group of people without delusions on this measure. Conversely, Peters *et al.* (1997) did find a significant difference in early probability estimates, with individuals with delusions expressing higher estimates than both depressed and non-clinical controls.

Other studies have investigated the performance of people with delusions on a variety of reasoning tasks. John & Dodgson (1994) compared the performance of a group of 12 people with delusions and a diagnosis of schizophrenia, to that of a group of depressed people and a group of non-clinical controls. Their task required participants to discover the identity of an object by asking questions. Only questions that could be answered with a "yes" or with a "no" were permitted. They found that the group with delusions requested less information than either control group and made more errors, indicating that a JTC bias was demonstrated by this task.

Young & Bentall (1995) found a trend for a group of 16 people with persecutory delusions to generate fewer correct hypotheses than depressed or non-clinical controls on a hypothesis-testing task. They also found that people with delusions were more likely to change their hypotheses than controls after being given positive feedback. There was evidence of a relationship between task performance and non-verbal IQ. Bentall & Young (1996) gave similar groups a questionnaire that asked them to choose between three methods of testing hypotheses. They found no difference between the groups, which were matched for age, IQ, sex and years in full time education. They concluded that people with persecutory delusions were able to employ sensible hypothesis testing strategies.

Kemp *et al.* (1997) compared the performance of a group of 16 people with delusions

(14 diagnosed with schizophrenia, one with delusional disorder and one with atypical psychotic disorder) with that of a group of non-clinical controls. Their tasks tested formal logic (syllogistic reasoning, judgements of probability and conditional reasoning). They found that both groups were poor at all tasks. However, the group with delusions endorsed more fallacious or invalid responses relative to controls, especially when emotive themes were involved. The groups were not matched for age, sex or IQ in this study, nor was there a clinical control group. Consequently, the differences in performance might by explained by non-specific factors rather than the presence or absence of delusions.

Linney *et al.* (1998) compared a group of 20 students scoring high on the Peters *et al.* Delusions Inventory (PDI; Peters *et al.*, 1999) with a group of 20 students scoring low on the PDI. They found no differences on Wason's selection task, which requires participants to employ an effective hypothesis testing strategy, or on the book/suicide problem, which requires participants to aggregate probabilistic information. They did find differences in performance on Wason's 2-4-6 problem and a coin-tossing task. In Wason's 2-4-6 problem, participants are asked to generate triplets of numbers and informed of a rule to which they conform (Dax: three numbers different, or Med: two or more numbers the same). They are required to discover these two rules by using the experimenter's feedback. This is similar to the task used by Young & Bentall (1995), except that participants are expected to gather their own feedback on Wason's 2-4-6 problem. The coin-tossing task was similar to that used by Dudley *et al.* (1997) and results were consistent with this study in that both groups were overinfluenced by strength in comparison to weight. However, an alternative method of analysis allowed Linney *et al.* (1998) to compare the influence of weight (i.e. sample size) between groups. This analysis indicated that the group scoring high on the PDI were less sensitive to variations in sample size relative to low scorers. Linney *et al.* (1998) concluded that insensitivity to the effects of random variation causes individuals to "jump-to-conclusions" because they fail to appreciate that a larger sample size is more representative.

Research into individuals without delusions who, nevertheless, score highly on measures of delusional ideation such as the PDI, is important because such individuals are assumed to have an increased risk of developing psychosis. Systematic differences in reasoning between groups scoring high and low on measures of delusional ideation indicate that these differences might influence delusion formation. Systematic differences between groups of people with and without delusions might indicate that these differences only influence the maintenance of delusions or even that the presence of delusions causes these differences. Linney *et al.* (1998) interpret their results as evidence of a relative lack of sensitivity to random variation in people with high delusional ideation. They suggest that this insensitivity will result in an underestimation of the probability that an event has occurred by chance and so trigger a search for an alternative, potentially delusional, explanation. Furthermore, a bias towards gathering inadequate evidence would result in the hasty acceptance of hypothetical explanations as facts.

Garety *et al.* (1991) found that on the "beads" task "seven (45%) of schizophrenics responded with a decision after one draw and four (29%) of those with delusional disorder." Although this result was not statistically significant (samples sizes were small), they point out that, if anomalous perceptions can account for delusion formation, then one would expect to find that individuals in whom anomalous experiences were less evident, would be more likely to show abnormalities of reasoning. It is not unreasonable to assume that people with a diagnosis of schizophrenia would be more likely to have anomalous experiences than people with a diagnosis of delusional disorder. They go on to state that "[o]ne intriguing association in these data is between the judgemental bias and perceptual anomalies; could both possibly result from a common cause?"

Criticisms of Garety & Hemsley's Model

There is compelling evidence of differences in performance between groups of people with delusions and groups of people without delusions on probabilistic inference tasks. However, the mechanism by which a "jump-to-conclusions" bias might lead to delusions is not self-evident. The task is based on Bayesian models of inference. This is a prescriptive model of inference that received great attention in the 1960's and 1970's. After years of work, most researchers concluded that human reasoning is not Bayesian. Consequently, Bayesian models are not useful as a prescriptive standard. However, its utility as a descriptive model remains (Fischoff & Beyth-Marom, 1983). The reasoning of individuals or groups of individuals can be described in terms of its adherence to, or deviance from Bayesian norms. Despite Huq *et al.* (1989) deriving their paradigm from Bayesian models they do not account for their findings in a Bayesian framework. The *conservatism* in individuals without delusions is generally accepted to result from a failure to take account of the change in the probability that the alternative hypothesis is true following each new datum, (Fischoff & Beyth-Marom, 1983). In the "beads" task, this results in individuals without delusions ignoring the fact that the probability of making consecutive draws of more than one green bead from a jar containing 15 green and 85 red beads is very low.

As a group, people with delusions do not show this conservatism and tend to decide at a point prescribed by Bayesian rules, after seeing two beads. As Maher (1992) points out this is somewhat problematic to theories of delusion formation that propose a causative role for biased inference since it suggests that people with delusions are less, not more, likely to draw invalid conclusions from evidence. However, further analysis of the results show that the distribution of performance of people with delusions is bimodal and the group average is highly influenced by people who decide on the basis of a single bead.

As noted above a number of hypothetical explanations for this phenomenon have been described but these have not been put back into a Bayesian framework. Another concern is the fact that Bayesian models of inference relate to hypothesis evaluation, not belief formation. The relevance of a task that demonstrates a data-gathering bias on a hypothesis evaluation task to the formation and maintenance of delusional beliefs is questionable.

The model suggests that the greater the ambiguity of sensory experience, the greater the influence of beliefs on perceptions because cognitive biases operate under conditions of uncertainty. This is a potential maintaining factor once a delusion has been formed. However, ambiguous sensory experience is more likely to result in perception that confirms current beliefs rather than result in novel, potentially delusional beliefs. In addition, Garety & Hemsley (1994) suggest that individuals who form hypotheses without taking into account existing knowledge about the world are more likely to form delusions. By the same logic, this information-processing style would decrease the probability of a delusion being maintained, since the delusion constitutes part of their knowledge about the world.

Finally, as Garety & Hemsley concede, the multifactorial nature of the model does not lend itself to group predictions. It can only be falsified by the identification of individuals with delusions in whom none of the processes that are hypothesised to cause delusions, are disturbed. The identification of individuals without delusions in whom any of these processes are disturbed also presents problems for the model. It would be better to test the model with a series of case studies focussing on the natural history of delusion formation. The theory lends itself to an approach commonly applied to cognitive neuropsychology, whereby dissociations of cognitive functions are as, if not more, meaningful than associations. For example, if one found two individuals with persecutory delusions, one of whom demonstrated normal negative priming but a JTC bias and the other abnormal negative priming and no JTC bias, then one could conclude that the phenomena depended upon separate cognitive processes.

Other Differences in Information-Processing amongst People with Delusions

In addition to the theoretical models of delusion formation proposed by Maher (1988) and Garety & Hemsley (1994), alternative models have been proposed by Frith (1979; 1987; 1992) and Bentall *et al.* (1991) and Hemsley (1996). These models vary in their specificity from all symptoms of schizophrenia (Hemsley, 1996; Frith, 1979) to persecutory delusions alone (Bentall *et al.*, 1991). They are not necessarily incompatible with Garety & Hemsley's (1994) model and have stimulated a great deal of empirical research.

Bentall's Model of Delusion Formation and Maintenance

Bentall *et al.* (1991) delineate a putative model to explain the existence of persecutory delusions. Following earlier theorists (e.g. Zigler & Glick, 1988), they propose that persecutory delusions are formed as a defence against low self-esteem. The theory predicts that individuals with persecutory delusions demonstrate a tendency to attribute the cause of negative events externally and the cause of positive events internally. This self-serving bias is reported to be present in the non-clinical population (Bentall *et al.*, 1994) but absent in individuals with depression (Peterson *et al.*, 1982). Furthermore, they predict that people with persecutory delusions tend to attribute blame for negative events to persons rather than circumstances more than people without persecutory delusions. This attributional style serves to protect individuals with delusions from the negative affect associated with low self-esteem so that they express positive evaluations of themselves. Bentall predicts that discrepancies exist between overt and covert self-esteem and that it is possible to access these underlying negative self-representations experimentally.

Garety & Freeman (1999) reviewed evidence for this theory and found considerable empirical support for the hypothesis that people with persecutory delusions demonstrate an externalising bias for bad events, when the material is self-referent. They also found evidence that people with persecutory delusions were more inclined to blame other people rather than situations or chance. Empirical support for the hypothesis that people with persecutory delusions demonstrate discrepancies between overt and covert self-esteem is less compelling. This work is not directly relevant to the current study and will not be considered further.

Frith's Model of Delusion Formation and Maintenance

Frith (1992) proposes that delusions of reference and persecution (and third person hallucinations) are caused by a "theory of mind" deficit, i.e. difficulty in generating accurate representations of the thoughts and feelings of others. By definition, such delusions necessarily involve misinterpretations of others' intentions. However, he suggests that there is a general problem in the psychological processes that contribute to the generation of representations of others' internal states that predate the formation of delusions and that this reflects a developmental disruption.

This represents an extension of his earlier theory (Frith, 1987) that positive and negative symptoms of schizophrenia reflect impairments in the perception and initiation of action. This theory replaced an earlier theory (Frith, 1979) that the symptoms of schizophrenia could be accounted for by a failure in cognitive inhibition that filters out irrelevant information before it reaches consciousness.

Garety & Freeman's (1999) review found convincing evidence that people with current symptoms of schizophrenia were deficient in their ability to understand the mental states of others. This was most clear amongst people with negative symptoms. The link between "theory of mind" deficits and delusions of persecution and reference is less convincing. Again, this work is not directly relevant to the current study and will not be considered further.

Hemsley's Cognitive Model of Schizophrenia

Hemsley's (1996) model is most relevant to the current study because it focuses on a fundamental information-processing bias that Garety & Hemsley (1994) suggest might be responsible for both JTC data-gathering biases and experiences of perceptual anomalies. The theory is based upon the findings of differential performance of people with schizophrenia and of psychosis-prone individuals on a number of paradigms that involve the inhibition of irrelevant information: latent inhibition, Kamin's blocking effect, pre-pulse inhibition and negative priming. It is this failure to inhibit irrelevant information that Garety & Hemsley (1994) suggest might account for both JTC and perceptual anomalies. Hemsley (1996) hypothesises that "a reduction in the influence of the regularities of past experience on current perception......results in ambiguous messages reaching awareness and hence fails to inhibit the emergence of material from long-term memory." The emergence of material from long-term memory manifests itself as hallucinatory experience. He goes on to state that "[n]ot only does the 'weakened influence of past regularities on current perception' result in the intrusion of redundant material into awareness, it also influences the assessment of covariation between X and Y. Hence abnormal causal relationships may be inferred on the basis of a single occurrence." Inferred abnormal causal relationships are, or have the potential to become, delusions.

There are a large number of studies that have demonstrated that psychotic individuals have difficulty inhibiting irrelevant information on negative priming tasks (e.g. Liotti *et al.*, 1993; Nestor *et al.*, 1992; Beech *et al.* 1989). Similar performance on negative priming tasks has been demonstrated amongst pychosis-prone individuals (e.g. Beech *et al.*, 1989; Beech & Claridge, 1987; Peters *et al.*, 1994). The findings most relevant to the present study are those of Ferraro & Okerlund (1996). They used a negative priming paradigm to demonstrate decreased influence of stored material on current sensory input amongst a group of psychosis-prone individuals. They presented participants with a series of letter pairs. Each pair contained one upper case and one lower case letter. Participants were instructed to respond by pressing a button that corresponded to the position of the upper case letter; either left or right. On critical trials the target letter (e.g. "A") had been a distracter (i.e. "a") on the previous trial. They found that participants scoring low on the Schizotypal Personality Scale (STA; Claridge & Broks, 1984) demonstrated normal negative priming in that their reaction times (RT) on critical trials were slower than on control trials. Participants with high STA scores responded to critical trials faster than control trials. They found a significant interaction between group (high STA, low STA) and condition (control, critical). Moreover, they found a significant correlation between STA score and amount of negative priming defined as critical RT minus control RT. The relationship between negative priming, experience of perceptual anomalies and the "jump-to-conclusions" data-gathering bias was investigated further by the current study.

Cognitive Influences on Perception

Garety & Hemsley's (1994) suggestion that people who "jump-to-conclusions" also "jump-to-perceptions", resonates with cognitive models of hallucinations, particularly auditory hallucinations. Recent research into the phenomenon has investigated the hypothesis that auditory hallucinations result from a failure in reality discrimination, the ability to determine whether the source of an experience is internal or external. In order to discriminate between events of internal origin and events of external origin, one requires not only an accurate mental representation of those events but also appropriate decision-making processes in cases where the source of the event is uncertain (Brébion *et al.*, 1998). Johnson (1993) suggested the concept of a threshold at which events are attributed to an external rather than an internal source. It has been proposed that, while people who experience hallucinations do encode accurate mental representations of events, biased decision-making processes result in an alteration of this threshold (Bentall *et al.*, 1994; Collicut & Hemsley, 1981; Fear *et al.*, 1996; Harvey, 1985). However, the relationship between this "jump-to-perceptions" bias, the "jump-to-conclusions" bias and the failure to inhibit irrelevant information has not been investigated directly.

People with sufficient language skills engage in an internal dialogue when processing information consciously. Vygotsky (1962) demonstrated that this dialogue is originally external by observing the propensity of children to talk to themselves when they attempt to solve a complex problem. Over time the dialogue becomes internalised, although many adults do speak to themselves out loud on occasion. Some research suggests that electrical activity in the articulatory musculature which corresponds to internal dialogue can be measured (Sokolov, 1972) and similar activity can be measured during an experience of auditory hallucination (McGuigan, 1966). Cognitive models assume that auditory hallucinations are parts of the internal dialogue that have been mislabelled as emanating from an external source.

There are a number of reasons why an internal cognition might be mislabelled as an external perception. Morrison & Haddock, (1997) propose that thoughts that are ego dystonic will be labelled external. They draw comparisons with intrusive thoughts and suggest that the content of auditory hallucinations are often experienced as intrusive thoughts before they are experienced as hallucinations. Hoffman (1986) and Frith (1987) present similar models which suggest that thoughts are mislabelled when they are experienced as unintended. Hoffman goes on to suggest that a process of corollary discharge that sends a signal back to the premotor cortex, analogous to that observed in non-articulatory motor systems, makes thoughts seem intended and it is this process that is disrupted in people who experience auditory hallucination.

Bentall *et al.* (1991) draw comparisons between reality discrimination and reality monitoring and suggest that they are influenced by similar factors: perceptual information, contextual information and meaning information. It is likely that emotional factors will also influence whether an experience is perceived as real or unreal. Certain thoughts might not be acceptable to certain individuals because of their personal beliefs about themselves and their ethical values. Such people would be motivated to label unacceptable thoughts as being of external origin because to label them as internal would challenge the beliefs they hold about themselves and cause distress.

Al-Issa (1978) reviews evidence for differing content and modality of hallucination across cultures and contexts. This suggests that expectations encoded in cognitive structures have an important influence on hallucinatory experience. Böcker *et al.*

(2000) also make the point that reality discrimination involves more than perceptual factors. The classification of experience as external will also be influenced by beliefs about whether it is possible for those experiences to have an external source (e.g. hearing the voice of a dead relative).

Bentall (1990, p.85), in his review of psychological research on hallucinations, presents evidence that hallucinators "jump-to-perceptions". Bentall & Slade (1985) developed a task to test this hypothesis from the perspective of signal detection theory. This predicts that people who hallucinate will demonstrate a bias towards detecting external stimuli but will not differ from controls on measures of perceptual sensitivity. They presented participants with a recording of the word "who" embedded in white noise at a level that was judged "extremely difficult to perceive" by the experimenters and audio-technicians. Participants listened to a tape containing 50 trials containing the hidden word and 50 trials consisting of white noise alone. They were instructed to indicate their certainty that the hidden word had been present on a five point scale: definitely no sound, probably no sound, possibly a sound, probably a sound and definitely a sound. Sensitivity (i.e. ability to detect a stimulus when a stimulus is present) and perceptual bias (i.e. willingness to believe a stimulus is present independent of whether it was presented or not) were calculated for each participant. They found that participants scoring high on the Launay-Slade Hallucination Scale (LSHS; Launay & Slade, 1981) demonstrated a bias toward perceiving the hidden word to be present but no difference in sensitivity. The experiment was repeated with a group of people with a diagnosis of schizophrenia. They found that those who experienced hallucinations showed a similar bias but no difference in sensitivity. They concluded that "subjects either experiencing hallucinations or highly disposed to hallucination differ from those not disposed towards hallucination in their willingness to believe that a stimulus is present, given a poor signal-to-noise ration and a reasonable expectation that a stimulus might be presented."

These results were replicated in a non-clinical sample by Rankin & O'Carroll (1995) who compared groups scoring high and low on the LSHS. Böcker *et al.* (2000) repeated the experiment in a clinical group. They failed to find differences in perceptual bias between groups of patients with and without hallucinations but did find a strong trend for severity of hallucinations scores and *z*-transformed auditory response bias to correlate amongst hallucinating participants. Participants also performed an analogous reality discrimination task in the visual modality. The *z*-transformed visual and auditory response biases correlated significantly with severity of hallucinations in the subgroup of participants who experienced auditory hallucinations.

Summary

Maher holds that disturbed reasoning processes are not a causal factor in the formation of most delusions but rather that delusions are reasonable explanations of anomalous perceptual experience. In contrast, Garety & Hemsley hold that disturbed reasoning processes are a causative factor in the formation of a large proportion of delusions. Moreover, they suggest that the "jump-to-conclusions" bias demonstrated by a subgroup of people with delusions is related to other information-processing biases demonstrated by people who experience hallucinations and people with a diagnosis of schizophrenia. These are a bias to attribute the source of perceptual events to an external origin and the failure to inhibit irrelevant information, respectively.

There is no published literature that investigates the relationship between anomalous perceptual experience and the "jump-to-conclusions" bias directly. Similarly, the relationship between the "jump-to-conclusions" bias, the externalising bias and the failure to inhibit irrelevant information has not been directly investigated. The present study addressed these issues by comparing a group of individuals with delusions with a "jump-to-conclusions" bias to a group of individuals with delusions with no "jump-to-conclusions" bias on measures of anomalous perceptual experience and information-processing biases.

Research Questions

1. In comparison to people with delusions who do not "jump-to-conclusions" on the "beads" task, do people with delusions who "jump-to-conclusions" on the "beads" task experience *more* or *less* frequent perceptual anomalies and hallucinations?

2. In comparison to people with delusions who do not "jump-to-conclusions" on the "beads" task, do people with delusions who "jump-to-conclusions" on the "beads" task also demonstrate an *increased* tendency to:

a. "jump-to-perceptions"?

b. fail to inhibit irrelevant information?

<u>Predicted Observations</u>

1. If Maher's hypothesis, that a bias in reasoning is only causal in the minority of delusions that are not normal attempts to explain anomalous experience, is correct, then the group of individuals with delusions with a "jump-to-conclusions" bias will experience *less* frequent perceptual anomalies and hallucinations than the group of individuals with delusions with no "jump-to-conclusions" bias. If Garety & Hemsley's hypothesis, that a breakdown in the normal relationship between stored material and current sensory input causes both a bias to "jump-to-conclusions" and anomalous perceptual experience, is correct, then the group of individuals with delusions with a "jump-to-conclusions" bias will experience *more* frequent perceptual anomalies and hallucinations than the group of individuals with delusions with no "jump-to-conclusions" bias.

2. If Garety & Hemsley's hypothesis, that a breakdown in the normal relationship between stored material and current sensory input causes both a bias to "jump-to-conclusions" and anomalous perceptual experience, is correct, then the group of individuals with delusions with a "jump-to-conclusions" bias will also:

a. demonstrate a bias to attribute the source of perceptual events to an external origin in the auditory and visual modalities.

b. fail to demonstrate slowed reaction time and decreased accuracy in response to negatively primed stimuli.

Issues of Statistical Power

1. The null hypothesis is that there is no systematic difference (i.e. other than that due to chance and measurement error) in the frequency of perceptual anomalies and

hallucinations experienced by the two groups. There are two alternate hypotheses: that the group of people with delusions who "jump-to-conclusions" will experience *less* frequent perceptual anomalies and hallucinations, as predicted by Maher's model, and that the group of people with delusions who "jump-to-conclusions" will experience *more* frequent perceptual anomalies and hallucinations, as predicted by Garety & Hemsley's model. Because there have been no previous attempts to compare subgroups of people with delusions selected according to the presence or absence of a "jump-to-conclusions" bias, it is not possible to estimate the size of the difference in mean frequency of perceptual anomalies and hallucinations (i.e. effect size) from existing literature.

This null hypothesis can be tested by an analysis of variance. The test should be two-tailed because it is necessary to establish which of the two alternate hypotheses is supported if the null hypothesis is rejected. Cohen (1992) calculated that, for a significance criterion (α) of 0.05 and a large effect size, two groups of 26 participants would be required to obtain statistical power of 0.80. So, with two groups of 26 participants, the probability of mistakenly rejecting the null hypothesis (i.e. committing type I error) is 0.05 and the probability of mistakenly accepting the null hypothesis (i.e. committing a type II error) is 0.20 (= 1 - 0.80). In order to achieve power of 0.80 for a medium effect size two groups of 64 participants are required and for a small effect size two groups of 393 participants are required. A group size of 26 is ambitious in psychosis research. In Garety & Freeman's (1999) review of eight studies of people with delusions, employing Bayesian probabilistic reasoning tasks, only one had a group containing 26 or more people with delusions. For this reason the current study aimed to achieve group sizes of 26 participants.

