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Aberrant Salience and Probabilistic Reasoning in Distressing Attenuated Positive Psychotic Symptoms: An Examination of a Two Factor Model

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Aberrant Salience and Probabilistic Reasoning in Distressing Attenuated Positive Psychotic Symptoms: An Examination of a Two Factor Model

By Huw Green

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Huw Green

This manuscript has been read and accepted for the
Graduate Faculty in Psychology to satisfy the dissertation
requirement for the degree of Doctor of Philosophy.

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Abstract

Aberrant Salience and Probabilistic Reasoning in Distressing Attenuated Positive Psychotic
Symptoms: An Examination of a Two Factor Model

By Huw Green

Advisor: Deidre Anglin

Theoretical psychological models of positive psychotic symptoms have increasingly
emphasized the interaction of multiple cognitive factors. Research into delusions in particular
has focused on the interaction of two factors; a perceptual anomaly that gives rise to a need for
explanation, and a bias toward premature acceptance of a hypothesis. Recently this two factor
approach has been applied to positive psychotic symptoms more broadly. Two candidate factors
have received extensive theoretical and empirical interest. The aberrant salience hypothesis
posits that salience regulation, mediated by dopamine, goes awry in psychosis, giving rise to a
generalized sense of undue significance that is applied to neutral perceptual stimuli. For the
person who experiences it, this unwarranted sense of significance seems to demand an
explanation. A second candidate factor, the jumping to conclusions bias has come to be regarded
as one of the most stable findings in psychosis research. Reliably associated with the presence of
delusions, but also associated with positive symptoms more broadly, the bias is seen when
psychotic participants make a probabilistic decision on the basis of less evidence than controls.
These factors may work in concert to establish unrealistic conclusions about the nature of
perceptual inputs, giving rise to psychotic explanations. In a quasi-experimental study,
individuals who endorsed an unusually high level of distressing attenuated positive psychotic
symptoms (DAPPS) were compared with controls who endorse a lower than average number.
Participants completed one behavioral and one self-report measure of aberrant salience, and a
commonly used task for assessing the presence of bias in probabilistic reasoning.

Results: Preliminary analyses revealed that participants in the current study did not respond in the expected way to the behavioral measure of aberrant salience. It is possible that the task used is insufficiently sensitive to detect subtle variations in salience processing among non-clinical individuals. In terms of the main results, multiple independent samples t-tests (corrected for multiple comparisons) revealed a group difference only on the self-report measure of aberrant salience. Groups showed no significant difference on the test of probabilistic reasoning, though the group with elevated rates of DAPPS requested more evidence than controls. Logistic regression models predicting group membership from the experimental variables suggested that while the inclusion of aberrant salience significantly improved predictive accuracy, neither probabilistic reasoning nor the interaction between aberrant salience and probabilistic reasoning increased predictive accuracy. This result is a consistent with an interpretation on which distressing attenuated positive psychotic symptoms are associated with aberrant salience attribution but not with probabilistic reasoning deficits. Further research is needed to establish whether these variables interact in clinical samples.

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Chapter 1: Introduction:

   Psychotic disorders, during which people lose the capacity to distinguish their subjective experiences from shared reality and experience symptoms including hallucinations, delusional beliefs and disorganized thought, are potentially devastating and poorly understood[1]. Often starting in late adolescence/early adulthood, they affect around 1% of the population, though this figure has proved to be more variable across time and place than was conventionally believed (Stilo and Murray, 2010). One approach to the investigation of psychosis that is increasingly gaining traction is the study of the cognitive "pathways" that contribute to potentially distressing psychological end state "positive symptoms" such as hearing voices or holding delusional beliefs (e.g. McCarthy Jones, 2012; Freeman and Garety, 2014).

   An attendant assumption of this literature is that there is no clear "cut-off" between psychosis and "health". Rather it is supposed that psychotic experiences lie on a continuum and can be considered to some extent analogous with experiences that have been found among healthy individuals (Meehl, 1962; Van Os et al. 2009). It is an implication of this assumption that the study of individuals without a psychiatric diagnosis, but demonstrating elevated rates of psychotic symptoms or "complaints" (Bentall et al., 1988), can inform our understanding of "full-blown" psychotic states. Individuals exhibiting "at risk" mental states represent a particularly promising population to study from this perspective (Fusar-Poli et al., 2013a).

   The study of "at risk" states arose from the hope that early intervention could arrest the development of psychosis and forestall its worst effects (McGlashan and Johannessen, 1996). A

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[1] The American Psychiatric Association defines psychotic disorders as follows: "They are defined by abnormalities in one or more of the following five domains: delusions, hallucinations, disorganized thinking (speech), grossly disorganized or abnormal motor behavior (including catatonia), and negative symptoms." (DSM-5, p.87)

number of structured interview protocols (e.g. McGlashan et al., 2009) and self-report questionnaires (e.g. Loewy et al., 2005) have been developed to assess for such states, and these can predict conversion to a DSM/ICD psychotic disorder in around 32% of untreated cases after three years (Fusar-Poli et al., 2013b)[2]. In addition to the benefits of identifying people early in a posited neurodevelopmental process, the construct of an "at risk" state offers the possibility of studying the psychological processes involved in psychosis, with greater confidence than that offered by the study of "normal" samples differentiated by psychometric "proneness" measures like the Peters Delusions Inventory (PDI; Peters et al., 1999) or the Launay Slade Hallucination Scale (LSHS; Launay and Slade, 1981).