When the analysis of variance leads to the rejection of the null hypothesis, power is not an issue because a type II error cannot have been committed. However, when the null hypothesis is accepted, this may have occurred because there is truly no systematic difference between the groups on the variables measured or because the difference was too small to be detected by the experimental design, i.e. there was insufficient power.

2. The same issues apply to the prediction that people with delusions will demonstrate a bias to attribute the source of perceptual events to an external origin in the auditory and visual modalities and the prediction that people with delusions will fail to demonstrate slowed reaction time and decreased accuracy in response to negatively primed stimuli. The null hypotheses in these cases will be that there are no systematic differences between the groups on measures of externalising perceptual bias or negative priming. However, there is only one alternate hypothesis derived from Garety & Hemsley's model, in each case. Consequently, one-tailed tests would be legitimate. Therefore, to achieve power of 0.80 at a significance criterion of 0.05, group sizes of 20, 50 or 310 participants would be required for large, medium and small effect sizes, respectively.

METHOD

Ethical Approval

Approval for the research project was obtained from the Ethical Committee (Research) of the Institute of Psychiatry and South London and Maudsley NHS Trust (Study No. 096/00; see Appendix 1: Ethical Approval Letter).

Design

The study employed an independent groups design. Participants were divided into two independent groups dependent on the presence or absence of a "jump-to-conclusions" (JTC) data-gathering bias. Participants were assigned to the JTC group or the No-JTC group on the basis of their performance on the "beads" task. Extreme responders, who requested only one bead before deciding which of the two jars had been selected, were assigned to the JTC group. Participants who requested more than one bead were assigned to the No-JTC group.

Five dependent variables were compared in the two groups:

1. *Auditory reality discrimination.* Performance on the auditory perceptual task was analysed using the method described by McNicol (1972, p. 123) to derive a measure of perceptual bias in the auditory modality (B_a).

2. *Visual reality discrimination.* Performance on the visual perceptual task was analysed using the method described by McNicol (1972, p. 123) to derive a measure of perceptual bias in the visual modality (B_v).
3. *Frequency of anomalous perceptions.* Likert ratings for each sensory modality assessed by the Structured Interview for Assessing Perceptual Anomalies (SIAPA; Bunney *et al.*, 1999) were summed and divided by five to provide a mean Likert rating.
4. *Severity of hallucinations.* The Scale for the Assessment of Positive Symptoms (SAPS; Andreason, 1984) was used to determine a global hallucinations rating, which incorporated auditory, visual, olfactory and tactile hallucinations.
5. *Influence of past, learned regularities on the processing of current stimuli.* Ferraro & Okerlund's (1996) negative priming task provided measures of accuracy and mean reaction time to negatively primed and control stimuli.

Statistical Analyses

All data were analysed using SPSS for Windows version 9.0. The distribution of each variable within each of the two groups was tested for normality. Where non-normal distributions were present transformations were made in order to normalise them. In cases where this was not possible, non-parametric statistics were used in their analysis.

The two groups were compared first on potentially confounding participant characteristic variables (age, gender, IQ, *etc.*) using Student's *t*–tests or Mann-Whitney *U* tests for scale variables, depending on distribution, and Wilcoxon's signed-ranks tests for nominal variables. Where significant differences between groups were found, these were taken into account when differences in experimental variables were analysed. For parametric statistical analyses, this involved covarying out these participant characteristic variables. For non-parametric analyses, this was achieved by performing a linear regression analysis with the experimental variable as the dependent variable and the participant characteristic variables as independent variables. The unstandardised residuals of this linear regression analysis were then analysed using non-parametric statistics.

The groups were compared on the first four experimental variables (auditory reality discrimination, visual reality discrimination, frequency of anomalous perceptions and severity of hallucinations) using a one-way analysis of variance (ANOVA) or a Mann-Whitney *U* test, depending on the distributions of the variables. The fifth variable (influence of past, learned regularities on the processing of current stimuli) was analysed using a two-by-two ANOVA with trial type (negatively primed or control) as a within subjects factor.

Participants

Fifty patients, 34 men and 16 women, of the South London and Maudsley NHS Trust were recruited. Forty-five were in-patients, five were out-patients.

Recruitment proceeded as follows. The experimenter sent a letter to 28 consultant psychiatrists employed by South London and Maudsley NHS Trust, describing the study and requesting permission to recruit patients under their care (see Appendix 2: Letter to Consultants). Nineteen consultants gave their permission. The experimenter then sent a similar letter to 14 ward managers and community team leaders who provided care to the consultants' patients (see Appendix 3: Letter to Ward Managers and Team Leaders). These letters were followed up by telephone calls, during which the experimenter arranged a meeting with the ward manager or team leader and offered to present the study to the staff team and to patient groups.

Once contact had been established, potential participants were identified by discussion with staff nurses, senior house officers and senior registrars. Patients were initially approached by the experimenter together with a member of medical or nursing staff who was known to them. The experimenter gave a brief description of the experiment and asked if they would be interested in taking part. Of 84 approached, 34 (40.5%) refused to participate. Refusal rates are not commonly reported by researchers investigating psychotic phenomena. The relevance of this omission will be discussed later.

Patients were approached if they were deemed, by medical or nursing staff, to have held one or more delusion currently or within the last month. The presence of delusions was confirmed by a review of case notes and a global delusions rating of three or more on the SAPS administered by the experimenter. Because the study investigated a symptom of psychosis, namely delusions, participants were selected on the basis of symptomatology rather than diagnosis. Therefore people with diagnoses associated with more transient delusions (e.g. borderline personality disorder, bipolar affective disorder, *etc.*) were not excluded.

Patients under 18 or over 65 years of age, patients not fluent in English, patients with a primary diagnosis of drug or alcohol abuse and patients with known organic cerebral pathology were excluded. Patients with severe formal thought disorder were not recruited because they were not able to give informed consent to participate. Patients with poor concentration and agitated patients were not recruited because the assessment required them to pay attention for one to two hours. Assaultative patients were not recruited because of the potential risk to the experimenter and apparatus. As with refusal rates, these issues are seldom addressed in psychosis research and will be discussed later.

Once recruited, participants were given a sheet containing information about the study (see Appendix 4: Information for Participants) and this was read out to them by the experimenter. The experimenter answered any questions raised by the participants, who then signed a consent form (see Appendix 5: Consent Form for Participants).

Participants' age, gender, number of years in education after 16, number of years in contact with mental health services, number of days spent in hospital as a result of mental health problems and number of admissions to hospital as a result of mental health problems were obtained by direct questioning of participants and corroborated by reference to medical notes. Participants' most recent diagnosis was obtained from medical notes and current medication from drug charts. An estimate of participants' verbal intelligence quotient (IQ) was derived from their performance on the Quick Test (QT; Ammons & Ammons, 1962). The SAPS was used to determine a global delusions rating, which incorporated delusions of persecution, of jealousy, of sin and guilt, of reference, of mind reading, of thought broadcasting, of thought insertion, of thought withdrawal, grandiose delusions, religious delusions and somatic delusions. This information is displayed in table 1.

One man in the No-JTC group only provided data for the "beads" task and the auditory perceptual task. The data from all other variables were missing for this participant. There were missing data from other participants on a number of tasks. This occurred for a number of reasons including computer malfunction, inability of participants to perform the tasks and participants' requests to omit a specific element of the assessment. Consequently, many of the group comparisons involve less than 50 participants.

Age was distributed normally in both the JTC (Kolmogorov-Smirnov (22) = 0.162, $p = 0.136$) and the No-JTC group (Kolmogorov-Smirnov (27) = 0.101, $p > 0.200$). A parametric comparison revealed no significant difference (t (47) = -0.858, $p = 0.395$).

The number of years spent in education after the age of 16 was not distributed normally in either the JTC group (Kolmogorov-Smirnov (22) = 0.291, $p < 0.0001$) or the No-JTC group (Kolmogorov-Smirnov (27) = 0.179, $p = 0.027$). A non-parametric comparison revealed that the No-JTC group spent a significant longer period in education (Mann-Whitney $U = 192.0$, $p = 0.028$).

Table 1. Participant characteristics by group

Group (N)	JTC (22)	No-JTC (28)
Mean age / years (SD)	33.5 (11.1)	36.1 (10.1)
Mean number of years of education after 16 (SD)	1.11 (1.69)*	2.59 (2.72)*
Mean number of years of contact with mental health services (SD)	9.82 (7.94)	10.1 (9.58)
Mean number of days spent in hospital (SD)	310 (330)	569 (847)
Mean number of admissions to hospital (SD)	4.59 (4.23)	5.96 (5.69)
Mean dose of antipsychotic medication / mgs chlorpromazine equivalent (SD)	394 (450)	411 (406)
Mean estimated IQ (SD)	88.1 (9.33)*	95.7 (9.12)*
Mean Global Rating of Severity of Delusions (SD)	3.64 (0.727)	3.52 (0.935)
Number of male participants (percentage of group)	14 (63.6%)	20 (71.4%)
Number of female participants (percentage of group)	8 (36.4 %)	8 (28.6%)
Number of participants with a diagnosis of schizophrenia (percentage of group)	7 (31.8%)	7 (25.0%)
Number of participants with a diagnosis of paranoid schizophrenia (percentage of group)	4 (18.2%)	7 (25.0%)
Number of participants with a diagnosis of psychotic illness (percentage of group)	4 (18.2%)	6 (21.4%)
Number of participants with a diagnosis of bipolar affective disorder (percentage of group)	5 (22.7%)	2 (7.1%)
Number of participants with a diagnosis of schizo-affective disorder (percentage of group)	2 (9.1%)	3 (10.7%)
Number of participants with a diagnosis of psychotic depression (percentage of group)	0 (0%)	1 (3.6%)
Number of participants with a diagnosis of delusional disorder (percentage of group)	0 (0%)	1 (3.6%)

* Group difference significant at 0.05 level.

The number of years in contact with mental health services was distributed normally in the JTC group (Kolmogorov-Smirnov (22) = 0.177, $p = 0.070$) but not in the No-JTC group (Kolmogorov-Smirnov (27) = 0.181, $p = 0.024$). A non-parametric comparison revealed no significant difference (Mann-Whitney $U = 291.0$, $p = 0.904$).

The number of days spent in hospital as a result of mental health problems was not distributed normally in either the JTC group (Kolmogorov-Smirnov (22) = 0.270, $p < 0.0001$) or the No-JTC group (Kolmogorov-Smirnov (27) = 0.252, $p < 0.0001$). A non-parametric comparison revealed no significant difference (Mann-Whitney $U = 282.0$, $p = 0.763$).

The number of admissions to hospital as a result of mental health problems was not distributed normally in either the JTC group (Kolmogorov-Smirnov (22) = 0.234, $p = 0.003$) or the No-JTC group (Kolmogorov-Smirnov (27) = 0.191, $p = 0.012$). A non-parametric comparison revealed no significant difference (Mann-Whitney $U = 266.5$, $p = 0.536$).

All participants, except one, were prescribed at least one psychoactive medication at the time of testing. These included antipsychotics, mood stabilizers, antidepressants and anxiolytics. Eighteen percent of the sample were prescribed anticholinergic medication. Tamlyn *et al.* (1992) reported that procyclidine (the most commonly prescribed anticholinergic) does not affect memory performance in people with a diagnosis of schizophrenia at doses of 15 mg/day. Only one participant was prescribed a dose exceeding this (20 mg/day). The prescribed dose of antipsychotic medication was converted into chlorpromazine equivalents using data provided by Taylor *et al.* (2001). Unfortunately, no such data is available for quetiapine, olanzapine or amisulpiride, so participants prescribed these medications were not included in the analysis of medication. The prescribed dose of antipsychotic medication was not distributed normally in either the JTC group (Kolmogorov-Smirnov (16) = 0.230, $p = 0.024$) or the No-JTC group (Kolmogorov-Smirnov (19) = 0.225, $p = 0.012$). A non-parametric comparison revealed no significant difference (Mann-Whitney $U = 142.0$, $p = 0.763$).

There was no significant difference between the groups in gender, Pearson's χ^2 (1) = 0.344, $p = 0.558$.

Fourteen participants had a diagnosis of schizophrenia, 11 paranoid schizophrenia, 10 psychotic illness/episode/disorder, seven bipolar affective disorder, five schizo-affective disorder, one psychotic depression and one delusional disorder. This data is displayed in Table 1. When participants with a diagnosis of schizophrenia were combined with participants with a diagnosis of paranoid schizophrenia and compared to participants with other diagnoses, there was no significant difference between the groups, Pearson's χ^2 (1) = 0.017, $p = 0.897$.

The estimated verbal IQ was distributed normally in both the JTC group (Kolmogorov-Smirnov (22) = 0.142, $p > 0.200$) and the No-JTC group (Kolmogorov-Smirnov (27) =

0.144, p = 0.157). A parametric comparison revealed that the mean IQ of the No-JTC group was significantly higher than that of the JTC group (t (47) = -2.845, p = 0.007).

The Global Rating of Severity of Delusions was not distributed normally in either the JTC group (Kolmogorov-Smirnov (22) = 0.309, p < 0.0001) or the No-JTC group (Kolmogorov-Smirnov (27) = 0.229, p = 0.001). A non-parametric comparison revealed no significant difference (Mann-Whitney U = 283.0, p = 0.760).

Apparatus

The three computerised tasks were presented on a Toshiba Satellite 2590CDT, which has 64 Mb RAM, 12.1" TFT screen and a processing speed of 400MHz. Responses on the perceptual tasks were recorded via a PCMCIA game controller. The auditory perceptual task was presented through Realistic PRO-VII stereo headphones. The "beads" task was presented using one hundred red beads and one hundred green beads of approximately 9mm diameter. These were placed in cylindrical glass jars of diameter 40mm and height 90mm.

Laminated sheets were prepared to aid responses to the "beads" task and the two perceptual tasks (see Appendix 5: Beads and Perceptual Tests Response Aids). Laminated copies of the words and pictures used in the Quick Test were also prepared (see Appendix 6: Quick Test Stimuli).

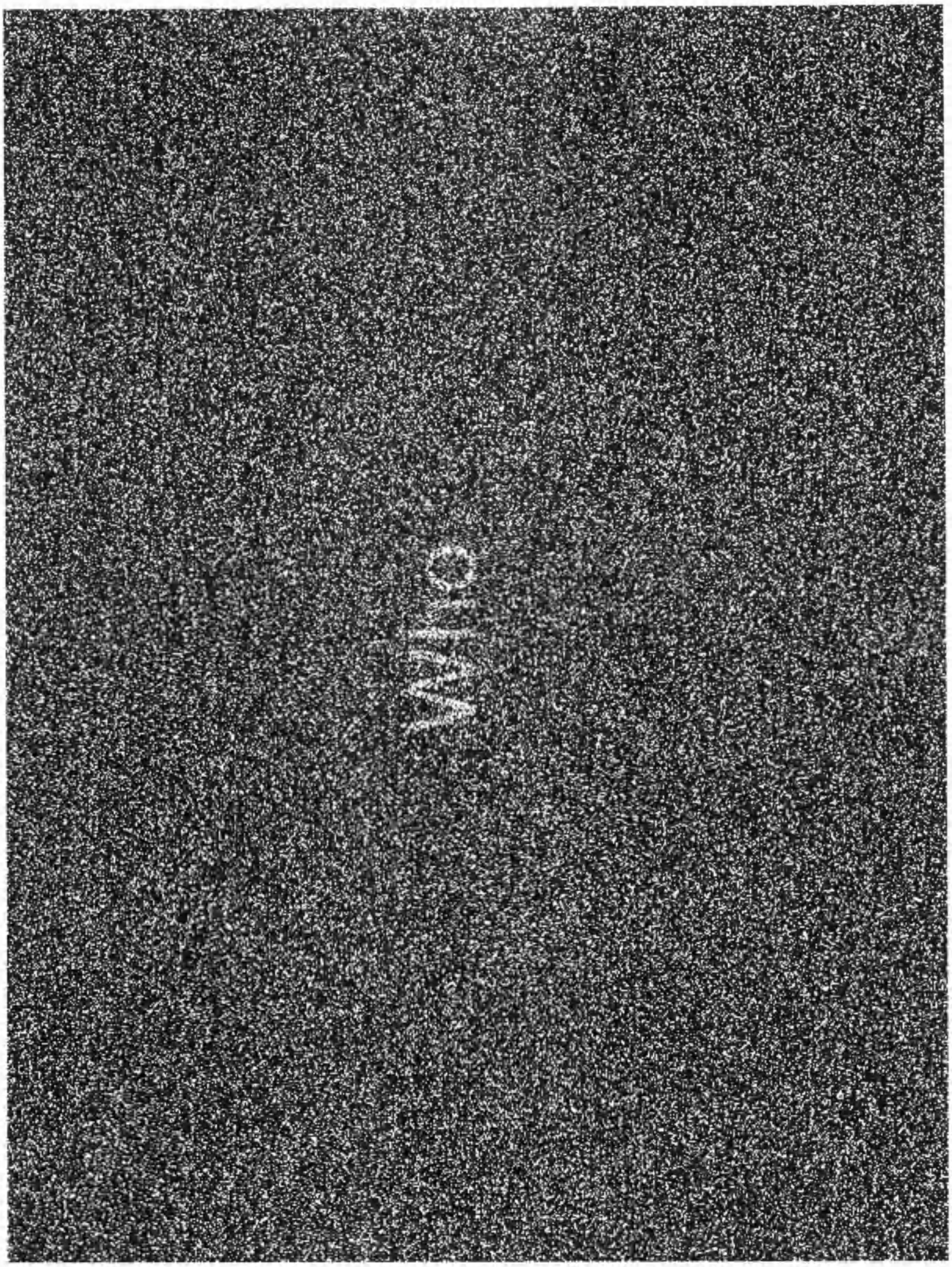
Software for the auditory perceptual task was developed following the model for the stimulus tape described by Bentall & Slade (1985). A program was created that presented computer generated auditory stimuli through headphones. Each trial consisted of a one second tone, one second of silence, five seconds of white noise and eight seconds of silence. Embedded in some of the periods of white noise, at a level close to threshold (two percent of white noise volume), there was a voice speaking a single word, "who." This was the voice of the (male) experimenter, recorded as an audio file, directly onto a computer. When present, this occurred after three seconds of noise. During the eight seconds of silence at the end of each trial, a scale (see Appendix 6) appeared on the computer screen. The program also recorded participants' responses into a data file.

During construction of the task, two different signal-to-noise ratios were prepared: one percent and two percent. At these ratios, the signal was judged extremely difficult to perceive by the experimenter and computer scientists who constructed the software. A pilot study presented 30 trials to 10 participants with no history of mental health problems. Ten of the trials presented white noise alone, 10 presented noise plus a recording of the voice at one percent of the noise volume and 10 presented noise plus a recording of the voice at two percent of the noise volume. On the trials with a signal-to-noise ratio of two percent, all 10 participants reported that they had definitely or probably heard a sound on at least five of these trials. On the trials with a signal-to-noise ratio of one percent, eight participants reported that they had definitely or probably heard a sound on at least one trial but two participants did not hear a sound on any of these trials. Consequently, the signal-to-noise ratio of two percent was selected as the ratio most likely to minimise floor effects. It was also hoped that the task would be more acceptable to participants if they were able to perceive a voice on at least some of the trials.

A test sequence of 40 trials was prepared: 20 with a voice and 20 without a voice. The order of trials was pseudo-random with the constraint that no more than three similar trials were presented consecutively. Two further sequences were prepared as practices. The first was a single trial with the signal at 20% of white noise volume. The second was 10 trials with the volume of signal as a percentage of white noise, varying as follows: 20, 20, 20, 0, 2, 2, 0, 2, 0, 2.

Software for a visual analogue of Bentall & Slade's (1985) task was also developed. Several hundred digital frames were prepared, each with a random array of black and white pixels. These frames were displayed sequentially, at a rate of 20 frames per second, to create an effect, similar to a television that is not tuned to a channel, which will be referred to as visual noise. The visual noise appeared on the screen as a square approximately 100mm by 100mm in size. The signal consisted of the word "who". An image of the word, written in white letters, was degraded by randomly removing 50% of the pixels. The height of the "h" was approximately 20mm. Several signal frames were prepared by overlaying the degraded image of "who" onto noise frames (see Figure 2). Five digital "movies", each of five seconds duration were prepared. These "movies" consisted of 60 frames of visual noise, between one and five signal frames, followed by between 35 and 39 further frames of visual noise.

Figure 2. Signal frame from visual perceptual task



The experimenter and computer scientists, who prepared the software, selected two "movies" in which the signal was judged to be extremely difficult to perceive. These were the "movie" in which one signal frame was presented and the "movie" in which two consecutive signal frames were presented. A pilot study presented 30 trials to the 10 participants who had completed the pilot sequence for the auditory perceptual task described above. Ten of the trials presented visual noise alone, 10 presented noise plus a single signal frame and 10 presented noise plus a two consecutive signal frames. On the trials with two signal frames, all 10 participants reported that they had definitely or probably seen an image on at least two of these trials. On the trials with a single signal frame, six participants reported that they had definitely or probably seen an image on at least one of these trials but four participants did not see an image on any of these trials. Consequently, the "movie" in which two signal frames were presented was selected as the one most likely to minimise floor effects. It was also hoped that the task would be more acceptable to participants if they were able to perceive an image on at least some of the trials.

A program was created that presented computer generated visual stimuli on the screen. Each trial consisted of a one second period of visual noise, one second of blank screen, five seconds of visual noise and eight seconds, at the end of each trial, when a scale (see Appendix 6) appeared on the computer screen. Embedded in some of the periods of visual noise, were two signal frames. When present these appeared after three seconds of noise. The program also recorded participants' responses into a data file.

A test sequence of 40 trials was prepared: 20 with a word and 20 without a word. The order of trials was pseudo-random with the constraint that no more than three similar trials were presented consecutively. Two further sequences were prepared as practices. The first was a single trial with three signal frames embedded in the visual noise. The second was 10 trials with the number of signal frames embedded in the visual noise, varying as follows: 3, 3, 3, 0, 2, 2, 0, 2, 0, 2.