Unlike "at risk" diagnoses, which identify individuals who are more likely to develop psychotic disorders (and who are frequently treatment seeking and experiencing significantly lower levels of social functioning and quality of life, Fusar-Poli et al. 2015), measures of proneness typically measure the prevalence of attenuated symptomatology in the healthy population with no reference to how much interference or dysfunction the symptoms cause to the individual who experiences them. Proneness is a broader category and tends to be defined in reference to the characteristics of any given sample. Thus a fairly typical research design examining psychosis proneness may administer the PDI or the LSHS to a sample of non-treatment-seeking individuals and then divide these into a prone and non-prone group on the basis of a split into the upper and lower quartile. Otherwise, researchers may use responses on a self-report measure to generate a continuous outcome variable. A difficulty with this approach is that psychosis proneness is a hypothetical variable which cannot necessarily be considered to be

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[2] Though Fusar-Poli et al. (2013b) also note that the rates of conversion appear to have declined over time in successive longitudinal studies, from a two year rate of around 45% in a 2004 study, to two year rate of around 10% in a 2011 study. Although these studies do not compare treated and untreated groups, Fusar-Poli et al. suggest that the change may be due to a greater availability of preventative interventions during the last decade.

linked to clinically relevant psychotic symptoms. David (2010) addresses this and suggests it is premature to assume that high scorers on, e.g. the PDI are on the same continuum as those who experience clinically relevant psychosis. For this reason, the current study adopts an approach in which participants are administered a self-report measure sensitive to both the presence of attenuated positive psychotic symptoms and to the clinical "at risk" state.

In the next section I will introduce contemporary psychological approaches to psychosis. A broad consensus of psychological researchers proposes that complex psychotic symptoms such as delusional beliefs and hallucinations are best understood in terms of multiple factors (e.g. Freeman, 2007). In an account of delusions offered by Coltheart et al. (2011), two factors in particular, an anomalous perceptual experience and a faulty reasoning style, are accorded significance. This two factor approach has recently been theoretically extended to a model designed to account for all positive psychotic experiences, not just delusions (Moritz et al., 2016). Specific candidate "factors" have been increasingly researched, and I will introduce two of these, "aberrant salience" and the "jumping to conclusions" bias (JTC), along with the growing empirical literature on their role in psychotic symptomatology. However, while the empirical literature on these phenomena has grown, the majority of studies have treated them as individual factors, and focused on ascertaining their presence in schizophrenia and other psychotic disorders.

I will go on to outline ways that aberrant salience and the JTC bias might interact to contribute to the early development of psychotic symptoms, suggesting that the two factor model supports the hypothesis that neither candidate is sufficient for a full blown psychosis. In the subsequent section I will propose an experimental procedure to examine how these variables

may be interacting in a group of individuals presenting with attenuated positive psychotic

symptoms (APPS).

Chapter 2: Literature Review:

2.1 Continuum approaches to psychosis and high risk:

Since the mid-1980s (Bentall et al, 1988; Bentall, 2004), researchers have increasingly advocated investigating cognitive models of risk for psychotic phenomena. This work has built on the growing consensuses that psychological phenomena may be significant in the causal pathways to psychotic experiences, and that there is no clear "cut off" between people who are psychotic and people who are not. Originating in theory and research about schizotypy (Meehl, 1962), research has increasingly focused on psychotic traits in normal people (Claridge, 1990) in order to understand the mechanisms of specific psychotic symptoms. This work has focused on experiences which indicate attenuated versions of more serious symptoms like hallucinations (defined as the presence of a "perceptual response", often auditory, in the absence of an appropriate external stimulus which could have caused it, Launay and Slade, 1981; McCarthy Jones et al. 2014) and delusions (defined as "false beliefs" which are not concordant with a person's culture, and which are held in spite of contradictory beliefs of others and evidence to the contrary, Coltheart et al., 2011). Scales developed by Launay and Slade (The Launay Slade Hallucination Scale, LSHS, 1981) and by Peters et al. (The Peters Delusions Inventory, PDI, 1999) assess for the presence (respectively) of "hallucination-like" and "delusion-like" experiences. Both scales assess for experiences which resemble psychotic symptoms. Thus the LSHS asks participants about intrusive thoughts and anomalous visual and auditory experiences across 10 items (i.e. "In the past, I have had the experience of hearing a person's voice and then found that no one was there"). The PDI uses 40 items (or 21 in a briefer, recent version) developed from canonical accounts of delusions (i.e. Schneider's "first rank symptoms") and also assesses for frequency, conviction and degree of distress. The presence of symptoms is

taken to indicate a degree of "proneness" in healthy populations, though typically a "prone" group is defined not in terms of a standard "cut off" number of items, but in relation to the quantitative characteristics of the sample from which it is drawn (i.e. the upper quartile of scorers being selected). This assumption has widened the scope of research into mechanisms that underlie these symptoms by enabling researchers to examine risk factors and mechanisms in non-clinical samples (e.g. Barkus et al., 2007, Laroi et al., 2005, Gracie et al., 2007). However, such research rests on the assumption that there is a meaningful relationship between this form of "proneness" and the symptoms experienced in psychotic illness.

The view that psychotic phenomena lie on a continuum, with clinically diagnosable illness only representing one extreme of a more widely distributed set of experiences, has gained moderate support. A meta-analytic review by Van Os et al. (2009) assessed the validity of a psychosis continuum by aggregating data from an international range of studies of psychotic experiences in general population samples. The review confirmed a number of predictions made by the continuum hypothesis, namely that the prevalence and incidence of psychotic experiences is much higher than that of psychotic illnesses; that such experiences are associated with the same etiological risk factors (and the same cognitive mechanisms) which have been linked to psychotic illnesses, and that the presence of such attenuated experiences raises the risk of an individual developing a full blown psychotic illness. This last finding has been particularly important in the emergence of a new approach to mental health care, identifying people manifesting "at risk states" for psychosis, who are regarded as especially vulnerable to developing schizophrenia or another psychotic disorder (Fusar-Poli et al. 2013a).

However, the notion of a psychosis continuum has been challenged by David (2010) who suggests that advocates for the idea have overstated their case. Meanwhile, some have queried whether the existence of a continuum calls into question any meaningful cut off between ill and healthy altogether. In practice, a number of diagnostic conventions have arisen to help clinicians and researchers distinguish those "at risk" from those who have already "transitioned" to illness. Broadly the central component separating these groups is the presence of *reality testing*. Individuals can experience quite elaborate symptoms, but these remain "attenuated" for as long as they are able to attribute them to plausible causes (i.e. to their "eyes playing tricks" rather than the presence of someone or something which could not reasonably be there). This places the capacity for doubt at the center of the distinction between healthy and well, and results in a high degree of subjective judgment on the part of clinicians.

The concept of "at risk" status for psychosis has emerged over the last 15-20 years, principally as researchers sought ways to identify populations at greater risk of transition to full psychotic illness, with the hope of offering preventative clinical intervention pre-emptively (McGlashan and Johannessen, 1996; Daneault et al. 2013). This effort has been particularly pronounced in the United States, with the NAPLS study (see, Addington et al. 2012 for an overview). A wide range of measures and different criteria have been developed to assess whether individuals can be considered "at risk", starting with the Perceptual Aberration scale developed by Chapman and Chapman (1987). Subsequent instruments have been created at multiple sites internationally, many of them involving the delivery of structured interviews by trained clinicians or researchers (Daneault et al. 2013). This multiplicity of measures has yielded different approaches to what constitutes "at risk" status, with some measures focusing on the presence "attenuated symptoms" (i.e. experiences which are taken to constitute less problematic

versions of psychotic symptoms, such as "overvalued beliefs" and perceptual anomalies), and others focusing on "basic symptoms" (i.e. disturbances of drive, affect or attention, Ruhrmann et al., 2010, which can be considered the first stages of a psychotic illness like schizophrenia). Proponents of the latter approach have argued that, in addition to "at risk" individuals having an elevated chance of receiving a diagnosis of a psychotic illness like schizophrenia, they should also be regarded as ill in their own right, and as eligible for psychiatric diagnosis and treatment (Ruhrmann et al., 2010). A meta analytic review of social functioning and measures of quality of life by Fusar Poli et al. (2015) found that "at risk" groups were rated as showing substantially lower levels of functioning than healthy groups (hedges g=-3.01), with a smaller difference between them and people with psychotic disorders (hedges g=0.34). This has led some (Tsuang et al., 2013; Fusar Poli et al., 2014) to advocate that an "attenuated psychosis syndrome" should be included in the next version of the Diagnostic and Statistical Manual of Mental Disorders (DSM). This syndrome would consist of symptoms very similar to those seen in psychosis, but in less severe form, and not accompanied by the same degree of conviction as a full psychotic illness[3].

The notion of an "attenuated psychosis syndrome" raises again the question of where the cut-off between "ill" and "healthy" should be thought to lie. The idea of a clear distinction has never been without controversy, and as Fusar-Poli et al.'s (2014, 2015) work, and that of the suggests, there is good reason for thinking that many of those currently excluded from the DSM are also experiencing some degree of clinically relevant impairment. However, others (e.g.