The negative priming task was presented using the same software as Ferraro & Okerklund (1996), which Dr Ferraro kindly provided. The program presented 136 letter pairs in a pre-arranged order. Each pair consisted of one upper case and one lower case letter and was preceded by a row of ten asterisks. The asterisks appeared for one second, the screen was blank for one second, then a letter pair (e.g. Hq) appeared. Participants responded using the computer's keyboard: "1" if the upper case letter was on the left of the letter, "0" if it was on the right. The letters remained on the screen until the participant pressed either the "1" or "0" key, at which point the sequence recommenced. If no key was pressed within two seconds, a tone sounded and the sequence recommenced. Likewise, when an incorrect response was made, a tone sounded and the sequence recommenced. Reaction times and accuracy were recorded to a data file. If participants failed to respond within the allotted time, no reaction time was recorded and the trial was recorded as "missed" in the accuracy data.

Procedure

Each participant undertook two structured interviews, a data-gathering/reasoning task, three computer-administered tasks and a test of verbal intelligence. It took between one and a half and two hours to administer all the tasks and interviews to each participant. All participants completed the assessment in one session. There were no scheduled breaks and no breaks were requested by participants.

The data-gathering/reasoning task was administered first in order to determine the group to which participants were assigned. The three computerised tasks were administered next. There were six possible sequences in which the computerised tasks could be presented: abc, acb, bac, bca, cab, cba. Once group membership had been determined, participants were assigned to the sequence following that assigned to the previous group member. In this way the order of computerised tasks were counter-balanced. The QT was administered after the computerised tasks, then the SIAPA and finally the SAPS. The tasks are described below:

1. "Beads" Task (Data-gathering/reasoning style)

The presence or absence of a data-gathering bias was assessed using the procedure descibed by Garety, Wesseley & Hemsley (1991). Participants were asked to decide from which jar, hidden from view, beads were being drawn. Participants were informed that one jar contained 85 red beads and 15 green beads and that the other jar contained 85 green beads and 15 red beads. The jars were removed from view and participants were asked to decide from which jar beads were being drawn (see Appendix 8: Verbatim Instructions for the "Beads" Task).

They were shown one bead at a time. They were asked to point to one of two boxes on a piece of paper placed in front of them. If they pointed to the box reading, "More beads please" they were shown another bead. If they pointed to the box reading, "No more beads, I have decided" they were asked, "Are you sure?" If they indicated that they were sure, then the test was terminated. They were then asked from which of the two jars the beads had been drawn. If they indicated that they were not sure, more beads were shown until they pointed to the box reading, "No more beads, I have decided" and indicated that they were sure on questioning.

The same beads were presented in the same order to each participant (R R R G R R R R R G G R R R R R R R R G) in accordance with previous applications of this task. The measure of interest was the number of beads seen before participants indicated that they were as sure as they could be, from which jar the beads were being drawn. The presence of a "jump-to-conclusions" (JTC) data-gathering bias was inferred from a decision being made after seeing one bead. This task took approximately five minutes to administer.

2a. Auditory Perceptual Task (Auditory reality discrimination)

The extent to which participants "jumped-to-perceptions" (JTP) in the auditory modality was assessed using the procedure described by Bentall & Slade (1985). The stimuli were generated by a computer and presented through headphones (see Apparatus section). Before the test was administered, participants were asked to listen to a single trial, with the signal at 20% white noise volume, and describe what they heard. They then listened to 10 practice trials. After they had responded to each trial, they were informed of the presence or absence of the signal in the noise in that trial. After the 10 practice trials, they were asked if they had been able to identify the content of the signal. As well as familiarising participants with the task, the practice also created an expectancy that a signal would be present.

Participants were then asked to listen to the test sequence of 40 trials. They were told that there was another sound hidden in the noise on some of the trials. They were asked to use a button box, connected to the computer, to move the scale, which appeared after each stimulus (see Appendix 6), to 5 if they were sure that they had heard another sound or 1 if they were sure that they had not heard another sound. They were asked to respond 2, 3 or 4 if they were unsure whether or not they had heard another sound, depending on their level of certainty (see Appendix 9: Verbatim Instructions for the Auditory Perceptual Task). Whilst explaining the task to participants, the experimenter did not use the word "voice", so as to avoid influencing their expectations. At the end of the 40 trials they were asked if they had been able to identify the content of the signal.

The measure of interest was the participants' perceptual bias in the auditory modality (B_a); low scores indicate greater tendency to JTP and, therefore, poorer reality discrimination in the auditory modality. This task took approximately 15 minutes to administer.

2b. Visual Perceptual Task (Visual reality discrimination)

The extent to which participants "jumped-to-perceptions" (JTP) in the visual modality was assessed using an analogue of the procedure described by Bentall & Slade (1985). The stimuli were generated by a computer and watched on a screen (see Apparatus section). Before the test was administered, participants were asked to watch a single trial, containing three consecutive signal frames (so that the signal lasted approximately 150 milliseconds), and describe what they saw. They then watched 10 practice trials. After they had responded to each trial, they were informed of the presence or absence of the signal in the noise in that trial. After the 10 practice trials, they were asked if they had been able to identify the content of the signal. As well as familiarising participants with the task, the practice also created an expectancy that a signal would be present.

Participants were then asked to watch 40 trials. They were told that there was an image hidden in the noise on some of the trials. They were asked to use a button box, connected to the computer, to move the scale, which appeared after each stimulus (see Appendix 6), to 5 if they were sure that they had seen an image or 1 if they were sure that they had not seen an image. They were asked to respond 2, 3 or 4 if they were unsure whether or not they had seen an image, depending on their level of certainty (see Appendix 10: Verbatim Instructions for the Visual Perceptual Task). Whilst explaining the task to participants, the experimenter did not use the word "word", so as to avoid influencing their expectations. At the end of the 40 trials they were asked if they had been able to identify the content of the signal.

The measure of interest was the participants' perceptual bias in the visual modality (B_v); low scores indicate greater tendency to JTP and, therefore, poorer reality discrimination in the visual modality. This task took approximately 15 minutes to administer.

2c. Negative Priming Task (Inhibition of irrelevant information)

The influence of stored material on the processing of current sensory input was assessed using a negative priming task described by Ferraro & Okerklund (1996) and was presented using the same software (see Apparatus section). Instructions appeared on the screen and were read out by the experimenter (see Appendix 11: Verbatim Instructions for Negative Priming Task). On critical trials, an uppercase letter was presented which had been presented on the preceding trial in lowercase. Therefore, the letter which was previously irrelevant (because it was lowercase) became relevant (because it was uppercase).

There was a total of 136 trials: 68 critical and 68 control. They were presented in a pseudo-random order. The upper-case letter appeared on the right for 34 critical trials and on the left for 34 critical trials. The same applied to control trials and the order was pseudo-random. There was no practice but the first six trials were excluded from the analysis to control for this. Three of these trials were critical and three were control. The upper-case letter appeared on the right for three of these trials and on the left for the other three.

The negative priming phenomenon, usually observed, results in faster and more accurate responses to control trials than to critical trials. The measures of interest were the differences, in reaction time and accuracy, between responses to control trials and responses to critical trials. Participants whose processing of current sensory input was less influenced by stored material, would be expected to respond comparatively faster and more accurately to critical trials. This task took approximately five minutes to administer.

3. Quick Test (QT; Verbal intelligence)

Verbal intelligence was assessed using form one of the QT as modified by Mortimer (1995). Participants were shown four pictures and a list of 50 words. As each word was read out, they were required to point to the picture that it fitted best. The number of correct responses was used to derive an estimated intelligence quotient (IQ).

Normative data was derived from a community sample of 458 people, selected to be representative of the population of the United States of America as determined by census information. Data from the QT was standardised by making the mean score and standard deviation correspond to IQs of 100 and 15 points. Shallice *et al.*, (1991) found that IQ derived from the QT correlated with those derived from the Wechsler Adult Intelligence

Scale (WAIS) with a coefficient of 0.91. The pictures and words in the QT were modified slightly by Mortimer (1995) in order to make them more appropriate to a contemporary British population. She found that both versions of the QT significantly overestimated IQ compared to the Wechsler Adult Intelligence Scale - Revised (WAIS-R) but the modified version was more highly correlated with the WAIS-R (0.77) than the unmodified version (0.69).

This task took approximately five minutes to administer.

4. Structured Interview for Assessing Perceptual Anomalies (Frequency of perceptual anomalies, excluding hallucinations)

In order to evaluate Maher's model systematically, tools were required to assess anomalous perceptions reliably. Bunney at al. (1999) designed a Structured Interview for Assessing Perceptual Anomalies (SIAPA) that measures the frequency of three forms of anomalous perceptual experience in five sensory modalities, making a total of 15 items. The three forms of anomalous perceptual experience were: hypersensitivity, inundation or flooding and selective attention to external sensory stimuli. They measured the frequency of these anomalies over the past week in a group in a group of people with a diagnosis of schizophrenia and a group of undergraduates without a personal history of psychiatric illness and without a first degree relative with a psychotic illness. The proportion of patients reporting any perceptual anomaly was 52.2% compared to 25.5% for controls. For the patient group auditory and visual anomalies were significantly more prevalent than tactile or gustatory anomalies and significantly more auditory, but not visual, anomalies were reported compared to olfactory anomalies. The mean Likert ratings of the schizophrenia group were significantly greater than the control group for perceptual anomalies in the auditory, visual and olfactory modalities as well as for overall ratings. The number of participants reporting tactile and gustatory anomalies was extremely small.

Frequencies were recorded on a five point Likert scale as: never (0), rarely (1), half the time (2), often (3) or always (4). The scale provides scores between zero and four for each modality and a total score of between zero and 20. Bunney *et al.* (1999) suggests probes for the auditory modality. These were used as a model to develop probes for the visual, tactile, olfactory and gustatory modalities (see Appendix 12: SIAPA Probes). Whereas, Bunney et al, (1999) recorded the frequency of perceptual anomalies over the last week, participants were asked about frequency over the last month, which is the time period assessed by the SAPS (see below). The measure of interest was the frequency of perceptual anomalies over the last month. A mean rating was calculated by summing the Likert ratings across modalities and dividing the result by five. This allowed a comparison between the grand mean and ratings within individual modalities as reported by Bunney, *et al.* (1999). The SIAPA took approximately 10 minutes to administer.

5. Scale for the Assessment of Positive Symptoms (Severity of delusions and hallucinations)

The SIAPA is specifically designed to measure non-hallucinatory perceptual experience. However, when Maher refers to perceptual anomalies he clearly includes hallucinatory experience. The Scale for the Assessment of Positive Symptoms (SAPS; Andreason, 1984) contains a semi-structured interview that probes for hallucinations (see Appendix 13: SAPS Probes). It includes the categories: General Auditory Hallucinations, Voices Commenting, Voices Conversing, Somatic or Tactile Hallucinations, Olfactory Hallucinations and Visual Hallucinations. The frequency of each category over the last month is assessed on a six point Likert scale comprised of: none (0), questionable (1), occasionally (2), weekly (3), daily (4) and all the time (5). There is also a Global Rating of Severity of Hallucinations recorded on a six point Likert scale as: none (0), questionable (1), infrequent or occasional doubt (2), vivid but occasional (3), frequent and pervasive (4), almost daily, sometimes bizarre, very vivid and extremely troubling (5).

The SAPS also contains a semi-structured interview that probes for delusions (see Appendix 13: SAPS Probes). Delusions of Persecution, of Jealousy, of Sin and Guilt, Grandiose Delusions, Religious Delusions and Somatic Delusions are assessed on a six point Likert scale as: none (0), questionable (1), simple and occasional doubt (2), clear, consistent and firmly held (3), acted upon (4), complex, preoccupying or bizarre (5). Delusions of Reference are assessed on a six point Likert scale as none (0), questionable

(1), occasional (2), weekly (3), two to four times weekly (4), frequent (5). Delusions of Mind Reading, of Thought Broadcasting, of Thought Insertion, of Thought Withdrawal, are assessed on a six point Likert scale as: none (0), questionable (1), occasional doubt (2), two or three times weekly (3), frequent (4), pervasive and effects behaviour (5). There is also a Global Rating of Severity of Delusions, which is recorded on a six point Likert scale as: none (0), questionable (1), definitely present but occasionally questions (2), convinced but occurs infrequently and has little effect on behaviour (3), firmly held, occurs frequently and affects behaviour (4), complex, well formed and pervasive; firmly held and have a major effect on behaviour; may be somewhat bizarre and unusual (5).

The experimenter was trained in the use of the SAPS by observing video recordings of clinical interviews. These were accompanied by brief summaries of the patients' histories. On the basis of the interview and history, ratings were made for each item of the SAPS and the Schedule for the Assessment of Negative Symptoms (SANS; Andreason, 1984). These ratings were then compared with those made by experienced users of the schedule. This process was repeated until none of the 20 ratings, from the hallucinations and delusions sections of the SAPS, varied by more than one point and at least 16 (80%) were exactly the same.

As well as assessing delusions and hallucinations, the SAPS also probes for bizarre behaviour, positive formal thought disorder and inappropriate affect. The SANS probes for affective flattening or blunting, alogia, avolition-apathy, anhedonia-asociality and attention. Initial attempts to administer both schedules in their entirety proved impractical, because of the length of time required, and the decision was made to restrict the interviews to the assessment of delusions and hallucinations. The measures of interest were the Global Rating of Severity of Hallucinations, the Global Rating of Severity of Delusions and the ratings of subcategories of hallucinations and delusions. This structured interview took approximately 15 minutes to administer.

RESULTS

"Beads" Task (Data-gathering/reasoning style)

The "beads" task was administered to 50 participants. The number of beads requested ranged between one and six. The median number of beads requested was two, the mean was 2.02 and the standard deviation (SD) was 1.20. The variable, "beads to decision" was not normally distributed (Kolmogorov-Smirnov (50) = 0.242, $p < 0.0001$). The distribution is illustrated in Figure 3. Twenty-two participants (44%) reached a decision after seeing only one bead. These participants were assigned to the "jump-to-conclusions" (JTC) group. The remaining 28 participants formed the No-JTC group.

Scale for the Assessment of Positive Symptoms (Severity of Hallucinations)

The SAPS was administered to 49 participants (22 JTC, 27 No-JTC). The Global Rating of Severity of Hallucinations from the SAPS provided an experimenter-rated measure of the severity of hallucinations during the last month across four sensory modalities: auditory, visual, somatic and olfactory. The maximum rating was "5: Severe: Hallucinations occur almost daily and are sometimes unusual or bizarre; they are very vivid and extremely troubling" and the minimum rating was "0: none". The mean rating for the JTC group was 1.727 (SD = 2.074) and 2.222 (SD = 1.826) for the No-JTC group (see Table 2). The distribution of the variable was normal in the No-JTC group

Figure 3. The number of beads requested by participants

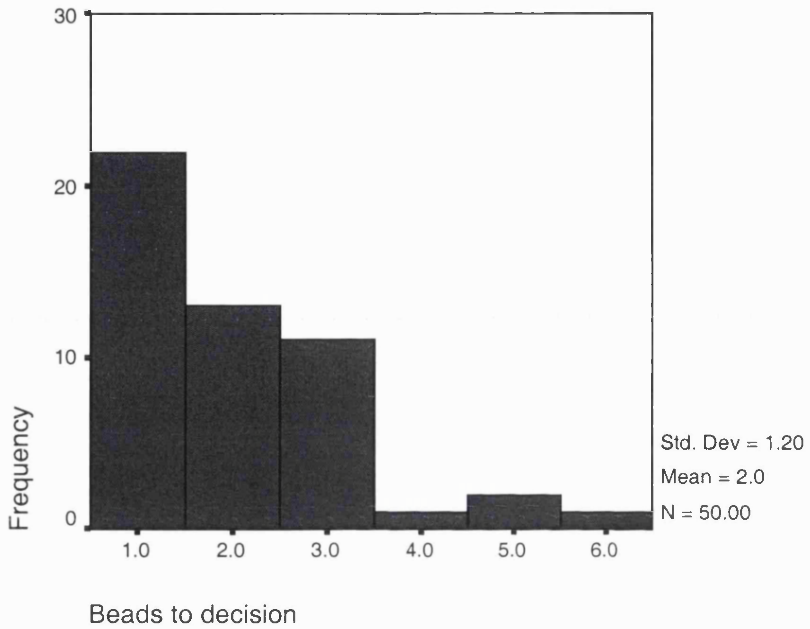


Table 2. Means, medians and standard deviations for each group on each task

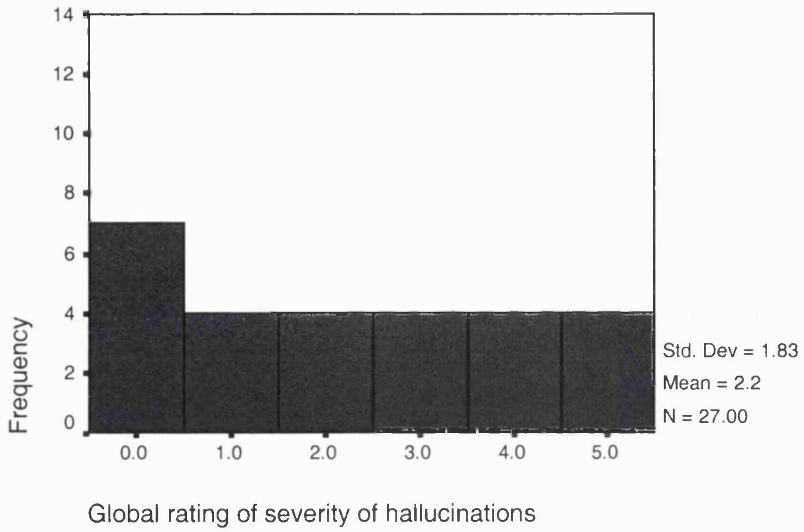
	No-JTC			JTC		
	Median	Mean	SD	Median	Mean	SD
Auditory Reality Discrimination (B_a)	3.72	3.11	1.25	3.00	2.59	1.47
Visual Reality Discrimination (B_v)	3.17	3.06	1.14	2.85	2.70	1.34
Frequency of Anomalous Perceptions (SIAPA Rating)	0.400	0.778	0.874	0.400	0.691	0.892
Severity of Hallucinations (SAPS Rating)	2.00	2.222*	1.826	0.00	1.727*	2.074
Negative Priming:						
Critical RT (msecs)	649.4	689.2	126.2	684.6	682.6	135.5
Control RT (msecs)	645.6	682.9	121.5	654.3	665.4	121.0

* Group difference significant at 0.05 level.

(Kolmogorov-Smirnov (27) = 0.156, $p = 0.091$ but not in the JTC group (Kolmogorov-Smirnov (22) = 0.343, $p < 0.0001$). In fact the distribution appeared to be bimodal in the JTC group, with one group having no hallucinations and another having "4: marked" or "5: severe" hallucinations (see Figure 4). A linear regression was performed with Global Rating of Severity of Hallucinations as the dependent variable and years of education after 16 and estimated IQ as the independent variables. The unstandardised residuals were saved and a non-parametric statistic was used to compare the two groups on these residuals. A significant difference was found (Mann-Whitney $U = 199.0$, $p = 0.049$), indicating that people with delusions and no reasoning bias experience more severe hallucinations than people with delusions and a reasoning bias.

An exploration of the ratings for subtypes of hallucinations (Auditory, Voices Commenting, Voices Conversing, Somatic or Tactile, Olfactory and Visual) revealed that none of them were distributed normally in either group. Six linear regressions were performed, with a different hallucination subtype rating as the independent variable in each, and years of education after 16 and estimated IQ as the dependent variables in all of them. The unstandardised residuals were saved and non-parametric statistics were used to compare the groups on these residuals. The mean ratings were higher for the No-JTC group for all hallucination subtypes except Somatic or Tactile (see Figure 5). The difference was significant for Auditory Hallucinations (Mann-Whitney $U = 200$, $p = 0.051$), Voices Commenting (Mann-Whitney $U = 158$, $p = 0.005$), Olfactory Hallucinations (Mann-Whitney $U = 189$, $p = 0.030$) and Visual Hallucinations (Mann-Whitney $U = 194$, $p = 0.038$).

Figure 4. Distribution of Global Rating of Severity of Hallucinations in the No-JTC Group.



Distribution of Global Rating of Severity of Hallucinations in the JTC Group.

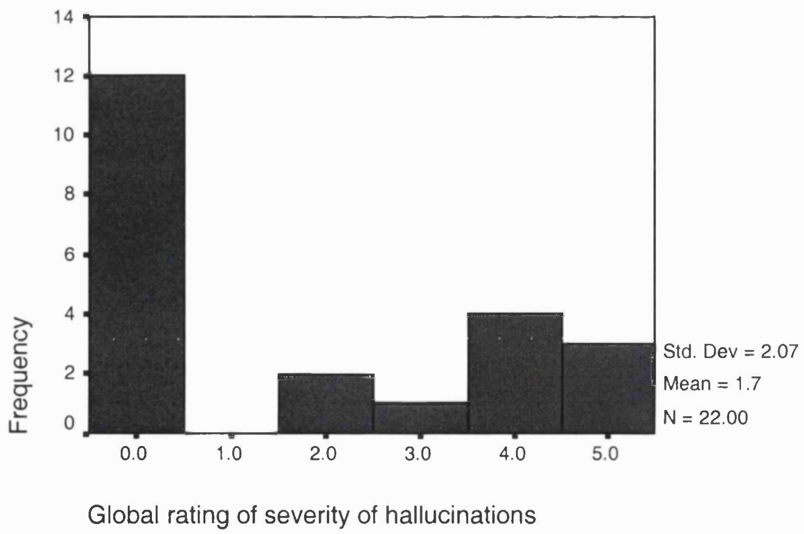
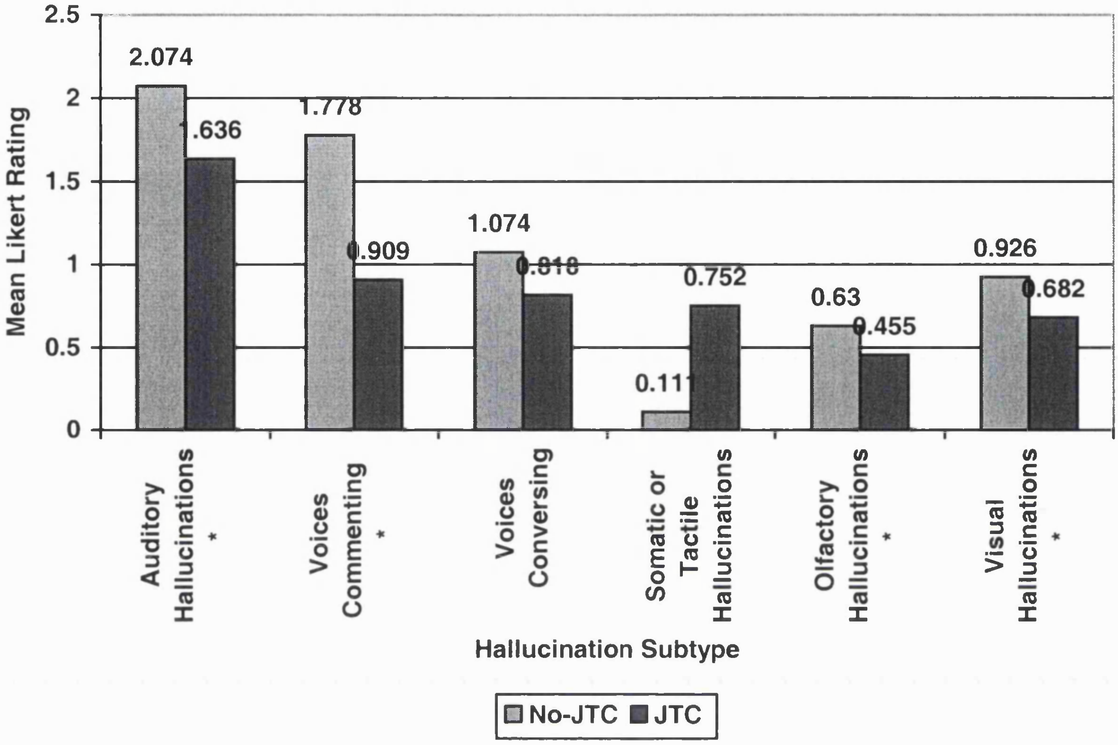


Figure 5. Mean hallucination ratings for JTC and No-JTC groups by subtype

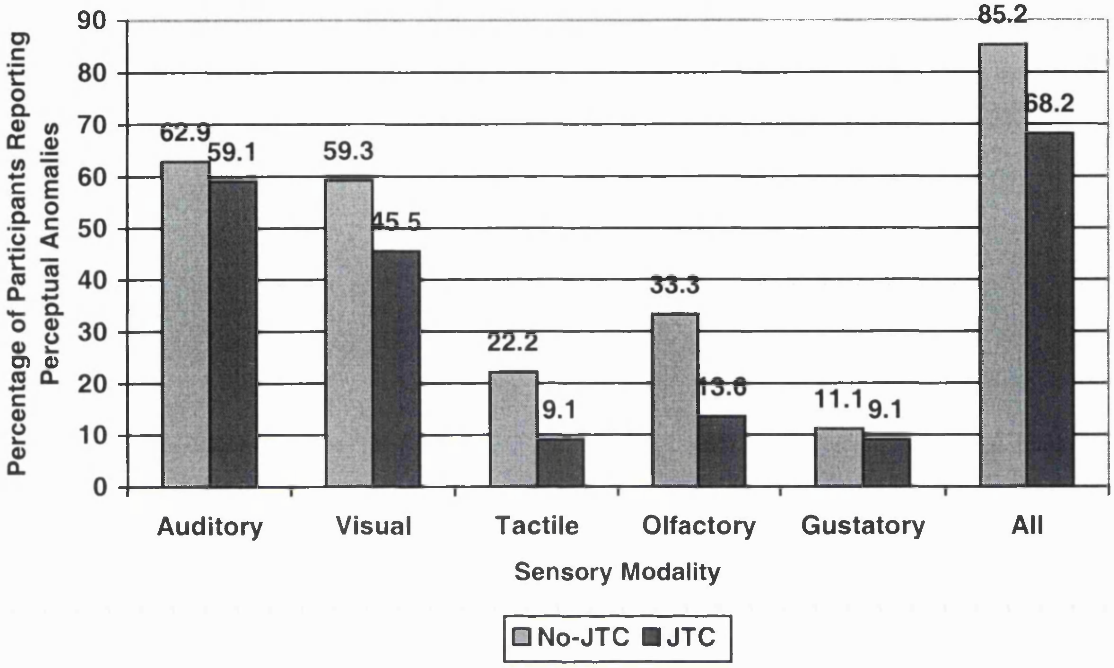


* Group difference significant at 0.05 level.

Structured Interview for Assessing Perceptual Anomalies (Frequency of perceptual anomalies, excluding hallucinations)

The SIAPA was administered to 49 participants (22 JTC, 27 No-JTC). Following Bunney *et al.* (1999), both frequency (the number of participants reporting any perceptual anomalies) and severity (mean Likert ratings within each modality and a grand mean across all modalities) data were compared across groups. In the No-JTC group, 85.2% reported anomalous perceptual experience in the last month (i.e. a rating of at least "rarely" on one of the 15 items) compared with 68.2% of the JTC group (see Figure 6). The prevalence of anomalous perceptual experience was compared across groups using a two-by-two cross-tabulation with JTC/No-JTC in columns and presence/absence of perceptual anomalies (as indicated by a rating of at least "rarely" on one of the 15 items of the SIAPA) in rows. The "No-JTC" by "perceptual anomalies absent" cell contained only four cases, so Fisher's exact test was used. This revealed that the two groups were not significantly different (Pearson's χ^2 (1) = 2.201, p = 0.156; Fisher's Exact Test p = 0.141 (one-sided)). Bunney *et al.* (1999) found that perceptual anomalies were most prevalent in the auditory modality with 41.8 % of a group of participants with a diagnosis of schizophrenia, reporting at least one experience in the last week. In the present study, the prevalence of anomalous experience in the auditory modality in the last month was greater: 62.9% for the No-JTC group and 59.1% for the JTC group.

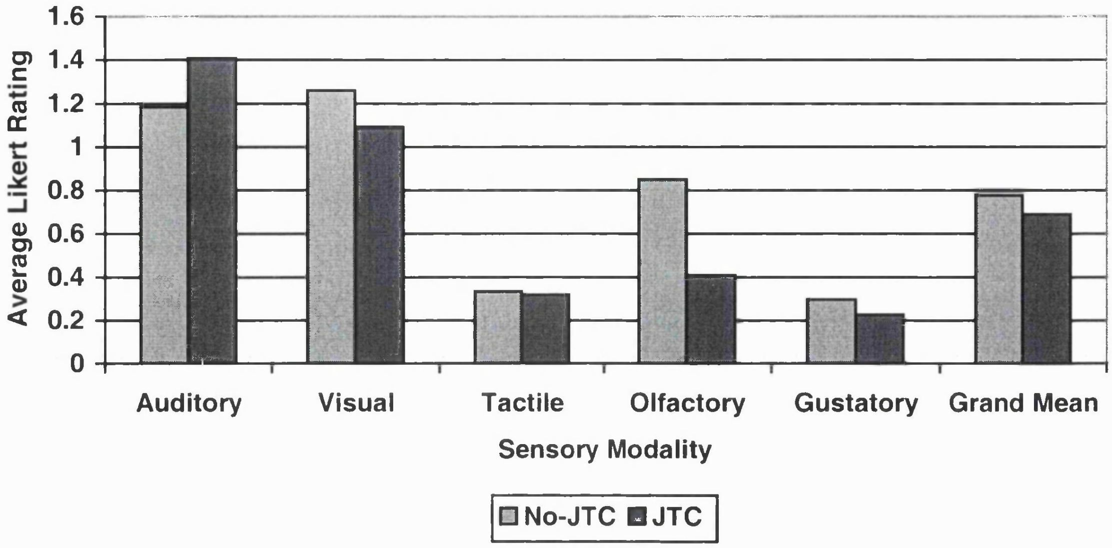
Figure 6. Percentage of participants in each group reporting at least one perceptual anomaly (i.e. endorsing at least "rare" on one or more items of the SIAPA) for each sensory modality



Likert ratings of the frequency of anomalous perceptions during the last month, as measured by the SIAPA, were summed across each sensory modality: auditory, visual, tactile, olfactory and tactile, and divided by five to provide a mean Likert rating. The maximum rating was "4: all the time" and the minimum was "0: never". The mean rating for the JTC group was 0.691 (SD = 0.892) and 0.778 (SD = 0.892) for the No-JTC group (see Table 2). The variable was not distributed normally in either the JTC group (Kolmogorov-Smirnov (22) = 0.264, $p < 0.0001$) or the No-JTC group (Kolmogorov-Smirnov (27) = 0.223, $p = 0.001$). A natural logarithm transformation was performed on the variable after adding 0.2 (that being the smallest increment by which participants' scores could vary) to allow for scores of 0. The distribution of the transformed variable was normal for the No-JTC group (Kolmogorov-Smirnov (27) = 0.142, $p = 0.175$) and very close to normal for the JTC group (Kolmogorov-Smirnov (22) = 0.188, $p = 0.043$). A parametric test of the transformed mean Likert rating, covarying out years of education after the age of 16 and estimated intelligence, did not show a significant difference between groups (F (1, 45) = 0.919, $p = 0.343$).

The mean Likert ratings for the No-JTC and the JTC groups, separated according to modality, are presented in Figure 7. The distribution of the scores was normal in neither group for all the modalities. Non-parametric analyses, of the unstandardised residuals obtained from a linear regression of SIAPA ratings against years in education and IQ, revealed no significant differences between the groups in any modality.

Figure 7. Mean Likert ratings for the No-JTC and JTC groups according to modality



Bunney *et al.* (1999) found that, in a group of participants with a diagnosis of schizophrenia, the prevalence of anomalies in the auditory and the visual modality did not differ. They also found that auditory and visual anomalies were significantly more prevalent than tactile and gustatory anomalies, and significantly more auditory, but not visual, anomalies were reported compared with olfactory anomalies. In order to investigate the equivalence of the present study's sample with that of Bunney *et al.* (1999), similar analyses were carried out. There was no difference in the prevalence of perceptual anomalies in the auditory and visual modalities (Wilcoxon's signed-ranks test $z = -0.943$, $p = 0.346$). Auditory anomalies were more prevalent than tactile (Wilcoxon's signed-ranks test $z = -4.69$, $p < 0.0001$), gustatory (Wilcoxon's signed-ranks test $z = -5.00$, $p < 0.0001$) and olfactory (Wilcoxon's signed-ranks test $z = -3.53$, $p < 0.0001$) anomalies and visual anomalies were more prevalent than tactile (Wilcoxon's signed-ranks test $z = -4.025$, $p < 0.0001$) and gustatory anomalies (Wilcoxon's signed-ranks test $z = -4.583$, $p < 0.0001$). In contrast to Bunney *et al.* (1999), the current study also found that visual anomalies were more prevalent than olfactory anomalies (Wilcoxon's signed-ranks test $z = -3.300$, $p = 0.001$).

Bunney *et al.* (1999) found that, in the group of participants with a diagnosis of schizophrenia, the highest average Likert ratings were in the auditory modality. Their scale rated an absence of perceptual anomalies as 1 whereas the present study rated an absence as 0. Adjusting for this difference, the average Likert rating in the auditory modality was between 0.5 and 0.6 (exact figures are not reported). In the present study, average Likert ratings in the auditory modality were 0.395 for the No-JTC group and 0.470 for the JTC group, slightly lower than those obtained by Bunney *et al.* (1999).

Auditory Perceptual Task (Auditory reality discrimination)

Forty-eight participants completed the auditory perceptual task (20 JTC, 28 No-JTC). Using a two-button box, they were able to respond with values between 1 and 5, where 5 indicated that a voice had definitely been heard in the noise and 1 indicated that a voice had definitely not been heard in the noise. Failure to respond was recorded as 0 by the computer. For the purpose of analysis the 0 responses were combined with 1 responses.

All but one of the participants reported that they heard a voice on at least one of the stimulus trials. None of them accurately described the stimulus as the word "who" but one did identify it as the experimenter's voice. It was often described as a voice on the radio, presumably because of the white noise resembled interference. Most participants reported hearing a grunt or a single word such as "free" (three participants), "three" (three participants), "freeze" (two participants), "fees" (one participant), "grease" (one participant), "bee" (one participant), "beats" (one participant) or "speak" (one participant). One participant heard the phrase "Yes, thank you." Another heard someone talking about schizophrenia.

The data was analysed using the method described by McNicol (1972) and applied by previous studies of reality discrimination using this paradigm (Bentall & Slade, 1985;

Rankin & O'Carroll, 1995; Böcker *et al.*, 2000). By convention, categories indicating high certainty that a signal was present have been assigned low values and categories indicating low certainty have been assigned high values. Conforming to this convention required a reversal of the scale to which participants responded so that, for the purpose of analysis, the points on the rating scale were categorised as "1: definitely heard a sound", "2: probably heard a sound", "3: might have heard a sound", "4: probably did not hear a sound" and "5: definitely did not hear a sound".

Following the procedure for rating scale experiments described by McNicol (1972), "hit" rates (i.e. the probability of reporting a signal (a voice in this case) given the presence of a signal in the noise (p(S|s))) and "false alarm" rates (i.e. the probability of reporting a signal given the presence of noise alone (p(S|n))) were calculated for each participant at each of the four levels of certainty (i.e. "1: definitely heard a sound", "2: probably heard a sound", "3: might have heard a sound", "4: probably did not hear a sound"). McNicol (1972, p.26) describes the rational behind signal detection experiments using the rating scale procedure as follows, "Each point on the rating scale can be considered as corresponding to a different criterion. Points on the rating scale that indicate high certainty that a stimulus event was a signal correspond to strict criteria and we would expect these to give low false alarm rates. Points on the rating scale which indicate uncertainty as to whether an event was a signal or not will be laxer criteria and should give higher false alarm rates."

Previous experiments using similar tasks (Bentall & Slade, 1985; Rankin & O'Carroll, 1995; Böcker *et al.*, 2000) have calculated a non-parametric measure of sensitivity, P(A), which consists of the area beneath the ROC curve obtained by plotting individuals' response frequencies against the 4 levels of certainty. Several participants in the present study did not make use of all possible response categories; so accurate ROC curves could not be plotted. This may have been due to the small number of trials (40 as opposed to 100 in previous studies) or to differences in intensity of the signal (i.e. the voice) relative to the noise. Consequently, it was not possible to compare the sensitivity of the two groups. However, previous studies found no significant differences on measures of sensitivity between groups scoring high and low on a predisposition to hallucination scale (Bentall & Slade, 1985; Rankin & O'Carroll, 1995) or between hallucinating and non-hallucinating patients with a diagnosis of schizophrenia (Bentall & Slade, 1985; Böcker *et al.*, 2000). These studies did find significant differences between groups on measures of perceptual bias, and this was the variable of interest.

Previous studies have used the non-parametric measure of response bias (B_a) as an indicator of (the inverse of) reality discrimination, or at least one of the factors in reality discrimination, externalising perceptual bias. B_a consists of the hypothetical rating scale category for which the sum of the probability of a hit ($p(S|s)$) and the probability of a false alarm ($p(S|n)$) is equal to 1. B_a is low for people who are biased towards classifying internal events as external. In other words, people with a low B_a are biased towards perceiving noise as signal (in this case a voice), whereas people with a high B_a are biased towards perceiving signal as noise.

Table 3. Example calculation of B_a for one participant.

(a)

	Observer's response (frequencies)				
	High certainty signal to high certainty noise				
Category	1	2	3	4	5
Stimulus: s	10	0	2	3	5
n	4	0	1	3	12

(b)

	Observer's response (cumulative frequencies)				
	High certainty signal to high certainty noise				
Category	1	1+2	1+2+3	1+2+3+4	1+2+3+4+5
Stimulus: s	10	10	12	15	20
n	4	4	5	8	20

(c)

	Observer's response (probability ratios)				
	High certainty signal to high certainty noise				
Category	1	2	3	4	5
P(S|s)	0.5	0.5	0.6	0.75	1
P(S|n)	0.2	0.2	0.25	0.4	1
P(S|s)+P(S|n)	0.7	0.7	0.85	1.15	2

The means by which B_a is calculated is illustrated in Table 3. The task contained 20 trials in which a signal was present (stimulus: s) and 20 trials in which there was only noise (stimulus: n). Participants' responses are categorised according to how certain they were that a signal was present (between "1: definitely heard a sound" and "5: definitely did not hear a sound"). The number of responses in each category were summed (Table 3a). The frequency of responses in each category, and in categories indicating a higher level of certainty, were calculated (Table 3b). The probability of a hit and the probability of a false alarm were then calculated for each category (Table 3c). Hit and false alarm probabilities were then summed (e.g. for category 1, 10/20 + 4/20 = 0.7). In this example B_a (i.e. the point at which $p(S|s) + p(S|n) = 1$) lies between 3, where $P(S|s)+P(S|n) = 0.85$, and 4, where $P(S|s)+P(S|n) = 1.15$. In fact, it lies exactly halfway between 3 and 4 so B_a = 3.5.

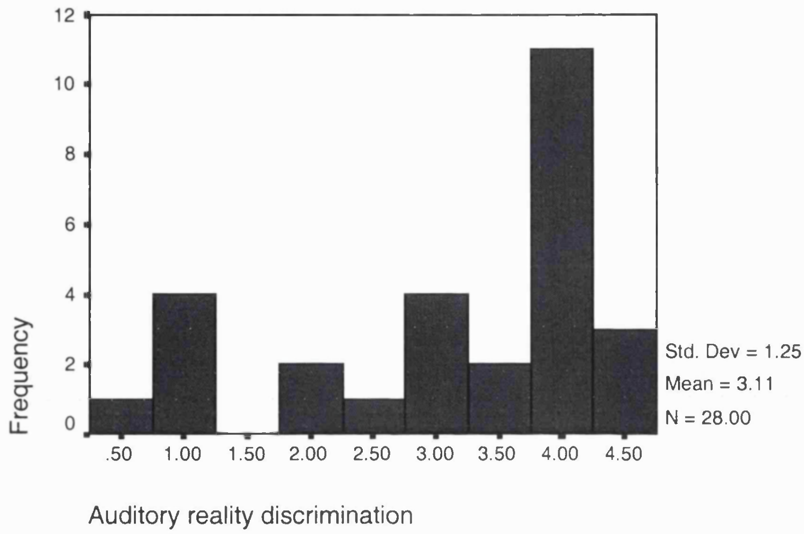
In this experiment, the maximum hypothetical value of B_a is 4.5, which would occur when all responses indicated that a voice was definitely not heard. In this case $p(S|s)$ and $p(S|n)$ is 0 for all levels of certainty (1-4) and the sum of $p(S|s)$ and $p(S|n)$ is 2 in the "definitely did not hear a sound" category (5). Therefore, the hypothetical rating scale category for which $p(S|s)$ plus $p(S|n)$ equals one, lies halfway between 4 and 5 (i.e. 4.5).

In cases where half the responses were in the "1: definitely heard a sound" category, $p(S|s)$ plus $p(S|n)$ equals one in category 1 but, if there were no responses in the following categories (2-4), $p(S|s)$ plus $p(S|n)$ also equals one in these categories. Therefore, B_a was given the value of the category below that where $p(S|s) + p(S|n) > 1$. Consequently, perfect performance (100% hits at maximum certainty, 0% false alarms) provided a B_a of 4, whereas 100% hits plus a single false alarm in the "2: probably heard a sound" category, resulted in a B_a of 1. Such a large influence of single observations was clearly undesirable but, nevertheless, unavoidable. The problem may be due to the relatively small number of trials or to participants' failure to make use of all available response categories. Previous reports of studies utilising similar tasks have not provided sufficient details of their analyses to ascertain whether or not similar problems have occurred and, if so, the way in which they have been managed.

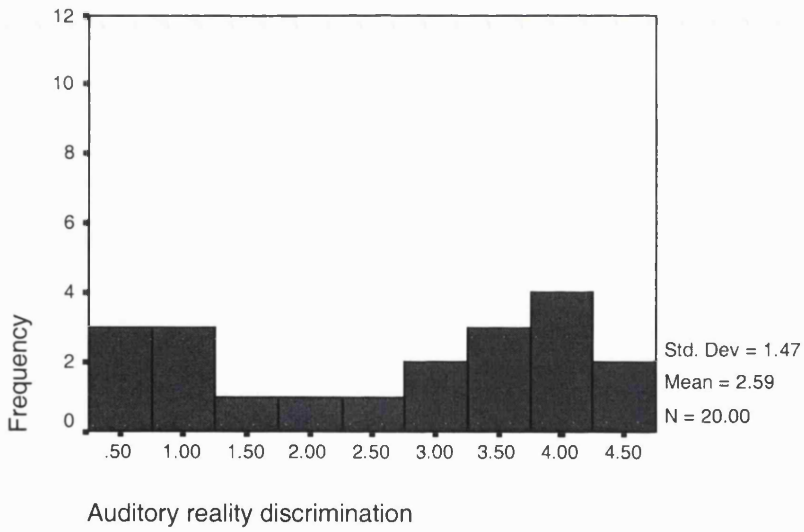
In cases where more than half the responses were in the "1: definitely heard a sound" category, the hypothetical rating scale category for which $p(S|s)$ plus $p(S|n)$ equals one, is less than 1. Following McNicol's (1972, p. 128) advice, the existence of a category 0 was assumed which has $p(S|s) = p(S|n) = 0$. This is a crude solution that is not likely to give a good estimate of B_a but it is necessary for statistical analysis. Again, previous reports of studies utilising similar tasks have not provided sufficient details to ensure exact replication of their analyses.

In the auditory modality, the No-JTC group demonstrated a mean perceptual bias (B_a) of 3.11 (SD = 1.25). The JTC group demonstrated a mean perceptual bias (B_a) of 2.59 (SD = 1.47; see Table 2). The variable was distributed normally in the JTC group (Kolmogorov-Smirnov (20) = 0.160, $p = 0.194$) but not in the No-JTC group (Kolmogorov-Smirnov (28) = 0.263, $p < 0.0001$). The distribution could not be normalised by square root or natural logarithm transformations because the distribution was bimodal (see Figure 8).

Figure 8. Distribution of B_a in the No-JTC group



Distribution of B_a in the JTC group



Because the two groups are significantly different on measures of education and IQ, a linear regression was performed with B_a as the dependent variable and years of education after 16 and estimated IQ as the independent variables. The unstandardised residuals were saved and a non-parametric statistic was used to compare the two groups on these residuals. No significant difference was found (Mann-Whitney $U = 245.0$, $p = 0.591$).