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[3] In fact an "attenuated psychosis syndrome" was included in the last version of the DSM, but only in the appendix "Conditions for Further Study". It is defined as follows: "Attenuated psychotic symptoms, as defined in Criterion A, are psychosis-like but below the threshold for a full psychotic disorder. Compared with psychotic disorders, the symptoms are less severe and more transient, and insight is relatively maintained. A diagnosis of attenuated psychosis syndrome requires state psychopathology associated with functional impairment rather than long-standing trait pathology. The psychopathology has not progressed to full psychotic severity. Attenuated psychosis syndrome is a disorder based on the manifest pathology and impaired function and distress" (APA, 2013, p.783)

Bentall, 2004) have argued that some of the individuals currently captured by psychotic diagnoses in the DSM might be best off not thought of as "ill", but rather as manifesting a reasonably "normal" response to their experiences (see also Longden et al. 2012). Until this question is resolved, there is likely to continue to be debate about where any cut-off should be drawn. For now, many clinicians presumably follow the suggestion by Wakefield (1992) that "illness" or "disorder" is present when there is a biological or cognitive dysfunction present which causes some form of harm (distress or a decline in social functioning) to a person. For the purposes of the distinction between fully psychotic and just "at risk", interview measures include a way of rating subjective degree of certainty with which beliefs are held or hallucinations accounted for (more on this below). Self-report measures ask participants about attenuated experiences and rule out individuals who would meet criteria for a psychotic disorder.

The Prodromal Questionnaire (PQ), developed by Loewy et al. (2005) is a self-report scale for attenuated symptoms which was developed to provide an instrument briefer than structured clinical interviews, but more comprehensive than symptom-specific measures. It's 92 item version (a shorter, 16-item version has subsequently been developed, Ising et al., 2012) lists a range of attenuated symptoms which participants respond "true" or "false" to, depending on whether they have experienced them within the last month. Constructed by using items from the Structured Interview for Prodromal Symptoms (SIPS, Miller et al., 2002) and the Schizotypal Personality Questionnaire (SPQ, Raine, 1991), the PQ assesses prodromal status by providing a tally of the number of attenuated psychotic symptoms (i.e. "I have heard things other people couldn't hear like voices of people whispering or talking"; "I have thought that things I saw on the TV or read in the newspaper had a special meaning for me") a person has experienced. The authors of the scale conducted a validity study, establishing a cut score of 8 or more endorsed

items for reliably diagnosing "at risk" status (Loewy et al., 2005), but the measure also provides the possibility of a continuous measure as it yields a count of symptoms and an assessment of whether they are felt to be distressing. The PQ is rooted in an "attenuated symptom" approach as, although it does assess distress, it does not include clinician-based assessment of functional impairment.

To a greater extent than research that has focused on the administration of psychometric measures of symptoms within "normal" populations, the study of high risk states entails the recruitment of populations of people regarded as meeting criteria for a clinically relevant syndrome. This gives research into high risk states greater face validity as a source of information about psychosis. At risk screening measures like the PQ offer the possibility of assessing the presence "attenuated positive psychotic symptoms" (APPS) and examining the risk factors and cognitive mechanisms which are associated with being more or less at risk of psychosis. The fact that around a third of people who meet criteria for high risk states will transition to full psychosis (Fusar-Poli et al. 2013a) makes this population potentially particularly informative to study relative to healthy populations in which the risk of developing psychosis is unknown.

Ideally the criteria for being "at risk" would be narrowed down yet further, and Fusar-Poli et al. (2013) identify five factors which elevate the risk of transition within "at risk" samples. These are: genetic risk (psychotic illness among 1st degree relatives) with an attendant functional decline, high unusual thought content decline, high suspicion/paranoia, low social functioning and history of substance abuse. More recently, the importance of social functioning in particular has been highlight by Fusar-Poli et al. 2015, who confirmed that lower functioning predicts transition to psychosis in a high risk group with a moderate effect size (g=0.43). Work

on automated speech analysis (Bedi et al. 2015) has also recently pointed to characteristics of speech as potentially diagnostic. Using a program which parsed the speech individuals at high risk for semantic coherence and syntactic structure, researchers were able to predict with 100% accuracy who would develop psychosis in the next two years. This result drew on a relatively small sample (34, of whom 5 transitioned to full psychosis), but it suggests that verbal behavior may have a particularly powerful role in distinguishing "at risk" who will become psychotic from those who won't. However, while these diagnostic factors can be assessed by clinical and research protocols, the criteria for specifying "at risk" status have not, at present, been changed to integrate them.

2.2 Psychological approaches to delusions as a route to understanding psychosis

Delusions are considered a central component of psychosis, having been identified as one of nine "first rank symptoms" of schizophrenia by the German psychiatrist Kurt Schneider (Bentall, 2004) and subsequently incorporated into DSM definitions of schizophrenia in every edition since the introduction of formal criteria in DSM-III. Understanding how delusions arise can thus provide an important route to understanding psychosis more generally. The latest version of the DSM (APA, 2013) defines delusions relatively briefly as "fixed beliefs that are not amenable to change in light of conflicting evidence". The manual then goes on to distinguish "Persecutory delusions" (the belief "that one is going to be harmed, harassed, and so forth by an individual, organization, or other group"); "Referential delusions" (the belief "that certain gestures, comments, environmental cues, and so forth are directed at oneself"); "Grandiose delusions" (an individual's belief that "he or she has exceptional abilities, wealth, or fame"); "Erotomanic delusions" (an individual's false belief "that another person is in love with him or her); Nihilistic delusions ("the conviction that a major catastrophe will occur"), and somatic delusions ("preoccupations regarding health and organ function").

However, there is considerable controversy about when a belief can be considered "delusional" as opposed to merely mistaken or unusual (David, 1999), and even whether the phenomena commonly labelled "delusions" ought to be considered as *beliefs* at all (e.g. Hamilton, 2007; Radden, 2010). DSM-5 explicitly acknowledges the first of these difficulties, saying that "the distinction between a delusion and a strongly held idea is sometimes difficult to make and depends in part on the degree of conviction with which the belief is held despite clear or reasonable contradictory evidence regarding its veracity" (APA, 2013, p.87). In practice, certain belief-like states of mind are taken by clinicians to be sufficiently distressing and ungrounded in evidence that they warrant clinical attention. Where an individual lacks insight or the capacity to entertain doubt about such a belief (i.e. a loss of "reality testing") it is considered delusional (Arango and Carpenter, 2011). Some authors (e.g. Cermolacce et al., 2010) have suggested assessing delusions not only in terms of their verbal content, but also in terms of the "conditions of intersubjective encounter" between the clinician and the patient. Whether or not delusions can be said to be beliefs (as opposed to attitudes, as suggested by Radden, 2010), they nonetheless have a distinctive cognitive structure (Gerrans, 2013), which it behooves clinical psychological researchers to understand.

Just as there is no entirely uncontroversial distinction between delusional and non-delusional beliefs/attitudes, so there is no widely accepted distinction between fully psychotic delusions and attenuated/prodromal delusion-like states. Measures of attenuated symptoms like the PQ or the SIPS include items that resemble delusions, but which are more closely akin to "normal" experiences than the strong conviction entailed by the DSM criteria for a delusion (e.g. items 38 is "I have felt that other people were watching me or talking about me;" these experiences are taken to be prima facie less unusual than delusions, but similar in character). The

section of the SIPS which deals with positive symptoms (and thus includes experiences similar to delusions) refers to "overvalued ideas" rather than delusions, and one way in which the distinction between an attenuated symptom and a psychotic symptom is made is by reference to whether the individual is able to entertain doubt regarding the veracity of their belief (McGlashan et al., 2010).

Much recent psychological research on delusions has built on the conclusion that the cognitive psychological aspects of this manifestation of psychosis may be substantially shared between people who manifest "full and frank" delusional symptomatology and people who display "at risk states" or "proneness" (Garety and Freeman, 2013). One theme that emerges from this research is that delusions are not merely epiphenomenal manifestations of an underlying brain disorder, but also have psychological characteristics, which may play a significant role in their etiology. One of these, the "jumping to conclusions bias", has been widely investigated in clinical and non-clinical samples, and will be discussed below. No single overarching factor has been identified as the cause of delusions, rather multi-factorial models are proposed (Garety and Freeman, 2013).

2.3 Multi-factor models

In one early theoretical cognitive account of delusions, Maher (1974) suggested that unusual reasoning processes were less important to the formation of delusions than some form of "unusual and intense phenomenological experience". Maher was responding to the suggestion that a delusional belief could only result from an "underlying disorder of thinking" such as "faulty syllogistic reasoning", leading to the drawing of a false conclusion (a delusion). However, according to Maher, this sort of disorder of inferential process might not be necessary; an anomalous experience would be sufficient, on its own, to result in a delusion. Theorists have

subsequently argued that this sort of anomalous experience is *necessary* but not *sufficient* for the formation of delusional beliefs (McKay, 2012). Why this is the case will be explained in greater detail below.

Contemporary cognitive theorists (e.g. Bell et al., 2006; Freeman, 2007) propose that a theory of the formation of delusions must contain multiple factors, to account for the various aspects that go together to make up the complex presentation of a clinical delusion. Each component of a delusion begs explanation; the nature of its content, the degree of conviction with which it is held and its immunity to being refuted. As Coltheart et al. (2011) point out, this multiplicity of components makes the explanatory task formidable. However, most models include at least two principal factors, and a subset of theorists have suggested that these may be sufficient to explain the core experience of delusions: how it comes to be that some people develop and hold highly unusual beliefs in the face of contradictory evidence. Here I focus on the two factor model proposed by Coltheart et al. (2011), who propose that in order to develop a delusional belief, two components may be sufficient; an "unusual perceptual phenomenon" (p.285), and "defective belief evaluation" (p.285).

Coltheart et al.'s model is intended to explain what they term "monothematic" delusions, such as the Capgras delusion, where a person comes to believe that their family members have been replaced by identical imposters. A two factor account of Capgras delusion was outlined by Ellis and colleagues (Ellis et al., 1990) who posited that this experience could arise from a deficit in the cognitive-affective processes involved in face recognition. Ellis et al. (1997) demonstrated that patients with Capgras delusion demonstrated an attenuated autonomic response to familiar faces, suggesting that they did not emotionally distinguish between relatives and strangers, even though they could visually recognize them. Here the relevant "first factor" is moderately clearly

delineated (an absence of the autonomic arousal normally associated with recognizing a family member). However, as Coltheart et al. (2011) point out, it is insufficient on its own, as not all individuals who experience this emotional-recognition deficit will develop the delusion. A second factor is required, namely a faulty inductive reasoning process whereby the individual starts with an anomalous subjective experience and derives an unwarranted inference to account for it. In the Capgras delusion, the unwarranted inference is the contention that a relative is in fact an imposter. This two-factor model is supposed to be able to account for all monothematic delusions, and Coltheart et al. (2007) have suggested it is also relevant in the context of schizophrenia.