A posteriori analyses were carried out in order to compare the results of the present study with previous research employing the same paradigm. Slade & Bentall (1985) studied the performance of people with a diagnosis of schizophrenia on a similar task. They found a significant difference in auditory reality discrimination between a group that were currently experiencing hallucinations (B_a: mean = 2.63, SD = 0.948) and a group that were not hallucinating at the time of the study (B_a: mean = 3.78, SD = 0.861). In the present study, the mean B_a of the 21 hallucinating participants, who completed the task, was 2.86 (SD = 1.37) and 2.88 (SD = 1.38) for the 26 non-hallucinating participants. These measures of perceptual bias were broadly equivalent to those obtained by Slade & Bentall from a group that were currently experiencing hallucinations but considerably less than the Slade & Bentall's non-hallucinating group.

In the present study, the distribution was normal for neither group (Kolmogorov-Smirnov (21) = 0.220, $p = 0.009$ and Kolmogorov-Smirnov (26) = 0.182, $p = 0.009$, respectively). A non-parametric comparison revealed no significant difference (Mann-Whitney U = 504.0, $p = 1.000$). When the analysis was restricted to only those participants with a diagnosis of schizophrenia, the distributions of both the hallucinating and non-hallucinating groups were normal (Kolmogorov-Smirnov (16) = 0.193, p = 0.115 and Kolmogorov-Smirnov (8) = 0.190, p > 0.200, respectively) but there was no significant difference between the groups (*t* (22) = 0.762, p = 0.454).

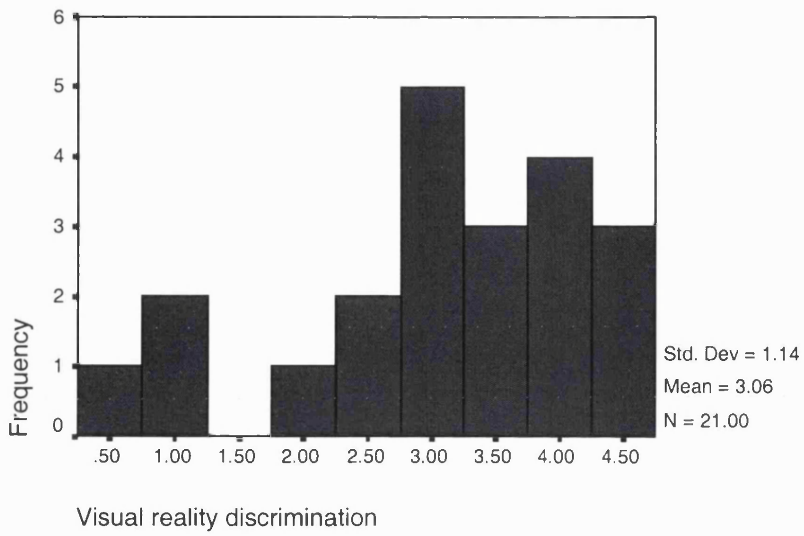
Böcker *et al.* (2000) also compared a group of people with a diagnosis of schizophrenia who were currently experiencing hallucinations with a group that were not, on a similar task. They do not report the measures of perceptual bias that they obtained, so no comparison to those obtained in the present study could be made. They failed to replicate Slade & Bentall's (1985) finding but did find a trend to a significant correlation between values of B_a (standardised against a non-psychiatric sample) and the severity of hallucinations in a group of people with a diagnosis of schizophrenia who had hallucinated in the week preceding testing. This comparison reached significance within the subgroup of patients showing only auditory hallucinations. No control group, against which to standardise scores, was available in the present study. There was no significant correlation between B_a and Global Rating of Severity of Hallucinations (as measured by the SAPS) amongst hallucinating participants (Spearman's ρ (24) = -0.200, p = 0.174 (one-tailed)). However, when speculative correlations between SAPS subscales relating to auditory hallucinations (Auditory Hallucinations, Voices Commenting and Voices Conversing) were calculated, a significant negative correlation between B_a and Voices Commenting was revealed (Spearman's ρ (24) = -0.358, p = 0.043). The degree of correlation increased when the analysis was restricted to participants showing only auditory hallucinations (Spearman's ρ (21) = -0.451, p = 0.020). When the analysis was restricted to hallucinating participants with a diagnosis of schizophrenia, these correlations were not significant (Spearman's ρ (14) = -0.021, p = 0.472 for Global Rating of Severity of Hallucinations and Spearman's ρ (14) = -0.355, p = 0.106 for Voices Commenting).

Visual Perceptual Task (Visual reality discrimination)

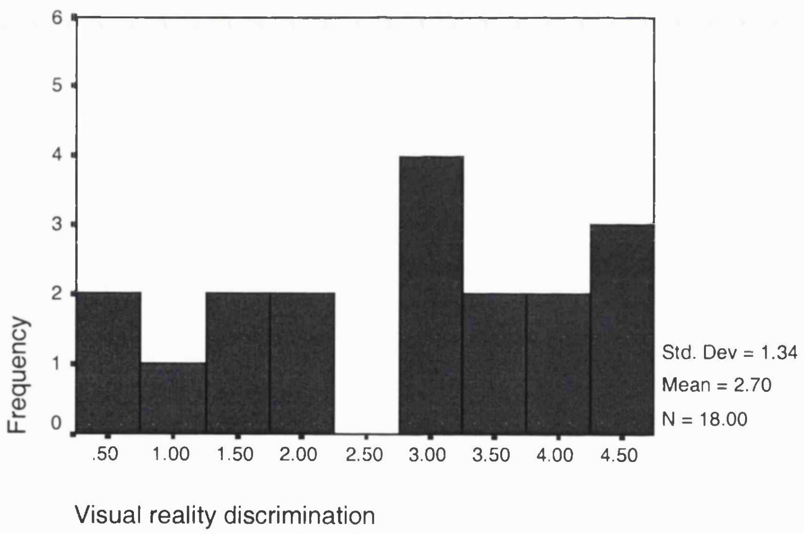
Thirty-nine participants completed the visual perceptual task (18 JTC, 21 No-JTC). Six participants did not complete the task because they were unable to see any image on the practice. One participant did not complete any tasks except the "beads" and the auditory perceptual task. The other missing data was due to the computer "crashing" during the task. One participant accurately described the stimulus as the word "who". Ten of the other participants recognised that the stimulus contained letters, often including "w" or similar letters such as "m" and "v". Most other participants described the stimulus as a flash or a white square. Five participants perceived more complex images such as an elephant, a monkey, a bearded man, an aeroplane and a house.

Responses were analysed in the same way as the auditory reality discrimination task. In the visual modality, the No-JTC group demonstrated a mean perceptual bias (B_v) of 3.06 (SD = 1.14). The JTC group demonstrated a mean perceptual bias (B_v) of 2.70 (SD = 1.34; see Table 2). The variable was distributed normally in both the No-JTC group (Kolmogorov-Smirnov (21) = 0.144, p > 0.200) and the JTC group (Kolmogorov-Smirnov (18) = 0.135, p > 0.200; see Figure 9). A parametric test of B_v, covarying out

Figure 9. Distribution of B_v in the No-JTC group



Distribution of B_v in the JTC group



years of education after the age of 16 and estimated IQ, did not show a significant difference between groups (F (1, 36) = 0.056, p = 0.815).

An a posteriori analysis was carried out in order to compare the results of the present study with previous research employing the same paradigm. Böcker *et al.* (2000) found no significant correlation between values of B_v (standardised against a non-psychiatric sample) and the severity of hallucinations in a group of people with a diagnosis of schizophrenia who experienced hallucinations. However, they did find a significant correlation when the analysis was restricted to participants showing only auditory hallucinations. This result was somewhat unexpected since one would predict that an externalising visual perceptual bias would be associated with visual rather than auditory hallucinations. No control group, against which to standardise scores, was available in the present study. B_v was distributed normally in both the hallucinating and the non-hallucinating group (Kolmogorov-Smirnov (20) = 0.132, p > 0.200 and Kolmogorov-Smirnov (19) = 0.137, p > 0.200, respectively). As with Bocker *et al.*'s (2000) study, there was no significant difference between groups (t (37) = -0.512, p = 0.612). There was no significant correlation between B_v and Global Rating of Severity of Hallucinations (as measured by the SAPS) amongst participants experiencing hallucinations or amongst participants experiencing only auditory hallucinations (Pearson's r (20) = 0.318, p = 0.113 (one-tailed) and Pearson's r (17) = 0.088, p = 0.369 (one-tailed), respectively). When the analysis was restricted to participants experiencing only auditory hallucinations with a diagnosis of schizophrenia, there was still no correlation (Pearson's r (12) = 0.342, p = 0.138 (one-tailed)). The correlation between B_v and Voices Commenting was not significant (Pearson's *r* (20) = 0.063, p = 0.396 (one-tailed)).

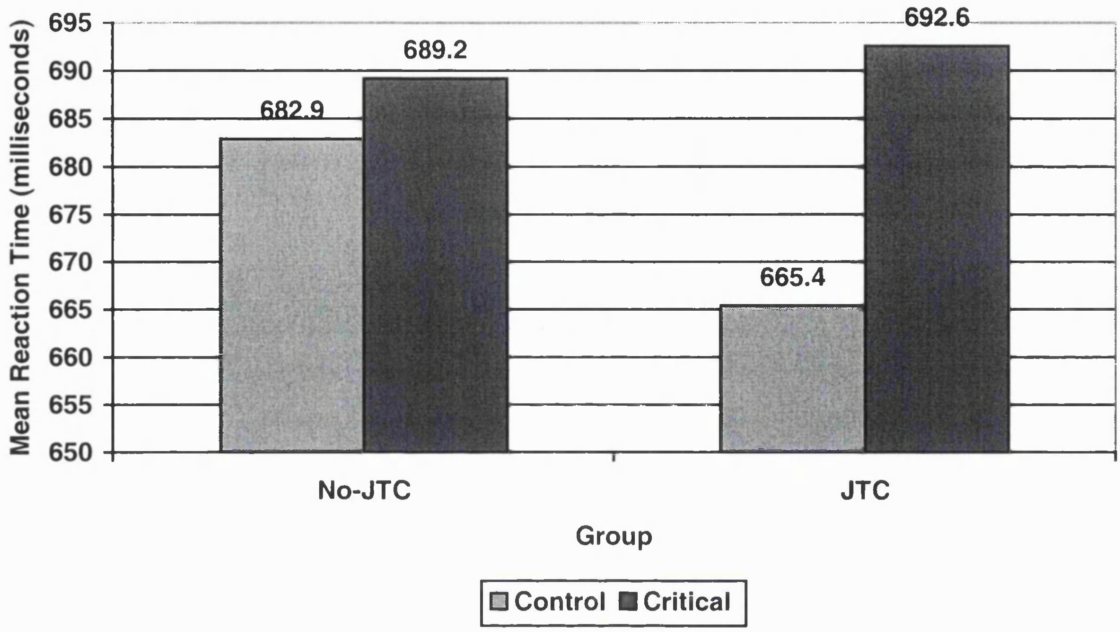
Negative Priming Task (Inhibition of irrelevant information)

Forty-five participants completed the negative priming task (20 JTC, 25 No-JTC). Because there was no practice for this task, the first six of the 136 trials were excluded from the analysis. The response accuracy for all but four participants was within one standard deviation (17.09%) of the mean (86.47%). The response accuracies of four participants (two JTC and two No-JTC) were greater than two standard deviations below the mean (maximum 51.53% accurate). These participants were excluded from further analysis.

For the JTC group, mean reaction time (RT) on critical trials was 682.6 milliseconds (SD = 135.5) and 665.4 milliseconds (SD = 121.0) on control trials. For the No-JTC group, mean RT on critical trials was 689.2 milliseconds (SD = 126.2) and 682.9 milliseconds (SD = 121.5) on control trials (see Table 2 and Figure 10). The distributions of all four RT variables were normal.

A two-by-two mixed (within and between subjects) analysis of covariance (ANCOVA), covarying out estimated IQ and years in education after 16, demonstrated no significant main effect of trial type (F (1, 37) = 0.230, p = 0.634), nor group (F (1, 37) = 0.110, p = 0.742). Nor was there a significant interaction between trial type and group (F (1, 37) =

Figure 10. Mean RTs to critical and control trials for No-JTC and JTC groups

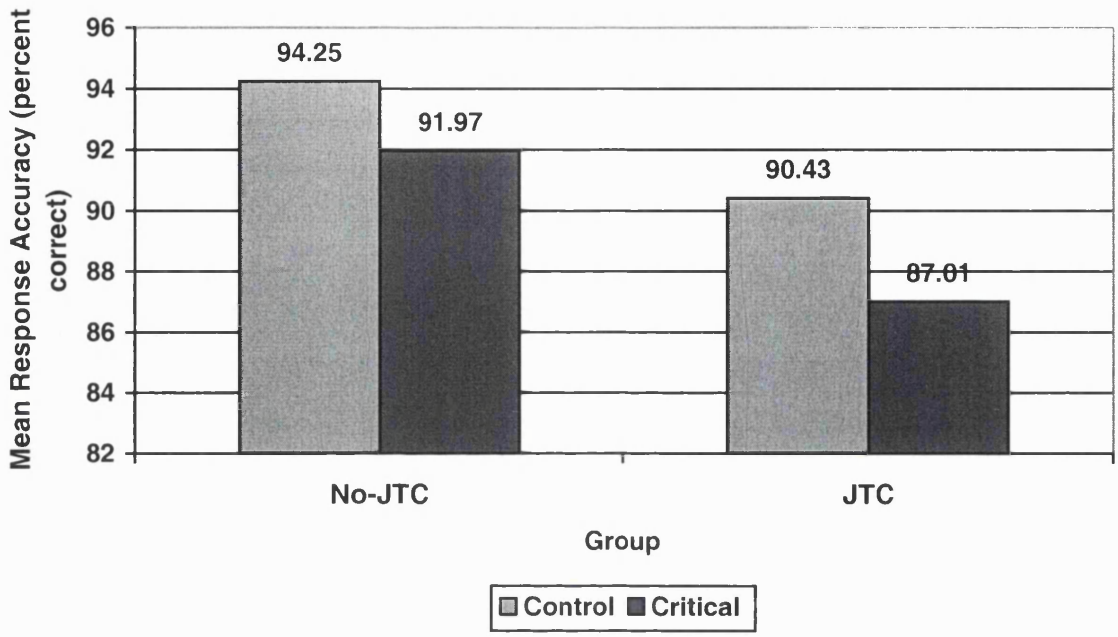


0.872, p = 0.356). This indicated that the negative priming effect was not found overall and that the two groups did not differ in overall RT or amount of negative priming.

Negative priming is operationally defined as slowed responses and lower accuracy to an object if a related object has recently been ignored (Neill, *et al.*, 1995). Therefore, response accuracy was also compared across groups. For the JTC group, mean accuracy on critical trials was 87.01% (SD = 8.834) and 90.43% (SD = 7.728) on control trials. For the No-JTC group, mean accuracy on critical trials was 91.97% (SD = 7.662) and 94.25% (SD = 5.086) on control trials (see Figure 11). The distribution of accuracy on critical trials was normal for the JTC group (Kolmogorov-Smirnov (18) = 0.157, p > 0.200) but not for the No-JTC group (Kolmogorov-Smirnov (23) = 0.249, p = 0.001). The distribution of accuracy on control trials was normal for neither the JTC group (Kolmogorov-Smirnov (18) = 0.239, p = 0.008) nor the No-JTC (Kolmogorov-Smirnov (23) = 0.188, p = 0.035). The distributions of an arcsin transformation of accuracy divided by 100, were normal for the JTC group (critical: Kolmogorov-Smirnov (18) = 0.126, p > 0.200; control: Kolmogorov-Smirnov (23) = 0.180, p = 0.129) and nearly normal for the No-JTC group (critical: Kolmogorov-Smirnov (18) = 0.197, p = 0.021; control: Kolmogorov-Smirnov (23) = 0.128, p > 0.200).

A two-by-two mixed (within and between subjects) analysis of variance, covarying out estimated IQ and years in education after 16, demonstrated no significant main effect for trial type (*F* (1, 37) = 1.417, p = 0.241), or between groups (*F* (1, 37) = 1.198, p = 0.281). Nor was there a significant interaction between trial type and group (*F* (1, 37) = 0.173,

Figure 11. Mean response accuracy to critical and control trials for No-JTC and JTC groups



p = 0.680). As with the RT data this indicated that the negative priming effect was not found overall and that the two groups did not differ in overall accuracy or amount of negative priming.

Ferraro & Okerlund (1996) used an identical task to test students who had completed the Schizotypal Personality Scale (STA; Claridge, Clark & Beech, 1992). They found a significant interaction between group (high versus low scorers on STA) and negative priming (control versus critical trials) and a significant correlation between STA score and amount of negative priming (operationally defined as (critical RT – control RT)). In an attempt to replicate this finding in a clinical sample, participants who experienced hallucinations (i.e. those scoring 2 or more on the Global Rating of Severity of Hallucinations) were compared with participants who did not experience hallucinations. When RT was used as the dependent variable, there was no significant difference between the groups (F (1, 39) = 0.166, p = 0.686), nor was the interaction significant (F (1, 39) = 0.16, p = 0.899). However, there was a significant effect of trial type (F (1, 39) = 6.081, p = 0.018), with RT on critical trials being slower, indicating that the task had elicited a negative priming effect that was abolished by covarying out IQ and education. When accuracy was used as the dependent variable, a similar pattern was found: no significant difference between the groups (F (1, 39) = 0.520, p = 0.475), no significant interaction (F (1, 39) = 0.073, p = 0.789) but a significant effect of trial type (F (1, 39) = 16.840, p < 0.0001). This implied that IQ and education influence performance on this negative priming task.

Speculative Analyses

Hemsley's (1996) model of schizophrenia predicts an association between negative priming and positive symptoms. Therefore, correlations were calculated between negative priming and measures from the SAPS (see Tables 4 and 5) and SIAPA (see Table 6). Clearly, this required a large number of statistical tests and one in 20 would be expected to give a significant result by chance alone (i.e. type 1 errors). However, the failure of most of these measures of positive symptomatology to correlate with a measure of negative priming was interesting in its own right. In fact the only significant correlation with a rating of a positive symptom, albeit a somewhat rare one, was with Olfactory Perceptual Anomalies (Spearman's ρ = -0.264, p = 0.048 (one-tailed)). The fundamental information-processing bias that accounts for abnormal negative priming is a plausible mechanism by which reality discrimination might be impaired, so correlations between negative priming and perceptual biases in the auditory and visual modalities were also examined. There was a significant correlation with visual perceptual bias (Pearson's r = -0.317, p = 0.034 (one-tailed)) and a trend towards significance with auditory perceptual bias (Spearman's ρ = -0.209, p = 0.097 (one-tailed)).

Despite, the absence of a significant difference between groups on measures of negative priming and perceptual bias, the possibility that an association had been obscured by the presence of participants with a "jump-to-conclusions" bias in the No-JTC group was tested by correlating the number of beads requested by participants with negative priming, with B_a and with B_v. There was no significant correlation with negative priming

Table 4. Correlations between negative priming and measures of hallucination

	Global rating of severity of hallucinations	Auditory hallucinations	Voices commenting	Voices conversing
Spearman's ρ	-0.112	-0.171	-0.115	-0.053
Significance (one-tailed)	0.244	0.143	0.237	0.372

		Somatic or tactile hallucinations	Olfactory hallucinations	Visual hallucinations
Spearman's ρ		-0.168	-0.178	0.034
Significance (one-tailed)		0.147	0.133	0.416

Table 5. Correlations between negative priming and measures of delusions

	Global rating of severity of delusions	Persecutory delusions	Delusions of jealousy	Delusions of sin or guilt	Grandiose delusions
Spearman's ρ	0.052	-0.150	-0.174	-0.199	0.153
Significance (one-tailed)	0.373	0.174	0.139	0.106	0.170

	Religious delusions	Somatic delusions	Delusions of reference	Delusions of control
Spearman's ρ	0.143	-0.040	0.184	-0.182
Significance (one-tailed)	0.186	0.403	0.125	0.128

	Delusions of mind reading	Thought broadcasting	Thought insertion	Thought withdrawal
Spearman's ρ	-0.112	-0.235	-0.051	-0.009
Significance (one-tailed)	0.243	0.070	0.376	0.477

Table 6. Correlations between negative priming and measures of perceptual anomalies

	Frequency of perceptual anomalies	Auditory perceptual anomalies	Visual Perceptual Anomalies	Tactile perceptual anomalies	Olfactory perceptual anomalies	Gustatory perceptual anomalies
Spearman's ρ	0.002	0.175	-0.100	-0.011	-0.264	0.026
Significance (one-tailed)	0.495	0.138	0.268	0.473	0.048*	0.435

* Correlation significant at 0.05 level.

(Spearman's $\rho = 0.008$, $p = 0.481$ (one-tailed)) or with B_v (Spearman's $\rho = 0.043$, $p = 0.404$ (one-tailed)) but with B_a the correlation showed a trend to significance (Spearman's $\rho = 0.236$, $p = 0.071$ (one-tailed)), indicating that participants requesting more beads were less likely to attribute the source of events to an external origin. This analysis also demonstrated a significant correlation between B_a and B_v (Spearman's $\rho = 0.425$, $p = 0.006$ (one-tailed)).

DISCUSSION

Main Findings

The primary issue addressed by this study concerned a comparison of two models of delusion formation. Maher's (1988) model suggests that the majority of delusions are reasonable explanations of anomalous experience. Garety & Hemsley's (1994) model suggests that a "jump-to-conclusions" bias is causal in the formation of a large proportion of delusions and that a fundamental information-processing bias is responsible for both the "jump-to-conclusions" bias and anomalous perceptual experience. These models make opposite predictions about the prevalence of perceptual anomalies in groups of people with delusions with and without a "jump-to-conclusions" bias. Maher's model predicts that participants with a JTC bias will experience less anomalous perceptions. Garety & Hemsley's model predicts the opposite pattern; that anomalous perceptual experience will be greater in the JTC group.