In comprehensive review of the psychological mechanisms associated specifically with paranoia, Freeman (2007) suggests that anomalous experiences (of the sort which could play a role as a first factor) had been under-researched in this area. One reason for this may be that, while the Capgras delusion has been frequently associated with specific neurological damage (such as lesions to the right lateral prefrontal cortex, Coltheart, 2007), many delusional syndromes, such as schizophrenia and other related psychotic illnesses have been less consistently associated with a specific neurological abnormality, making it harder to identify a consistent cause of a relevant "first factor" across all cases. (Radden, 2010, draws out this difference further, making a distinction between monothematic "deficit delusions" such as those seen after strokes or traumatic brain injury, and "complex paranoid systems", such as those seen in disorders like schizophrenia, Radden, 2010, p.27).

Nonetheless, Coltheart et al. (2011) propose that their model may have relevance for psychotic illnesses like schizophrenia, and suggest two potential candidates for a first and a second factor in delusions, the first of which has started to gain attention from psychosis

researchers, and the second of which has been widely researched since the late 1980s. They suggest that one relevant candidate for a relevant "first factor" could be aberrant salience (Kapur, 2003), a feeling of strange, undue significance, bestowed upon environmental phenomena which is posited to yield "unusual and intense" sensory experiences of the sort which demand some explanation. Meanwhile, a specific disorder of hasty inferential reasoning, a "Jumping-to-conclusions bias (JTC) or "epistemological impulsiveness" (Bentall, 2004) may be a viable "second factor", which leads people to draw a delusional inference to explain their anomalous experience. In the next sections I will review the existing evidence on these two posited "factors" and their prevalence in samples of people who exhibit them.

A difficulty with this two factor account of delusional ideation is that while it would be consistent with liberal acceptance of a belief most people would reject (i.e. the "taking hold" of an implausible belief), it is also consistent with subsequent acceptance of a *new* belief with minimal new evidence (i.e. the rapid rejection of a delusion in favor of an alternative candidate belief). Clinical delusions are described as beliefs held with an incorrigible degree of conviction, so how could a two factor theory explain this? One possibility is that the two factors are not the whole picture. Thus it may be that they are necessary but not sufficient factors (in which case an extra factor is required to account for the incorrigibility). Alternatively, it might be that a reasoning bias toward "jumping to conclusions" does not entail a willingness to relinquish conclusions which have already been reached. Fine et al. (2007) present some evidence which is consistent with this latter possibility, concluding that, although a tendency to "jump to conclusions" is reliably associated with delusional belief, a tendency to *update* beliefs in the face of contradictory evidence is not. Thus the presence of a jumping to conclusions bias does not

appear to entail a tendency to jump to *new* conclusions once an initial conclusion has been drawn. I will now discuss the two candidate factors in greater detail.

2.3.1. Factor One: Aberrant Salience

The aberrant salience framework was initially proposed by Kapur (2003), who suggested that the role of dopamine as a regulator of motivational salience (Berridge and Robinson, 1998, Berridge, 2007) could help to explain how a postulated dopamine dysregulation in psychosis could lead to the positive symptoms of this disorder. Salience refers to the way that an environmental stimulus is rendered appetitive or aversive rather than just a "cold bit of information" (Kapur, 2003, p.14). This process bestows a sense of significance on things we wish to acquire or avoid, allowing them to stand out for us against a background. However in psychosis the production of both stimulated and unstimulated phasic striatal dopamine is elevated (Abi-Dargham and Grace, 2011), and this may result in the attribution of "aberrant salience" (Kapur, 2003). By Kapur's account, the extra sense of significance also entails a demand for a subjective explanation, and it is this element which can contribute to the formation of a delusion.

Kapur suggests that this theoretical framework fits particularly well with the early stages of psychosis, as it is commensurate with phenomenological accounts given by people in the early stages of delusion formation, who describe a feeling of "heightened awareness" and a drive to "make sense" of the situation. Kapur's account of aberrant salience in these terms is thus commensurate with the description of an "intense and unusual phenomenological experience" described by Coltheart et al. (2011). Investigators have deployed experimental (Roiser et al. 2009) and self-report measures (Cicero et al.2010) in an attempt to assess aberrant salience in the context of psychosis.

2.3.2 Experimental Measure: The Salience Attribution Test:

Kapur's theory predicts that the way salience is assigned to objects will be different in individuals who demonstrated aberrant salience. This is described in terms of subjective changes in the experience of "significance" (Kapur, 2003), but given the putative centrality of "salience" to reward learning, it has also been possible to derive behavioral predictions about people's responses to learning tasks. Roiser et al. (2009) developed an experimental measure to assess salience attribution behaviorally; The Salience Attribution Test (SAT: see detailed description below). The SAT is based on an implicit-learning procedure and requires participants to learn the financial contingencies associated with different visual stimuli. Reaction times provide behavioral measures of implicit aberrant and adaptive salience, and ratings on a Visual Analogue Scale provide explicit aberrant and adaptive salience.

In this paradigm, the variables of greatest interest are implicit and explicit aberrant salience, both of which represent an effort to derive an index of the tendency to irrelevantly "tag" stimuli with salience, even when they are not rewarded (Kapur, 2003). Implicit aberrant salience is the tendency to show increased speeding to irrelevant trials, and explicit aberrant salience is the tendency to show evidence of a false-belief that they were more likely to be rewarded on these trials (see method section, below, for further details). The concept of adaptive salience arises from evidence suggesting that, under normal conditions, animals and humans will show a tendency to react more quickly (a "speeding" response) to stimuli that have come to be associated with a reward, and that this response is mediated by the mesolimbic dopamine system (Wyvell and Berridge, 2000; Roiser et al., 2009). This reasoning is rooted on the theory that dopamine's role in processing reward is grounded in regulating salience rather than the hedonic, pleasurable aspects of reward (Berridge, 2007).

Roiser et al. (2009) found that when they administered this task to people with and without a diagnosis of schizophrenia, there was evidence of differential salience attribution between groups. Individuals with a diagnosis of schizophrenia showed lower levels of adaptive salience than controls, and when they conducted an analysis directly comparing those patients with delusional symptoms to patients without, delusions specifically were associated with aberrant salience. Roiser et al. (2013) administered the SAT to a group of 18 individuals who met the criteria for an "at risk mental state" as measured by the Comprehensive Assessment of At Risk Mental State (CAARMS) and to 18 healthy controls. They also undertook fMRI scans of the participants during the procedure. At risk individuals were more likely to attribute salience to task-irrelevant features (showing significantly greater explicit aberrant salience), and this tendency was associated with a greater intensity of delusional ideation as measured by the "thought content" subscale of the CAARMS.

The SAT has subsequently been linked directly to the functioning of the human striatal dopamine system. Nagy et al. (2012) administered the task to individuals newly diagnosed with Parkinson's Disease (PD) and matched controls. Twelve weeks later the PD patient group had received a dopamine agonist (pramipexole or ropinirole) as part of treatment, and were administered the SAT a second time. Nagy et al. found that participants who had taken the dopaminergic drug showed an increase in aberrant and adaptive salience relative to the baseline measurement. Furthermore, the increase in aberrant salience (but not the increase in adaptive salience) was associated with self-reported anomalous subjective "psychotic-like" experiences as measured by the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE; Mason et al, 1995). Nagy et al. took this to suggest that while dopaminergic medications may enhance adaptive salience (a stand in for "acuity and motivation, which are degraded by Parkinson's

disease), they may also increase a tendency toward aberrant salience, and thereby elevate the risk of the psychotic symptoms, which are sometimes a side effect of these medications.

However, the behavioral results of Roiser et al. (2009) and (2013) were not replicated in a recent study (Smielskova et al. 2015), that used the SAT in an fMRI procedure. Smielskova and colleagues compared adaptive and aberrant salience across four groups: 34 individuals with a CAARMS defined "At Risk Mental State", 29 individuals with a first episode psychosis (divided into 17 who were taking antipsychotic medication and 12 who were not), and 19 healthy controls. A multiple group comparison revealed no group differences on any of the SAT behavioral outcomes. The authors suggest this may result from high within-group variability seem in their sample, and point out that their control group showed higher levels of explicit aberrant salience than Roiser et al.'s (2009). They also raise the possibility of differences between their first episode sample and Roiser et al.'s schizophrenic sample, who had been on potentially salience-disrupting medication for longer. Another possibility is that these relatively small samples produce under-powered statistical results and are prone to producing idiosyncratic, non-replicable results. Smielskova et al. did find group differences in the fMRI component of their study, consistent with activation of specific regions of the "salience network" (Palaniyappan and Liddle, 2013). However, without corresponding behavioral findings, this result lacks clear explanatory power.

Studies which employ the Salience Attribution Test have included measures of potentially confounding neuropsychological factors, including measures of IQ, and processing speed (Roiser et al., 2009; 2013). One potentially confounding factor that has not been examined is the capacity to switch from one set of task demands to an alternative. The SAT demands that a person be able to respond more quickly in to one set of stimuli than to others. It purports to be

measuring the presence of disrupted salience processing (i.e. a tendency to attribute less visual significance to stimuli). However, an important alternative and as yet untested possibility is that a failure of speeding to "task-relevant" stimuli over task irrelevant stimuli represents a general deficit in the speed with which an individual is able to undertake task switching. In the present study this possibility was controlled for by the inclusion of the trail making task from the Delis-Kaplan Executive Frontal System (Delis et al., 2001). It has been suggested that the trail making task measures speed and cognitive fluidity (Salthouse, 2011). If these motor factors are impacting performance on the SAT, a correlation would be expected between adaptive salience and TMT performance.