There was no difference between the groups on measures of subtle perceptual anomalies provided by the SIAPA. However, there was a significant difference between the groups on measures of hallucinations provided by the SAPS. Hallucinatory experience was rated as more severe in the No-JTC group than the JTC group. This supports Maher's model and contradicts Garety & Hemsley's model. A closer inspection of the SAPS data revealed that the No-JTC group experienced significantly more frequent auditory hallucinations, voices commenting, olfactory hallucinations and visual hallucinations.

The second issue addressed by this study was the putative association between the "jump-to-conclusions" bias and other information-processing biases identified in groups of people experiencing psychotic phenomena. Garety & Hemsley (amongst others) suggested that the "jump-to-conclusions" bias is associated with a weakening of the influence of stored regularities on current perceptual processing, as measured by negative priming, latent inhibition, Kamin's blocking effect and pre-pulse inhibition paradigms. In addition, they suggested that people who "jump-to-conclusions" might also "jump-to-perceptions", resulting in hallucinations and other anomalous perceptual experiences. This "jump-to-perceptions" bias has been identified in people with a diagnosis of schizophrenia who experience hallucinations, using a signal detection task.

There were no significant differences between the JTC and the No-JTC groups on measures of reaction time or accuracy in response to negatively primed stimuli. There were no significant differences between the JTC group and the No-JTC group on measures of "jump-to-perceptions" bias in either the auditory or visual modality. These results contradict the hypothesis that the "jump-to-conclusions" bias is associated with a weakening of the influence of stored regularities on current perceptual processing or with the "jump-to-perceptions" bias.

Presence of the "Jump-to-Conclusions" Bias

The decision to allocate participants to the JTC group if they requested only one bead and to the No-JTC group if they requested more than one bead, was made on the basis of the findings of Huq *et al.* (1988) and Garety *et al.* (1991). They showed that there was considerable variability in the performance of people with delusions on this task. People with delusions requested less beads than people without delusions but, as a group, their reasoning conformed more closely to the decision point prescribed by Bayes' Theorem (i.e. after two beads have been presented). However, the mean number of beads requested by the groups of people with delusions was highly influenced by subgroups of "extreme" responders who requested only one bead. Huq *et al.* (1988) and Garety *et al.* (1991) found that 47% and 41% of participants with delusions, respectively, requested only one bead.

The proportion of participants with delusions requesting only one bead in the present study was 44%, which is consistent with the findings of Huq *et al.* (1988) and Garety *et al.* (1991). Garety *et al.* found that the mean number of beads requested by participants with delusions satisfying Research Diagnostic Criteria for Schizophrenia (Spitzer *et al.*, 1978) was 2.38 and 3.00 for participants meeting DSM-IIIR (APA, 1987) diagnostic criteria for delusional disorder (paranoia). Dudley *et al.* (1997) found that the mean number of beads requested by participants with delusions with a diagnosis of schizophrenia or delusional disorder on a computerised version of the same task was 2.4. However, at least one other study has found a much higher mean of 6, amongst participants with delusions (Peters & Garety, submitted). This was significantly less than the mean number of beads requested by the control groups (i.e. a mean of 6 indicated a "jump-to-conclusions' bias).

The mean number of beads requested by participants with delusions in the present study was 2.02. This is less than other studies that have used the "beads" task. If this difference is significant, it raises the possibilities that there was either something unusual about the administration of the task that caused more participants to request only one bead or that there was something unusual about the sample, which meant that even participants requesting more than one bead exhibited a "jump-to-conclusions" bias. The former explanation is unlikely to be correct because the proportion of participants requesting only one bead is similar to that found by Garety *et al.* (1991) and Dudley *et al.* (1997). The latter explanation, that the No-JTC group did in fact demonstrate a "jump-to-conclusions" bias is profoundly relevant to the interpretation of the results.

Although Garety *et al.* (1991) did not report the mean number of beads requested by participants with delusions who reached a decision after more than one bead (i.e. the equivalent of the present study's No-JTC group), it is possible to calculate it as 3.88 (SD = 2.03). Their anxious control group's mean was 3.71 (SD = 1.68) and their normal control group's mean was 5.38 (SD = 3.15). In the present study, the mean number of beads requested by the No-JTC group was 2.82 (SD = 1.06). The difference between the present No-JTC group and Garety *et al.*'s No-JTC group almost reached significance (Mann-Whitney U = 151.0, p = 0.058).

If it was the case that the No-JTC group, or at least some of the participants assigned to that group, did in fact demonstrate a "jump-to-conclusions" bias, then the failure to find differences between the groups on other tasks might be explained by this fact. However, the finding that the No-JTC group did experience more severe hallucinations, as predicted by Maher, makes this interpretation less likely. Also, the fact that previous research has demonstrated that the overall performance of people with delusions on the "beads" task is highly influenced by a subgroup of "extreme" responders who request only one bead makes the comparison of "extreme" responders (i.e. the JTC group) to "non-extreme" responders (i.e. the No-JTC group) legitimate.

If the "jump-to-conclusions" bias is a consequence of the cognitive disturbance measured by negative priming as predicted by Garety & Hemsley (1994), then the inclusion of participants with a "jump-to-conclusions" bias in the No-JTC group would have obscured the association between performance on the "beads" task and performance on the negative priming task. However, the correlation between beads to decision and negative priming was not significant when the JTC and No-JTC groups were combined, as it would have been if the association had simply been obscured by the inclusion of participants with a "jump-to-conclusions" bias in the No-JTC group. The correlation between beads to decision and B_v was not significant but the correlation between beads to decision and B_a did show a trend to significance. The size of the correlation is modest and may be spurious but it raises the possibility that there is an association between the "jump-to-conclusions" bias and the "jump-to-perceptions" bias in the auditory modality.

However, this association is not mediated by the cognitive disturbance measured by negative priming as suggested by Garety & Hemsley (1994).

Group Differences in Reports of Anomalous Perceptual Experience

Anomalous perceptual experience was measured by both the SAPS and the SIAPA. The former rated the severity of hallucinatory experience while the latter rated the severity of more subtle perceptual anomalies. The No-JTC group experienced more severe hallucinations in general and more frequent auditory hallucinations, voices commenting, olfactory hallucinations and visual hallucinations in particular. The groups did not differ on SAPS ratings of Voices Conversing or of Somatic or Tactile Hallucinations. Nor were any significant differences found between the groups on any of the SIAPA ratings.

Maher's (1988) model predicts that individuals with delusions who reason normally experience more perceptual anomalies. This prediction was born out by the results of the present study in the case of hallucinations. The prevalence of somatic or tactile hallucinations and experiences of voices conversing was low, which may account for the failure to demonstrate group differences on these measures. The absence of group differences on any SIAPA ratings may be due to a lack of sensitivity in this instrument (see Limitations of Tasks section). The model predicts that only the minority of people with delusions who do reason abnormally, will not experience perceptual anomalies. In the present study, these individuals were assigned to the JTC group and the mean ratings of hallucinatory experiences were lower in the JTC group.

Figure 4 illustrates the bimodal distribution of the Global Rating of Severity of Hallucinations in the JTC group. Although, 54.5% of the group did not report any hallucinations in the last month, 45.5% had experienced hallucinations of varying severity. So these people had two factors influencing the formation of delusions: anomalous perceptual experience and a "jump-to-conclusions" bias. Also of note, is the fact that at least 25.9% (or 40.7% if "questionable" responses are included) of the No-JTC group did not report any hallucinations in the last month. Some of these participants did report experiencing hallucinations in the past but there were also a few who did not. Assuming that their reports were reliable, this finding begs the question how did they come to form delusions. It may be that these participants illustrate "a second route to psychosis" in which "life events trigger only disturbed affect [rather than disturbed affect and cognitive disturbance], which in turn directly activates biased appraisal processes and maladaptive self/other schemas leading to an externalising appraisal (i.e. the delusion) for the life event or the disturbed affect." (Garety *et al.*, 2001).

Amongst the subtypes of hallucination, the difference between the JTC and the No-JTC groups was greatest for SAPS ratings of Voices Commenting. This suggests that hearing a voice commenting on ones thoughts and behaviour is particularly associated with delusional explanations, even amongst people who reason normally. One reason why this symptom is often considered to be pathognomonic for schizophrenia may be that it is rare to generate "naturalistic" explanations for it.

In an attempt to replicate Böcker *et al.*'s (2000) finding of a significant correlation between severity of hallucinations and B_a amongst participants with auditory hallucinations, an a posteriori analysis revealed a significant correlation between B_a and SAPS ratings of Voices Commenting but not SAPS ratings of Auditory Hallucinations and Voices Conversing. Although, as a post hoc finding, this should be interpreted with caution, it implies that an externalising auditory perceptual bias is particularly associated with the misperception of internal dialogue as externally generated. The externalising perceptual bias measures only one aspect of reality discrimination. This metacognitive skill is also influenced by beliefs about what kinds of events are real and what kinds of events are imaginary. These beliefs are encoded in cultural practices but are also likely to be influenced by personal experience. Consequently, hallucinatory experiences may persist in individuals who no longer demonstrate an externalising perceptual bias.

Association between the "Jump-to-Conclusions" Bias and Negative Priming

There was no difference between the JTC and the No-JTC groups in measures of a weakening of the influence of stored regularities on current perceptual processing. There are a number of difficulties in the interpretation of these results since the usual negative priming effect was not found in either group. Previous research has shown that the usual negative priming effect is abolished in people with psychotic illnesses (e.g. Liotti *et al.*, 1993; Nestor *et al.*, 1992; Beech *et al.* 1989). The results of the current study's a priori analysis demonstrated no significant difference between negatively primed stimuli and control stimuli in RT or accuracy. This is consistent with previous research, since all participants were diagnosed with a psychotic illness. If it was the case that the No-JTC group did have a "jump-to-conclusions" bias (see above) then these results are also consistent with Garety & Hemsley's (1994) model.

Another possible interpretation is that the task failed to elicit a negative priming effect in participants that do inhibit irrelevant information. This seems unlikely for two reasons. Firstly, a negative priming effect was observed when IQ and education were not covaried out in an a posteriori comparison of hallucinators with non-hallucinators. Secondly, Ferraro & Okerlund (1996) did find a significant interaction between group (high STA and low STA students) and stimulus (negatively primed and not negatively primed) using an identical task.

Association between the "Jump-to-Conclusions" Bias and the "Jump-to-Perceptions" Bias

There was no difference between the JTC and the No-JTC groups in measures of the "jump-to-perceptions" bias. Whether or not the perceptual tasks successfully elicited a "jump-to-perceptions" bias from participants is unclear. The present study found that the mean B_a calculated for the JTC group was 2.59 which is similar to that obtained by Bentall & Slade's (1985) hallucinating group (2.63) but considerably less than that obtained by their non-hallucinating group (3.78). The mean B_a calculated for the No-JTC group was 3.11, suggesting that an auditory "jump-to-perceptions" bias was present in the

JTC group but not in the No-JTC group, even though the groups were not significantly different.

The mean value of B_a reported by Rankin & O'Carroll (1995) for a group of people with no diagnosis of mental illness and scoring low on the LSHS was 2.60, equivalent to the mean values obtained by the JTC group from the present study and to mean values obtained by the hallucinating group in Bentall & Slade (1985) study. Rankin & O'Carroll found that the mean value of B_a for a group of people with no diagnosis of mental illness and scoring high on the LSHS was 1.8, whereas Bentall & Slade found a mean value of 2.69 in a similar group. Bentall & Slade state that the values of B_a obtained by their clinical and non-clinical samples cannot be compared because of differences in the procedures used to obtain them. This argument is given added weight by the size of the difference between the values of B_a obtained by Bentall & Slade and those obtained by Rankin & O'Carroll in an apparently similar sample.

The application of the task used in the present study to a clinical sample, grouped according to presence or absence of hallucinations, or to a non-clinical sample, grouped according to high or low scores on the LSHS would clarify the issue by demonstrating the task's ability to replicate previous findings. An a posteriori comparison of hallucinators and non-hallucinators failed to discriminate the groups on B_a, suggesting that the task failed to elicit a "jump-to-perceptions" bias.

Association between Negative Priming and the "Jump-to-Perceptions" Bias

Although the association between negative priming and the "jump-to-perceptions" bias was not tested directly by the present study, it is implicit in Garety & Hemsley's (1994) model, which suggests that both the "jump-to-conclusions" bias and the "jump-to-perceptions" bias are a result of a weakening of the influence of stored regularities on current perceptual processing. In the present study, a posteriori analyses revealed a significant negative correlation between negative priming and the externalising visual perceptual bias (B_v). The negative correlation between negative priming and the externalising auditory perceptual bias (B_a) showed a trend to significance. This suggested that the cognitive disturbance measured by the negative priming task was associated with more frequent misidentification of internal events as external. However, this finding must be interpreted with caution. Firstly, 31 correlations were performed with no control of error rate so one of these would be expected to be significant by chance alone. Secondly, there was only one significant correlation with an anomalous perceptual experience (SIAPA rating of Olfactory Perceptual Anomalies) and a trend to a significant correlation with one type of delusion (SAPS rating of Thought Broadcasting). If the failure to inhibit irrelevant information is causative in the experience of perceptual anomalies, then one would expect negative priming to correlate with more self-report measures of those experiences. One possible interpretation is that, because the measures of anomalous experience covered the preceding month, they were endorsed by participants who demonstrated the usual negative priming effect at the time of testing, whereas B_v and B_a reflected the immediate state of cognitive processing and were therefore associated with an absence of the negative priming effect. Alternatively, the apparent association between negative priming and perceptual bias may be due to non-specific factors related to the performance of these computerised tasks.

Limitations of the Study

Issues of Statistical Power

As discussed in the introduction a sample size of 26 participants in each group would result in the correct rejection of the null hypothesis for four out of every five samples (i.e. a power of 0.80), provided the effect size is large. In the case of the significant difference in hallucinatory experience between the JTC and the No-JTC group, power is not an issue since the null hypothesis was rejected according to the convention that the observed data would occur in less than five percent of samples if the null hypothesis was true (i.e. a significance of criterion of 0.05). In cases where significant differences between the groups were not observed the issue of power is important to consider in the interpretation of the results.

The fact that no significance difference between the JTC and the No-JTC groups were observed on measures of non-hallucinatory anomalous experience, negative priming and externalising perceptual biases may indicate that there really are no differences between the groups on these measures. However, since the sample size of the JTC group is less than 26, one would expect to mistakenly accept the null hypothesis for more than one in five samples of this size when the effect size is large. If the effect size is not large, then the null hypothesis would be mistakenly accepted even more frequently. Therefore, the failure to observe associations between the "jump-to-conclusions" bias and non-hallucinatory anomalous experience, negative priming and externalising perceptual biases cannot be interpreted as definitive evidence that no such association exists.

Limitations of the Sample

The process by which participants were recruited to the present study are reported in some detail in the Introduction chapter. The question of which people who experience psychotic phenomena give informed consent to participate in research, needs to be addressed in order to assess the extent to which findings can be generalised. This is particularly relevant to psychosis research since many people with psychotic illnesses have explanations for their experiences that are not consistent with those of mental health professionals responsible for their care or those of mental health researchers. Few papers report any data about refusal rates. In the present study 40.5% of patients approached, refused to participate. There were also an unknown number of patients who, following advice from clinical staff, were not even approached because they were considered to be too disturbed, too suspicious, a potential danger to the researcher, unable to concentrate for long enough to complete the assessment or too thought disordered to comprehend instructions or even the fact that they were being asked to participate in a research project.

Examining the question of which patients refuse and which patients participate is problematic since data concerning patients who have not given consent cannot be considered. As Freeman & Garety (2000) point out, the patients most likely to refuse are probably those at the most severe stages of illness. This results in an unrepresentative sample and distorted research findings. However, this problem of representativeness is not particular to the present study so one would expect its results to be consistent with other research findings. The problem lies in the validity of applying theories based on these findings to all people with delusions. In one sense, the problem of representativeness poses fewer difficulties to the present study than to most because, although both groups might be unrepresentative of people with delusions in general, any differences between the groups cannot be explained by factors influencing participation, as they might be in comparisons between groups of people with delusions and groups of people without delusions.

Most participants who refused to participate in the present study did not give a reason but examples of those given were: that the white noise would be unpleasant, that they would not be able to do the tasks, that they were not mentally ill, that they were sleepy, that the drugs had messed them up, that they would put too much of themselves into the computer or even that the experimenter might steal their brain.

Because the SAPS investigated the month preceding assessment, several participants who had held delusional beliefs in the last month, were recruited despite the fact that their conviction in, their preoccupation with or the influence of those beliefs on behaviour had decreased to a level at which they would no longer be classified as delusions. This clearly has implications for the interpretation of the results. However, the specific implications depend on whether the "jump-to-conclusions" bias, the "jump-to-perceptions" bias and the failure to inhibit irrelevant information are conceptualised as trait variables that remain stable over time or state variables that change. Garety & Hemsley's (1994) model suggests that all three are trait variables, in which case associations between the variables would be predicted even if no delusions were currently present. However, a recent refinement and extension of the model implies that the failure to inhibit irrelevant information is a state variable triggered by adverse life events (Garety *et al.*, 2001). If this is correct then the absence of associations between negative priming and other variables might be explained by a cessation of the cognitive disturbance that abolishes the usual negative priming effect in people with psychotic illnesses.

Limitations of the Tasks

Limitations of the "Beads" Task

There were some subtle differences in the administration of the "beads" task that may have influenced the mean number of beads requested by participants. Firstly, the instructions used by Garety *et al.* (1991) directed participants to indicate from which jar the beads were coming only when they were "completely certain". In the present study participants were directed to indicate from which jar the beads were coming when they were "as sure as they could be". Secondly, the jars used in the present study were smaller than those used by Garety *et al.* (1991). Unfortunately, Garety *et al.* do not report the size of the beads that they use but if they were similar in size to the ones used in the present study they would have only filled about one quarter of the jam jar, which they used as a container. In the present study a smaller jar was used, which the beads filled to the top. This may have influenced participants' judgements as to whether beads were truly being drawn at random. The influence of these subtle differences in presentation on performance requires further empirical research.

<u>Limitations of the Scale for the Assessment of Positive Symptoms</u>

Two parts of the SAPS were administered to participants. The delusions section was intended to confirm the presence of a delusion. The hallucination section was used to derive measures on which to compare groups. The No-JTC group experienced more severe hallucinations than the JTC group as predicted by Maher's model of delusion formation. Closer inspection of the data revealed that the No-JTC experienced significantly more frequent auditory hallucinations, voices commenting, olfactory hallucinations and visual hallucinations but there were no significant differences between the groups in ratings of Voices Conversing or of Somatic or Tactile Hallucinations. This pattern is the opposite to that predicted by Garety & Hemsley's model.

All assessments were carried out by the same interviewer so no checks on inter-rater reliability were available. However, considerable effort was made to train the interviewer before data collection commenced (see Method chapter).

The fact that participants were asked about experiences in the last month is notable since a number of them reported a considerable improvement or even cessation of symptoms over the last month, often following admission to hospital. This meant that several participants who had held delusional beliefs in the last month, were recruited despite the fact that the severity of their delusions had decreased to a level at which their status as delusions was questionable. Likewise, a number of participants who reported hallucinations in the last month were experiencing less severe symptoms at the time of testing. This would not have been a problem if the other variables (i.e. "jump-to-conclusions" bias, "jump-to-perceptions" bias and abnormal negative priming) were stable trait variables but might lead to spurious conclusions if they varied with conviction or other dimensions of delusions.

There may have also been an issue of under-reporting of symptoms. Some participants were detained under sections of the Mental Health Act and, although they were assured that information would not be passed back to clinical staff unless there was a serious issue of risk, it is possible that some participants did not trust the experimenter enough to disclose experiences, which they had withheld from clinical staff. There was also a more general problem created by individual variation in suggestibility and acquiescence. These factors would be expected to influence responses to any instrument measuring non-observable experiences. They were controlled for, to some extent, by asking for specific examples of the experiences reported.

Limitations of the Structured Interview for Assessing Perceptual Anomalies

There was no significant difference between the JTC and the No-JTC groups on ratings of anomalous perceptual experience. Bunney *et al.* (1999) found significant differences between a group of people with a diagnosis of schizophrenia and a group of people with no diagnosis of mental illness. It was predicted that the cognitive processes that lead to hallucinations would also lead to more subtle perceptual experiences. Therefore a significant difference between the groups in hallucinatory experience but not in more subtle perceptual experiences is surprising.

Although the period of time investigated by the SIAPA was changed from one week to one month in order to harmonise it with the SAPS and minimise floor effects, other features of the scales differed. Whereas the SAPS had anchors at: none (0), questionable (1), occasionally (2), weekly (3), daily (4) and all the time (5), the SIAPA had anchors at: never (0), rarely (1), half the time (2), often (3) or always (4). In practice the SIAPA's scale proved difficult to use. Firstly, there was a question of whether "often" is generally considered to be more frequent than "half the time". Secondly, there was a question of whether an experience that occurred half the time would be perceived to be anomalous. For example, if participants experienced hyper-alertness or poor selective attention more than half the time this might be perceived as a "normal" state and the absence of hyper-alertness and poor selective attention as abnormal or anomalous. Thirdly, there is a lack of sensitivity in a scale that has no anchors between "rarely" and "half the time". The vast majority of participants who reported anomalous perceptual experience (excluding hallucinations) described its frequency as less than half the time and were consequently assigned to the "rarely" category.

It was not always possible to determine whether participants' responses to probes described hallucinatory experience, anomalous perceptual experience or normal perception. For example, in response to the question, "Have you ever had the feeling or sensation your sense of smell was particularly keen or sensitive?" one participant reported smelling dinner before it arrived. This might have been an olfactory hallucination, an anomalous intensification of olfactory perception or a normal experience. Similarly, in response to the question, "Have you ever had the feeling or sensation that sounds were louder than usual?" one participant reported that he was sometimes able to hear staff talking in the office.

The SIAPA only provided standard probes for anomalous perceptual experiences in the auditory modality. Although probes were created for use in the present study, the lack of a standardised interview schedule made comparison across different studies unreliable. There was also an issue of reliability within the present study. All the assessments were carried out by the same interviewer with no checks on inter-rater reliability. However, Bunney *et al.* (1999) found good inter-rater agreement and internal reliability on items of the SIAPA.

Differences in the prevalence of perceptual anomalies between sensory modalities in the present sample were broadly equivalent to those identified by Bunney *et al.* A quantitative comparison of their sample with the current sample is problematic both because their sample was selected on the basis of a diagnosis of schizophrenia and also because it is not clear how they calculated their figures. However, it seems as if participants in the present study reported slightly less frequent perceptual anomalies than Bunney *et al.*'s group of participants with a diagnosis of schizophrenia but considerable more than their group of non-psychiatric controls.

Limitations of the Auditory Perceptual Task

There was no difference between the JTC and the No-JTC groups in a measure of perceptual bias (B_a) derived from this task. Nor did this task replicate the findings of Bentall & Slade (1985) who found a significantly lower mean B_a in a group of participants who experienced hallucinations than in a group who did not. The present study found that the mean perceptual biases calculated for both the hallucinating and the non-hallucinating groups (2.66 and 2.68, respectively) were similar to that obtained by Bentall & Slade's hallucinating group (2.63) but considerable less than that obtained by their non-hallucinating group (3.78). Assuming that these differences are not simply due to error, they could be explained by differences in the tasks or in the samples.

The task used in the present study presented only 40 trials as opposed to the 100 trials used by Bentall & Slade (1985). Although this difference was offset by an equivalent increase in the number of participants: 50 as opposed to 20, the measurement error within each participant might have obscured systematic differences in perceptual biases between hallucinators and non-hallucinators. The decision to decrease the number of trials was made in order to make the task more acceptable to participants. Bentall & Slade also used a total of 50 trials as practice whereas the present study used only 10. Consequently, an exact replication of Bentall & Slade's task would have required participants to listen to stimuli for at least 37.5 minutes. This was impractical since a number of other tasks were included in the assessment. In addition, it was suspected that only a restricted number of people with delusions would be willing to complete such a task, thus compromising the ecological validity of any findings. Indeed one participant refused to complete the task because she found it aversive and two potential participants specifically cited the prospect of listening to 50 five-second episodes of white noise as a reason not to participate.

Limitations of the Visual Perceptual Task

The visual perceptual task was designed as a visual analogue of Bentall & Slade's (1985) auditory perceptual task. The assumption was made that the experience of visual hallucination was influenced by the same factors as auditory hallucination. As in the auditory modality, visual reality discrimination is determined by existing beliefs about the possibility of seeing specific images in certain contexts and the tendency to attribute the source of perceptual events to external origins under conditions of uncertainty. It is this externalising bias that the task sought to measure.

Between the planning and execution of the present study Böcker *et al.* (2000) published details of a similar task. This presented participants with a word covered by dots on a PC monitor. The duration of presentation and the extent to which the word was obscured were not reported. They found no significant difference in perceptual bias (B_v) between a group of people with a diagnosis of schizophrenia who had experienced hallucinations in the last week, a group of people with a diagnosis of schizophrenia who had not experienced hallucinations in the last week and a group of people with no diagnosis of mental illness. Within the hallucinating group, there was no significant correlation between z-transformed B_v and a rating of the severity of hallucinations. However, there was a significant correlation when the analysis was restricted to the subgroup of participants showing only auditory hallucinations.

The present study found no difference between the JTC and the No-JTC groups in B_v. It also failed to replicate Böcker *et al.*'s (2000) findings of a correlation between B_v and a rating of the severity of hallucinations amongst participants with only auditory hallucinations. Böcker *et al.* do not report their rationale for excluding participants who experienced visual, tactile, olfactory and gustatory hallucinations. So, it is difficult to interpret the meaning of no significant correlation in the hallucinating group as a whole but a significant correlation in a subgroup with only auditory hallucinations.

The results of the present study can be interpreted in two ways. Firstly, it might be that the task failed to discriminate hallucinators from non-hallucinators because of the small number of trials it presented. Secondly, the processes that lead to visual hallucinations might have important differences to those that lead to auditory hallucinations. If the latter is true, then the assumption that decreasing the signal-to-noise ratio of the stimulus would impair reality discrimination might be invalid. Similarly, externalising perceptual biases might not impair reality discrimination. The scarcity of visual hallucinations relative to auditory hallucinations in psychiatric populations does imply that the phenomena are generated by different mechanisms. There was a significant correlation between B_a and B_v in the present study, indicating an association between factors that influence performance on these tasks. However, these factors may be specific to the computerised tasks rather than perceptual bias they are designed to measure.

Limitations of the Negative Priming Task

There was no difference between the JTC and No-JTC groups in their performance on the negative priming task as measured by reaction time (RT) or accuracy. When education after the age of 16 and estimated IQ were covaried out of the analysis no negative priming effect (i.e. slowed RT or decreased accuracy to a stimulus when a related stimulus has recently been ignored) was observed overall. However, when hallucinators were compared to non-hallucinators, without covarying out education and IQ, there was a significant overall negative priming effect but still no difference between groups.

Ferraro & Okerlund (1996) used an identical task to investigate negative priming in students scoring high and low on the STA. They found no overall negative priming effect and no overall difference between groups in reaction time or accuracy but did find an interaction between group and trial type (negatively primed or not negatively primed). They did not identify the effect of education IQ on negative priming because, although they matched their groups on these variables, they did not explore the association between negative priming and IQ. It seems likely that the groups in their sample had higher IQ's (mean WAIS-R Vocabulary scores of 47.62 and 50.32) than participants in the present study. This might explain the absence of a significant interaction between negative priming trial type and groups of hallucinating and non-hallucinating participants.

Limitations of the Design

The absence of both a psychiatric and a non-psychiatric control group in the present study makes the interpretation of some of the results problematic. The inclusion of control groups would have clarified questions regarding the ability of the tasks employed to replicate previous findings. The performance of a group of people without delusions on the "beads" task could be compared to that of the No-JTC group in order to confirm the absence of the "jump-to-conclusions" bias in this group. A comparison of groups with and without psychotic illness would confirm the ability of the negative priming task to discriminate participants with and without a weakening of the influence of stored regularities on current processing.

More general limitations of the design concern the extrapolation of group differences to make predictions of individual performance (Shallice, 1988; Marshall & Newcombe, 1988). Maher's model predicted that the group of people with a "jump-to-conclusions" bias would include participants who had formed delusions in the absence of anomalous perceptual experience. The model did not preclude the presence of both "jump-to-conclusions" bias and anomalous perceptual experience in one individual, so some participants in the JTC group might also experience perceptual anomalies. However, it predicted that, as a group, participants with a JTC bias would experience less anomalous perceptions.

A potential explanation for the failure to find an association between information-processing biases is that, despite being more common amongst people with delusions as a group, they might influence delusion formation and maintenance independently of each other. There is good evidence that a subgroup of people with delusions demonstrate a "jump-to-conclusions" bias. There is also good evidence that, as a group, people with a diagnosis of schizophrenia, many of whom would be expected to have delusions, demonstrate decreased inhibition of irrelevant information, which is interpreted as a weakening of the influence of stored regularities on perceptual processing. There is also evidence that, as a group, people who experience hallucinations are more willing to attribute the source of mental events to external origins. Because these three characteristics: hallucinatory experience, delusional beliefs and diagnosis of schizophrenia, often co-occur within individuals it is tempting to suggest that they have a common cause. Of course, the characteristics are not independent. Delusional beliefs and hallucinatory experience are likely to lead to a diagnosis of schizophrenia if they cause personal distress or socially unacceptable behaviour. The drive to explain anomalous experience will often result in delusional beliefs. Conversely, delusional beliefs might also lead one to accept mental events as real (i.e. from an external source).

The interpretation of literature reporting associations between psychotic phenomena and cognitive biases is difficult to interpret because of the lack of group specificity. Research on hallucinations suffers least from this lack of specificity although even this could be improved by distinguishing between sensory modalities and content. There is some empirical support for this finer grained analysis in that Böcker *et al.* (2000) only found significant differences in perceptual task performance when analysis was restricted to participants with auditory hallucinations. In the present study, a posteriori analyses of hallucination subtypes indicated a much greater difference between the JTC and the No-JTC groups in the SAPS rating of Voices Commenting than ratings of other hallucinatory experiences.

Making connections between differences in group performance (e.g. people with delusions *versus* people without delusions) and the cognitive mechanisms that result in specific symptoms conferring membership of that group is risky. For example, although people with a diagnosis of schizophrenia, as a group, demonstrate slowed reaction time to negatively primed stimuli in comparison to a group of people without a diagnosis of schizophrenia, this does not mean that each member of this group fails to inhibit irrelevant information. Indeed, Peters *et al.* (2000) note the extent of variation within their sample in a study that demonstrated an association between positive symptomatology and cognitive inhibition as measured by a negative priming task. Linking differential performance on information-processing tasks to psychotic phenomena requires that those phenomena are specified in more detail than is often the case in psychosis research.

Future Research

Despite the failure of the present study's results to support Garety & Hemsley's (1994) hypothesised association between information-processing biases ("jump-to-conclusions" bias, "jump-to-perceptions" bias and abnormal negative priming) demonstrated by people experiencing psychotic phenomena, the results are consistent with a multi-factorial model of delusion formation and maintenance. Multi-factorial models are able to account for differences in the performance of people with delusions on the measures employed. However, they often fail to generate predictions about differences in group performance and, consequently, cannot always be tested with group studies.

Since the present study was designed, a refinement and extension of Garety & Hemsley's (1994) model has been published (Garety *et al.*, 2001). Garety *et al.* (2001) described a cognitive model of the positive symptoms of psychosis. They proposed that there are two proximal routes to psychosis. The most common proceeds via a combination of cognitive and affective disturbances. The less common proceeds via affective disturbances alone. They suggested that, in most cases, an event causes a disturbance in cognitive processes, and that disturbance leads to anomalous conscious experiences. These anomalous experiences trigger emotional responses such as anxiety. They also trigger a search for meaning. The hypotheses that people generate to account for these anomalous experiences are influenced by their existing beliefs about themselves, other people and the world and by their access to alternative hypotheses. The acceptance of one hypothesis as an explanation is influenced by factors such as JTC bias, externalising attributional biases and theory of mind deficits. People who are able to reject the hypothesis that their anomalous experiences have an external cause, do not develop full-blown psychotic symptoms.

Future research should continue to apply the symptom approach to the study of psychotic phenomena. However, closer attention should be paid to the specific phenomenology of individuals studied. Garety *et al.*'s (2001) model implies that a distinction could be made between primary phenomena, resulting directly from a cognitive disturbance, and secondary phenomena, resulting from an appraisal of primary phenomena. Unfortunately, people who make a psychotic appraisal of their experiences and continue to have those experiences, because they have not (yet) responded to treatment are the people least likely to participate in research. A more fruitful approach would be longitudinal studies of psychosis-prone populations in order to discover whether cognitive disturbances really are a temporary (state) reaction to life events and which stable (trait) characteristics (e.g. JTC bias, externalising attribution bias, theory of mind deficits) increase the risk of psychotic appraisals.

Differences between groups of participants with and without delusions on the "beads" tasks are highly influenced by a subgroup of people that request only one bead before reaching a conclusion. It is possible that this bias is particularly associated with one delusional subtype or a cluster of delusional subtypes. Increased specificity in the categorisation of delusions would address this question empirically. Single case studies are able to meet this demand for increased specificity and have already been applied to the study of delusion formation and maintenance (Shallice *et al.*, 1991; Halligan & Marshall, 1996). Multi-factorial models of psychosis suggest that psychotic phenomena are a result of different interacting processes. The assumption that all people with delusions share common psychological, biological or social features is not valid within these models. Therefore, group studies may obscure rather than reveal factors relevant to psychosis.

Theoretical Implications

As mentioned previously, a new cognitive model of the positive symptoms of psychosis has recently been published (Garety *et al.*'s 2001). This model suggests that the most common route to psychosis proceeds via a cognitive disturbance that can be conceptualised as a deficit in the "self-monitoring of intentions and actions (Frith, 1992)" or "a weakening of the influences of stored memories of regularities of previous input on current perception" (Hemsley, 1996) and that these two conceptualisations have similarities in that they both imply a breakdown in "willed intention" activity (Hemsley, 1998). The negative priming task would be expected to measure this cognitive disturbance. Garety *et al.* (2001) suggest that this "cognitive disturbance leads to anomalous conscious experiences (e.g. heightened perceptions, actions experienced as unintended, racing thoughts, thoughts appearing to be broadcast, thoughts experienced as voices, two unconnected events appearing to be causally linked)." Those participants with more severe anomalous conscious experiences would be expected to fail to inhibit irrelevant information on the negative priming task.

As a multi-factorial model it is difficult to derive group predictions from it; so the implications of the current findings are not clear. The present study, showed that people who do not exhibit a "jump-to-conclusions" data-gathering bias, experience more severe hallucinations. This might be interpreted to suggest that people with delusions and a JTC bias are more willing to accept delusional explanations for anomalous experience and, therefore, require less severe anomalous experience before doing so. In fact, there was a bimodal distribution of severity of hallucinations in the JTC group. This suggested that a subgroup of people with a JTC bias form delusions in the absence of anomalous perceptual experience. However, the SAPS and SIAPA only measured experiences in the last month and delusional beliefs may be maintained by normal cognitive processes even after the experiences that lead to their formation have ceased.

These results suggest that the psychological processes that result in hallucinations are independent of the psychological processes that result in a JTC bias. Therefore, in a group of people with delusions, one would expect to find some with anomalous perceptual experience and no JTC bias, some with a JTC bias and no anomalous perceptual experience but also some with both or neither. Therefore, the effect size of the overall difference between JTC and No-JTC groups would be small. The SAPS was just about sensitive enough to pick up this difference but the SIAPA was not.

Although neither B_v nor B_a were significantly lower (i.e. more externalising perceptual bias) in the group of participants with hallucinations, there was a significant negative correlation between B_a and the SAPS rating of Voices Commenting. This might indicate that a tendency to mistake internal thoughts for external perceptions imparts particular vulnerability to the misidentification of thoughts whose content refers to current behaviour or cognitive activity.

There were significantly more perceptual anomalies in visual and auditory modalities than tactile, gustatory and olfactory modalities. This might be due to relatively rapid changes in input to visual and auditory senses and the large amount of information to be processed. It is within these sensory modalities that a failure to inhibit irrelevant information would be most likely to result in perceptual anomalies. However, there was no significant correlation between negative priming and SIAPA ratings of auditory or visual perceptual anomalies, although this might have been due to the insensitivity of the instrument. Another interpretation of the increased prevalence of anomalous experience in visual and auditory modalities over other sensory modalities, relates to the depth of meaning inferred from visual and auditory information. Verbal information encoding complex concepts can be transferred through reading or listening but, with the exception of Braille readers, this does not occur in other sensory modalities.

The fact that normal negative priming was only observed when IQ and education were not covaried out suggests that these factors influence the cognitive disturbance thought to result in anomalous conscious experience. The way in which this influence acts is an empirical question. The relationship between anomalous conscious experiences and the cognitive disturbance that negative priming is thought to measure, needs to be clarified.

The status of this cognitive disturbance as a state rather than a trait variable, needs to be confirmed by comparing measures at different periods in time and relating them to life events and affective responses.

Clinical Implications

The findings are consistent with cognitive-behavioural approaches to the treatment of delusions (Fowler *et al.*, 1995; Chadwick *et al.*, 1996). The variability in the performance of people with delusions on the tasks and interviews administered, demonstrates the importance of a detailed individual assessment of the conscious experience, inferences and evaluations resulting in a delusional belief. The process that leads to the formation of the belief needs to be identified. Important life events and emotional responses at the point of origin need to be explored. The potential of these responses to influence cognitive processing and perceptual experience can then be incorporated into a formulation of the patient's difficulties.

The validity of specific inferences that lead to a delusional explanation of anomalous perceptual experience or affect should be scrutinised. These inferences should be put in the context of premorbid evaluative beliefs about the self, the world and others. These trait vulnerabilities might include an externalising and personalising attribution bias, a "jump-to-conclusions" bias and a theory of mind bias, but in some cases none of these will be present. Once an account of the processes involved in the formation and maintenance of a delusional belief has been formulated, a therapist can attempt to modify some of these processes and encourage the patient to consider alternative explanations for their experiences that are less distressing to themselves and more acceptable to other members of society.

The assessment of factors contributing to delusion formation and maintenance would be aided by reliable measurement tools. The "beads" task could be used to identify a "jump-to-conclusions" bias as part of a therapeutic assessment. It could also be used to illustrate the way in which people with "jump-to-conclusions" biases deviate from the norm in their decision-making processes. Awareness of such a deviation would give patients the option of considering the contribution of this bias to their decisions. The negative priming task might also be used in assessment. If Garety *et al.*'s (2001) is accurate, an easily administered task that measures the cognitive disturbance hypothesised to cause anomalous conscious experience would provide an objective indication of vulnerability and relapse. Relating conscious experience to changes in performance on such a task could also be used therapeutically to encourage non-delusional explanations for anomalous experiences. The perceptual tasks also have some therapeutic potential, both in the measurement of performance that deviates from the norm and also in illustrating the possibility of perceiving sounds and images that were not presented. Clearly, the clinical use of these tools would require that their administration was standardised and that normative data was collected.

Conclusion

The results of the study are consistent with a multi-factorial model of delusion formation. Hallucinatory experience was found to be more severe in people with delusions who do not "jump-to-conclusions" but present in many of those who do. There was an indication that the experience of voices commenting on thoughts and behaviour was particularly associated with delusional explanations and that this experience was associated with a "jump-to-perceptions" bias in the auditory modality. An association between participants' ability to inhibit irrelevant information and a "jump-to-perceptions" bias was also indicated. Future research should concentrate on mapping specific psychotic phenomena onto information-processing biases and thereby elucidating the mechanism by which they are generated.

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Appendix 1 : Ethical Approval Letter

Institute of Psychiatry

at The Maudsley

Ethical Committee (Research)

Research Ethics Co-ordinator
Margaret M Chambers MSc

Room W109
De Crespigny Park
Denmark Hill
London SE5 8AF
Tel 020 7848 0797
Fax 020 7848 0560
Email m.chambers@iop.kcl.ac.uk

KING'S College LONDON Founded 1829

ETHICAL COMMITTEE (RESEARCH)

27 June, 2000

Prof D Hemsley
Department of Psychology
Institute of Psychiatry

Dear Prof Hemsley

Re: The influence of perceptual anomalies and data-gathering bias on delusion formation (096/00)

The Ethical Committee (Research) considered and approved the above study at its meeting on 16 June 2000.

Initial approval is given for one year. This will be extended automatically only on completion of annual progress reports on the study when requested by the EC(R). Please note that as Principal Investigator you are responsible for ensuring these reports are sent to us.

Please note that projects which have not commenced within two years of original approval must be re-submitted to the EC(R).

Please let me know if you would like to nominate a specific contact person for future correspondence about this study.

Any serious adverse events which occur in connection with this study should be reported to the Committee using the attached form.

Please quote Study No. 096/00 in all future correspondence.

Yours sincerely,

Margaret M. Chambers

Margaret M Chambers
Research Ethics Coordinator

Appendix 2: Letter to Consultants

Paul Tabraham
Honorary Research Worker
Department of Psychology
Institute of Psychiatry
De Crespigny Park
Denmark Hill
London SE5 8AF

Telephone: XXX XXXX XXXX

E-mail: XXXX@XXXXXX.XXX

28th July 2000

Dear Dr X,

Re. Patients with delusions.

I am writing to request your permission to approach patients under your care for a research study. The study is supervised by Dr Emmanuelle Peters and will examine the processes involved in the formation and maintenance of delusions. I am seeking to recruit patients who are currently deluded and who would be willing to participate in interviews and computer-based tasks lasting one to two hours. Participants will be paid £10. The data can be collected wherever is most convenient to the patient and to yourself.

The Ethics Committee has approved the study. The nurse in charge will always be consulted in order to determine the suitability of the patient, before the patient him or herself is approached.

If you are willing to give your permission, please complete the enclosed slip and return it to Dr Peters in the addressed envelope enclosed.

Information about the study is contained in the appendix. If you require further information please do not hesitate to contact me.

Yours sincerely,

Paul Tabraham
Clinical Psychologist in Training

Purpose of Research

The study will compare two theoretical models of delusion formation. The first suggests that most delusions are caused by the application of normal reasoning to abnormal experiences (Maher, 1992). The second suggests that many delusions are caused by an information-processing bias that results in abnormal reasoning and abnormal experiences (Garety & Hemsely, 1994). The first model predicts that people with delusions, who demonstrate a reasoning bias, will experience less perceptual anomalies (e.g. hallucinations) than those who do not. The second model predicts that people with delusions, who demonstrate a reasoning bias, will experience more perceptual anomalies than those who do not. Deluded individuals, with and without a reasoning bias, will be compared in order to determine which of the two models is the most accurate.

Theoretical Background

Maher (1992) proposes that the origin of delusions lies most often in the nature of conscious experience of the patient, rather than the inferential processes that are brought to bear on that experience. He suggests that the reasoning of most people with delusions is normal but that they frequently experience perceptual anomalies, which require explanation. Delusions, like all beliefs, provide order and meaning for empirical observations.

Garety (1991) found that about 50% of people with delusions "jump-to-conclusions" (JTC) on a probabilistic reasoning task. She proposes that JTC data-gathering bias is causal in the formation of some delusions. She suggests that JTC is caused by a more fundamental bias, which has been observed in people with a diagnosis of schizophrenia and people, without a diagnosis of mental illness, who score high on paper and pencil measures of schizotypy; that is, a breakdown in the normal relationship between stored material and current sensory input. Garety & Hemsley (1994) suggest that this breakdown also accounts for frank hallucinations and more subtle perceptual anomalies because it causes people to "jump-to-perceptions" (JTP), i.e. to experience a sensation as real on the basis of inadequate perceptual information.

If the hypothesis, that both JTC and JTP are caused by a breakdown in the normal relationship between stored material and current sensory input, is correct then people who JTC on a probabilistic inference task will also JTP and fail to inhibit irrelevant stimuli more than those who do not.

If the hypothesis, that a bias in reasoning is only causal in the minority of delusions that are not normal attempts to explain anomalous experience, is correct, then people who JTC on a probabilistic inference task will JTP less than those who do not.

Measures

All subjects will be asked to undertake four computer-administered tasks, three structured interviews and one questionnaire. No task will last for more than ten minutes. The tasks are described below:

1. *Reasoning Task.* Images of two jars will be presented. Each jar will contain beads of two colours: black and white. The proportion of beads in one jar will be 85 black and 15 white; in the other the proportion will be 15 black and 85 white. Images of individual beads will be presented in a predetermined sequence. Subjects will be asked to indicate when they are sure from which jar the beads are being drawn. Performance on this task indicates the presence or absence of a "jump-to-conclusions" data-gathering bias.
2. *Negative Priming Task.* Images of two adjacent letters will be presented. Subjects will be asked to indicate which letter is upper case. This task measures the extent to which irrelevant information is inhibited, i.e. the influence of stored material on current sensory input.
3. *Visual Perceptual Task.* Images of visual noise (similar to a television that is not tuned to a channel) will be presented. Within half the trials an image of a word will be presented within the visual noise. The image of the word will be degraded to a point close to the threshold of perception. Subjects will be asked to indicate whether or not they believe the word is present. This task measures participants propensity to "jump-to-perceptions" in the visual modality.
4. *Auditory Perceptual Task.* Periods of white noise will be presented via headphones. Within half the trials a spoken word will be presented within the white noise. The word will be degraded to a point close to the threshold of perception. Subjects will be asked to indicate whether or not they believe the word is present. This task measures participants propensity to "jump-to-perceptions" in the auditory modality.

The structured interviews are described below:

1. The Scale for the Assessment of Positive Symptoms (SAPS) measures hallucinations, delusions, bizarre behaviour and positive formal thought disorder.
2. The Scale for the Assessment of Negative Symptoms (SANS) measures affect flattening or blunting, impoverished thinking, apathy, difficulty in experiencing pleasure, attention.
3. The Structured Interview for Assessing Perceptual Anomalies (SIAPA) measures hypersensitivity, inundation or flooding and selective attention in each of the five sensory modalities.

The questionnaire is the Peters *et al.* Delusion Inventory, which measures delusional ideation.

Design

Performance on the first task will be used to divide participants into two groups: those who demonstrate a "jump-to-conclusions" data-gathering bias and those who do not. The two groups will be compared on their performance on the other three perceptual/information-processing tasks and on their scores on the three structured interviews and the questionnaire.

Exclusion Criteria

Aged less than eighteen or more than sixty-five years.
Not fluent in English.
Primary diagnosis of drug or alcohol abuse.

Known organic brain damage.

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Garety, P. A., Hemsley, D. R. & Wesseley, S. (1991). Reasoning in deluded schizophrenic and paranoid patients: biases in performance on a probabilistic inference task. Journal of Nervous and Mental Disease, 179, 194-201.

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Maher, B. A. (1992). Delusions: Contemporary etiological hypotheses. Psychiatric Annals, 22, 260-268.

Peters, E. R., Joseph, S. A. & Garety, P. A. (1999). The measurement of delusional ideation in the normal population: Introducing the PDI (Peters et al. Delusions Inventory). Schizophrenia Bulletin, 25, 553-576.

I give my permission for Paul Tabraham to recruit patients, to whom I am consultant, to participate in the study titled "The influence of experience and reasoning on belief formation" (096/00). This permission is given on the condition that the nurse in charge is consulted in order to determine the suitability of the patient, before the patient him or herself is approached.

.... (Signature)

.... (Print name)

Appendix 3: Letter to Ward Managers and Team Leaders

XXX XXXXXXXXXX XXXX
XXX XXX

Telephone: XXX XXXX XXXX

E-mail: XXXX@XXXXXXXXX.XXX

13th October 2000

Dear Mr X,

Re. Patients with delusions.

I am conducting a study of psychological processes influencing the formation and maintenance of delusions. Dr X, Dr Y and Dr Z have given me permission to recruit patients to whom they are consultant. I will inform nursing staff before approaching patients on the ward. If you think it would be helpful, I could introduce myself, and the research, to staff at a suitable forum.

I am seeking to recruit patients who are currently deluded and who would be willing to participate in interviews and computer-based tasks lasting approximately one hour. Participants will be paid £10 for their time. The data can be collected wherever is most convenient to the patient and to yourself. I am available to collect data on Thursdays, Fridays, Saturdays, Sundays and after 5.30 everyday.

The study is supervised by Dr Emmanuelle Peters, Clinical Psychologist. The Ethics Committee has approved the study. The nurse in charge will always be consulted in order to determine the suitability of the patient, before the patient him or herself is approached.

Information about the study is contained in the appendix. If you require further information, would like to arrange a time for me to introduce myself to the staff team, or can advise me of the best times to recruit patients, please do not hesitate to contact me.

Yours sincerely,

Paul Tabraham
Clinical Psychologist in Training

The Influence of Experience and Reasoning on Belief Formation

Purpose of Research

The study will compare two theoretical models of delusion formation. The first suggests that most delusions are caused by the application of normal reasoning to abnormal experiences (Maher, 1992). The second suggests that many delusions are caused by an information-processing bias that results in abnormal reasoning and abnormal experiences (Garety & Hemsley, 1994). The first model predicts that people with delusions, who demonstrate a reasoning bias, will experience less perceptual anomalies (e.g. hallucinations) than those who do not. The second model predicts that people with delusions, who demonstrate a reasoning bias, will experience more perceptual anomalies than those who do not. Deluded individuals, with and without a reasoning bias, will be compared in order to determine which of the two models is the most accurate.

Theoretical Background

Maher (1992) proposes that the origin of delusions lies most often in the nature of conscious experience of the patient, rather than the inferential processes that are brought to bear on that experience. He suggests that the reasoning of most people with delusions is normal but that they frequently experience perceptual anomalies, which require explanation. Delusions, like all beliefs, provide order and meaning for empirical observations.

Garety (1991) found that about 50% of people with delusions "jump-to-conclusions" (JTC) on a probabilistic reasoning task. She proposes that JTC data-gathering bias is causal in the formation of some delusions. She suggests that JTC is caused by a more fundamental bias, which has been observed in people with a diagnosis of schizophrenia and people, without a diagnosis of mental illness, who score high on paper and pencil measures of schizotypy; that is, a breakdown in the normal relationship between stored material and current sensory input. Garety & Hemsley (1994) suggest that this breakdown also accounts for frank hallucinations and more subtle perceptual anomalies because it causes people to "jump-to-perceptions" (JTP), i.e. to experience a sensation as real on the basis of inadequate perceptual information.

If the hypothesis, that both JTC and JTP are caused by a breakdown in the normal relationship between stored material and current sensory input, is correct then people who JTC on a probabilistic inference task will also JTP and fail to inhibit irrelevant stimuli more than those who do not.

If the hypothesis, that a bias in reasoning is only causal in the minority of delusions that are not normal attempts to explain anomalous experience, is correct, then people who JTC on a probabilistic inference task will JTP less than those who do not.

Measures

All subjects will be asked to undertake three computer-administered tasks, two structured interviews and a reasoning task. No task will last for more than ten minutes. The tasks are described below:

1. *Reasoning Task.* Two jars will be presented. Each jar will contain beads of two colours: red and green. The proportion of beads in one jar will be 85 red and 15 green; in the other the proportion will be 15 red and 85 green. The jars will be removed from view. Individual beads will be presented in a predetermined sequence. Subjects will be asked to indicate when they are sure from which jar the beads are being drawn. Performance on this task indicates the presence or absence of a "jump-to-conclusions" data-gathering bias.
2. *Negative Priming Task.* Images of two adjacent letters will be presented. Subjects will be asked to indicate which letter is upper case. This task measures the extent to which irrelevant information is inhibited, i.e. the influence of stored material on current sensory input.
3. *Visual Perceptual Task.* Images of visual noise (similar to a television that is not tuned to a channel) will be presented. Within half the trials an image of a word will be presented within the visual noise. The image of the word will be degraded to a point close to the threshold of perception. Subjects will be asked to indicate whether or not they believe the word is present. This task measures participants' propensity to "jump-to-perceptions" in the visual modality.
4. *Auditory Perceptual Task.* Periods of white noise will be presented via headphones. Within half the trials a spoken word will be presented within the white noise. The word will be degraded to a point close to the threshold of perception. Subjects will be asked to indicate whether or not they believe the word is present. This task measures participants' propensity to "jump-to-perceptions" in the auditory modality.

The structured interviews are described below:

1. The portion of the Scale for the Assessment of Positive Symptoms (SAPS) that measures hallucinations and delusions.
2. The Structured Interview for Assessing Perceptual Anomalies (SIAPA) measures hypersensitivity, inundation or flooding and selective attention in each of the five sensory modalities.

Design

Performance on the first task will be used to divide participants into two groups: those who demonstrate a "jump-to-conclusions" data-gathering bias and those who do not. The two groups will be compared on their performance on the other three perceptual / information-processing tasks and on their scores on the two structured interviews.

Exclusion Criteria

Aged less than eighteen or more than sixty-five years.
Not fluent in English.
Primary diagnosis of drug or alcohol abuse.
Known organic brain damage.

References

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Garety, P. A. & Hemsley, D. R. (1994). Delusions: Investigations into the Psychology of Delusional Reasoning. Oxford University Press: Oxford.

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Appendix 4: Information for Participants

Title of the study: The influence of experience and reasoning on belief formation.

Researcher: Paul Tabraham, Clinical Psychologist in Training
Supervisor: Dr Emmanuelle Peters, Clinical Psychologist and Lecturer at Institute of Psychiatry

This is an invitation to participate in the study detailed below.

Aim

The aim of the present study is to investigate the way that people's personal experience and thinking style affect the beliefs that they hold.

The results of this study will contribute to a better understanding of how some people form beliefs that are unusual. I hope that by understanding the processes that lead to unusual beliefs it will be possible to help people who find their beliefs distressing and people whose beliefs cause them to act in a way that other people find difficult to understand.

What it involves

The study takes approximately one hour for each participant. You will be paid £10 for your time.

You will be asked to do a short exercise that measures the way that you use evidence to make decisions.

You will then be asked to complete three exercises on a computer. Each exercise lasts about 10 minutes. One measures the effect of learnt associations on reaction time. Another measures your ability to hear distorted sounds. The other measures your ability to see distorted images.

Finally, you will be interviewed about any unusual beliefs you hold and about any unusual experiences you have had.

You do not have to take part in this study. If you decide to take part you may withdraw at any time without giving a reason. Withdrawal from the study will not affect your treatment. Your decision whether to take part or not will not affect your medical care or treatment in any way. The information obtained from this study will be kept strictly confidential. However, I have a duty of care to inform medical staff if, at any time during the study, information is obtained that would suggest that you or any other person is in danger. I would not inform medical staff without informing you first.

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the ethics committee of the South London and Maudsley NHS Trust.

Appendix 5: Consent Form for Participants

Title of the study: The influence of experience and reasoning on belief formation.

Researcher: Paul Tabraham, Clinical Psychologist in Training
Supervisor: Dr Emmanuelle Peters, Clinical Psychologist and Lecturer at Institute of Psychiatry
Address: Sub-department of Clinical Health Psychology
University College London
Gower Street
London WC1E 6BT
Telephone: 020 7380 7897

To be completed by the patient: Delete as necessary

1) I have a copy of the "Information for Participants" and this has been read out to me by the investigator.	Yes/No
2) I have had the opportunity to ask any questions and have received satisfactory answers.	Yes/No
3) I understand that participation in the study is voluntary and I am free to withdraw at any time without giving a reason for withdrawing and without affecting my future care.	Yes/No
4) I understand that the information obtained from this study will be kept strictly confidential. However, if at any time during the study information is obtained which would suggest that I or any other person is in danger the researcher would have a responsibility to inform a member of medical staff. The researcher would not do that without informing me first.	Yes/No
5) I agree to take part in the study.	Yes/No

....
(Signature) (Date)

....
(Print name here)

THANK YOU FOR YOUR CO-OPERATION

Appendix 6: "Beads" Task and Perceptual Tests' Response Aids

More beads please.	No more beads, I have decided.

1	2	3	4	5
☐	☐	☐	☐	☐
Definitely did not hear a sound	Probably did not hear a sound	Might have heard a sound	Probably heard a sound	Definitely heard a sound

1	2	3	4	5
☐	☐	☐	☐	☐
Definitely did not see an image	Probably did not see an image	Might have seen an image	Probably saw an image	Definitely saw an image

Appendix 7: Quick Test Stimuli

WORD LIST

Belt	Graceful
Dancing	Fluid
Traffic	Solution
Whistle	Discipline
Fence	Benches
Drink	Crystallized
Wreck	Turntable
Music	Saccharin
Medicine	Immature
Gun	Cordiality
Pepper	Velocity
Racing	Decisive
Salt	Laceration
Woman	Foliage
Sugar	Imperative
Track	Intimacy
School	Concoction
Partner	Conviviality
Couples	Chevrons
Rail	Condiment
Respectful	Cacophony
Betting	Miscible
Daring	Imbibe
Stadium	Amicable
Pedestrian	Pungent

Appendix 8: Verbatim Instructions for the "Beads" Task

I'd like you to look at these two jars. One contains 85 red beads and 15 green beads. The other contains 15 red beads and 85 green beads. I'm going to remove the jars from view. I'll select one jar. Then I'm going to take beads from the jar I selected. Your job is to decide which jar the beads are being taken from: mostly red or mostly green. I'll continue to show you beads taken from the selected jar until you decide which one they're coming from. After I show you each bead I'll put it back so there'll always be 100 beads in the jar.

All the beads will be taken from the same jar. Each bead will be replaced, in the jar from which it was drawn, before the next bead is drawn. You're allowed to see as many beads as you need to be as sure as you can of which jar has been chosen.

After I show you each bead please point to one of these boxes. If you have already decided, point to this box saying "no more beads, I have decided." If you want to see more beads point to this box, saying "more beads please".

Appendix 9: Verbatim Instructions for the Auditory Perceptual Task

I'd like to test your hearing. Describe what you hear.

When the test starts you'll hear a short tone through the headphones. This reminds you to listen closely. Then you'll hear a hissing noise. Sometimes you'll hear another sound too but it may be difficult to make out from the background noise. At the end you'll be asked if you heard anything in the noise. Your job is to decide whether you heard another sound or not. Use the buttons on this box to move along a scale on the screen like this.

If you definitely hear a sound, press the right-hand button until all five boxes on the screen turn green. If you definitely don't hear a sound, press the right hand-button once so that only one box turns green. Use the left-hand button to move back if you make a mistake. If you are unsure whether you heard a sound or not, use the buttons to turn as many boxes green as you'd like, depending on how sure you are. Use this as a guide. The buttons are quite sensitive, so I'd like you to practice using them.

Now, listen to 10 examples. Some examples will be easier to hear than others. Some will be very hard to hear. When the scale appears, respond using the buttons and I'll tell you if there was a sound there or not. You only have 8 seconds to respond after the scale appears, so you have to move it quickly. Do you have any questions?

Now I'm going to play you 40 more. They'll all be difficult to hear. Please respond in the same way as before. This time I won't tell you if there was a sound there or not. Once you start you need to keep going for 10 minutes. Do you have any questions?

Appendix 10: Verbatim Instructions for the Visual Perceptual Task

I'd like to test your vision. Describe what you see.

When the test starts, you'll see a fuzzy square appear then disappear. This reminds you to watch the screen closely. The square will appear again, but this time it'll last for a few seconds. Sometimes another image will flash up in the centre of the fuzzy square. It will be difficult to see and you may not be able to make it out. Your job is to decide whether you saw another image or not. Use the buttons on this box to move along a scale on the screen like this.

If you definitely see an image, press the right-hand button until all five boxes on the screen turn green. If you definitely don't see an image you should press the right hand-button once so that only one box turns green. Use the left-hand button to move back if you make a mistake. If you're unsure whether you saw an image or not, use the buttons to turn as many boxes green as you'd like, depending on how sure you are. Use this as a guide.

Now, watch 10 examples. Some examples will be easier to see than others. Some will be very hard to see. Sit well back from the screen and take in the whole square. When there is an image it'll flash up right in the centre of the square very briefly. When the scale appears, respond using the buttons and I'll tell you if there was an image there or not. You only have 8 seconds to respond after the scale appears, so you have to move it quickly. Do you have any questions?

Now I'm going to play you 40 more. They'll all be difficult to see. Please respond in the same way as before. This time I won't tell you if there was an image there or not. Once you start you need to keep going for 10 minutes. Do you have any questions?

Appendix 11: Verbatim Instructions for Negative Priming Task

On each trial of this experiment you will see a display that contains two letters of the alphabet. Of the two letters, one will always be in uppercase (B) and one will always be in lowercase (a). Your task will be to decide which letter is in uppercase. That is, if the uppercase letter is on the left side of the display, press the '1' key. If the uppercase letter is on the right side if the display, press the '0' key. So, if the display comes up with Bf, then you would press the '1' key. If the display comes up with rH, then you would press the '0' key. Keep in mind that each display will contain one uppercase and one lowercase letter. Respond as quickly and as accurately as you can. A row of asterisks (******) will always come up before any letters. Use this row of asterisks as a fixation point to indicate where you should be looking. If you make a mistake a tone will sound. Do you have any questions?

There is no practice for this task. If you make a mistake just keep going. It'll last about 5 minutes.

Appendix 12: SIAPA Probes

I'd like to talk to you about your sense of hearing, vision touch and so on. Some of the experiences I'll ask you about are quite common, others are very unusual so the questions might seem a little odd. If the experience does not apply to you, just let me know. Let's start with your sense of hearing. Tell me about your hearing.
Is your hearing particularly good or sensitive, or particularly poor?
Have you ever had the feeling or sensation that sounds were particularly loud? Or louder than usual? Or that your sense of hearing was particularly keen or sensitive? Or that your ears were picking up the slightest detail of sounds?
Have you ever had the experience or felt like you were being flooded or inundated with sounds? Or that you couldn't block out sounds? Or that your ears were picking up everything going on around you?
Have you ever had the experience or felt that you couldn't pay attention to one sound or a conversation, because of interference from other sounds, like background noise? Do you find that your attention is captured by irrelevant sounds, like traffic noises, even though they are of no interest to you?

Tell me about your vision.
Is your vision particularly good or sensitive, or particularly poor?
Have you ever had the feeling or sensation that things were particularly bright or vivid? Or brighter or more vivid than usual? Or that your sense of vision was particularly keen or sensitive? Or that your eyes were picking up the slightest detail of things?
Have you ever had the experience or felt like you were being flooded or inundated with images or sights? Or that you couldn't block out images or sights? Or that your eyes were picking up everything going on around you?
Have you ever had the experience or felt that you couldn't pay attention to one image or sight, because of interference from other images or sights, like movement at the edge of your visual field? Do you find that your attention is captured by irrelevant images, like trees blowing in the wind, even though they are of no interest to you?

Tell me about your sense of touch.
Is your sense of touch particularly good or sensitive, or particularly poor?
Have you ever had the experience that your physical sensations were particularly intense? Or more intense than usual? Or that your sense of touch was particularly keen or sensitive? Or that your skin was picking up the slightest detail of everything it touched?
Have you ever had the experience or felt like you were being flooded or inundated with physical sensations? Or that you couldn't block out anything your felt? Or that your skin was reacting to everything it was in contact with so that it dominated your sensory experience or attention?
Have you ever had the experience or felt that you couldn't pay attention to one physical sensation, because of interference from other sensations, like the feeling of your clothes? Do you find that your attention is captured by irrelevant sensations, like the feel of your hair, even though they are of no interest to you?

Tell me about your sense of smell.
Is your sense of smell particularly good or sensitive, or particularly poor?
Have you ever had the feeling or sensation that smells were particularly intense? Or more intense than usual? Or that your sense of smell was particularly keen or sensitive? Or that your nose was picking up the slightest detail of perfumes and odours?
Have you ever had the experience or felt like you were being flooded or inundated with smells? Or that you couldn't block out smells? Or that your nose was picking up everything going on around you at once so that you felt permeated?
Have you ever had the experience or felt that you couldn't pay attention to one odour or perfume, because of interference from other smells, like cleaning products? Do you find that your attention is captured by irrelevant smells, even though they are of no interest to you?

Tell me about your sense of taste.
Is your sense of taste particularly good or sensitive, or particularly poor?
Have you ever had the feeling or sensation that tastes were particularly intense? Or more intense than usual? Or that your sense of taste was particularly keen or sensitive? Or that your tongue was picking up the slightest detail of food or drink?
Have you ever had the experience or felt like you were being flooded or inundated with taste sensations? Or that you couldn't block out taste sensations? Or that your tongue was reacting to everything in your mouth so that taste dominated your sensory experience and attention?
Have you ever had the experience or felt that you couldn't pay attention to one taste sensation or flavour, because of interference from other flavours in the background? Do you find that your attention is captured by irrelevant taste sensations, like saliva, even though they are of no interest to you?

(Can you describe a time when this occurred?)
(Has this occurred in the last month?)
(You have told me that ... Does anything like this, or analogous to this, ever happen with your vision/ sense of touch/ sense of smell/ sense of taste?)
(Some people report that [it seems like they hear all sounds at once and they are overwhelming]; have you had any experiences like this?)

Appendix 13: SAPS Probes

Have you experienced any problems in the last month? What is it that brought you to hospital?

Hallucinations

Have you ever heard voices or other sounds when no one is around?
What did they say?
Have you ever heard voices commenting on what you are thinking or doing?
What do they say?
Have you heard two or more voices talking with each other?
What did they say?
Have you ever had burning sensations or other strange feelings in your body?
What were they?
Did your body ever appear to change in shape or size?
Have you experienced any unusual smells or smells that others do not notice?
What were they?
Have you had visions or seen things that other people cannot?
What did you see?
Did this occur when you were falling asleep or waking up?

Delusions

Have people been bothering you in any way?
Have you felt that people were against you?
Has anyone been trying to harm you in any way?
Has anyone been watching or monitoring you?
Have you ever been worried that your husband/wife might be unfaithful to you?
What evidence do you have?
Have you ever felt that you have done some terrible thing that you deserve to be punished for?
Do you have any special or unusual abilities or talents?
Do you feel you are going to achieve great things?
Are you a religious person?
Have you had any unusual religious experiences?
What was your religious training as a child?
Is there anything wrong with your body?
Have you noticed any change in your appearance?
Have you ever walked into a room and thought people were talking about you or laughing at you?
Have you seen things in magazines or on TV that seem to refer to you or contain a special message for you?
Have people communicated with you in any unusual ways?
Have you ever felt you were being controlled by some outside force?

Have you ever had the feeling that people could read your mind?
Have you ever heard your thoughts out loud, as if they were a voice outside your head?
Have you ever felt your thoughts were broadcast so other people could hear them?
Have you ever felt that thoughts were being put into your head by some outside force?
Have you ever experienced thoughts that didn't seem to be your own?
Have you ever felt your thoughts were taken away by some outside force?