2.3.3. Self Report Measure: The Aberrant Salience Inventory (ASI):

Aberrant Salience has also been operationalized using self-report. The Aberrant Salience Inventory (ASI) is a pen and paper measure of Aberrant Salience (Cicero et al. 2010), which aims to assess for the presence of a heightening of various subjective phenomenological features associated with Kapur's theory of aberrant salience.

In the first study using the ASI, Cicero et al. (2010) conducted an exploratory factor analysis which suggested a five factor structure to aberrant salience, and confirmed the presence of a single higher order factor to which these were all related. The authors also assessed the convergence of their aberrant salience measure with other constructs considered to be related to psychosis (Eckbald & Chapman's 1983, Magical Ideation Scale; Chapman et al's 1978 Perceptual Aberration Scale, and Lenzenweger et al.'s 1997 Referential Thinking Scale) confirming that while the ASI correlated with these and not with measures of social anhedonia. When a "psychosis proneness" group was defined using the same measures, this group scored more highly on the ASI than controls. Finally, when the measure was administered to a clinical sample (36 of whom had a history of psychotic disorders and 28 of whom did not), the patients

with psychotic disorders had a significantly higher mean score on the ASI (Cohen's d= 0.57) than the non-psychotic psychiatric patients. A logistic regression analysis also suggested that the ASI successfully predicted to which group participants belonged.

Cicero et al. (2013) administered the ASI, alongside a measure of "Self-Concept Clarity" (SCC) ("the extent to which one's beliefs about one's attributes are clear, confidently held, internally consistent, stable, and cognitively accessible", Stinson, Wood, & Doxey, 2008, p. 1541, quoted by Cicero et al. 2013, p.34) to three larger samples of people with high levels of "psychotic like experiences" (PLEs). They hypothesized that low SCC and high ASI should interact to predict elevated rates of PLEs (measured by adding together results on the Perceptual Aberration scale, Chapman et al. 1978 and the Magical Ideation Scale, Eckblad & Chapman, 1983). They found that the relationship between ASI and PLEs was moderated by SCC, such that high ASI was only associated with PLEs under conditions of low SCC. A second study replicated this finding, and extended it by including a specific measure of delusional ideation and distress (The Peters' Delusions Inventory, Peters et al. 2004). A third study incorporated a measure of neuroticism to rule out the possibility that the ASI/SCC interaction could be accounted for this variable. No three-way interaction was revealed by this analysis, and there was no two-way interaction between either ASI and neuroticism, or SCC and neuroticism in predicting PLEs. The results of Cicero et al.'s large sample studies suggest that aberrant salience may not be sufficient to produce PLEs, but could work in concert with other psychological characteristics. They do not link this explicitly to the two factor framework, but do suggest that the nature of the interaction between ASI and SCC may result from the way that low Self-Concept Clarity impacts on the willingness an individual has to construct a psychotic explanation for an experience.

Cicero et al. (2015) extended this finding to 162 individuals screened using the Structured Interview for Prodromal Syndromes (SIPS), a more detailed interview measure of psychosis "at risk" state. In this study 162 undergraduate participants were divided into a "positive schizotypy" group (i.e., scoring high on measure of positive psychotic symptoms: n=53), a negative schizotypy group (i.e. scoring high on a measure of social anhedonia, a distinct component of schizotypy more akin to negative psychotic symptoms: n=64), and a comparison group of 45 individuals who did not meet criteria for these groups. The authors replicated the pattern of their (2013), finding that SCC was negatively correlated with interview rated psychotic like experiences at high levels of ASI, and confirmed that this interaction was only true in the case of positive schizotypy, and not in relation to negative schizotypy. This is what would be predicted by aberrant salience theory, which gives salience dysregulation a role in positive symptoms, but not in negative symptoms (Cicero et al., 2015).

2.3.4 Factor Two: The Jumping to Conclusions Bias
Recent psychological models of psychosis have suggested that anomalous experiences alone are insufficient to account for psychosis (Bell et al., 2007; Coltheart et al., 2011), and that a second factor is required. This second factor is posited to be some deficit in reasoning ability (as opposed to the single factor model of Maher, 1974, who specifically argued that normal reasoning processes could lead to delusional beliefs), which differs systematically from normal reasoning. Human reasoning under conditions of uncertainty is known to be suboptimal across multiple domains among normal individuals and even "experts" (see Kahneman, 2011 for a review). This makes it complicated to define "healthy" and "pathological" reasoning, and Huq et al. (1988) even suggest that the reasoning process manifested by people with delusions could even be closer to being "optimal" (as defined by Bayesian estimates of probability) than people without. Nonetheless, a tendency to draw inferences in a way that systematically differs from

normal, and which gave rise to delusions, could be considered pathological in virtue of its role in causing psychotic symptomatology. One candidate which has been proposed is a systematic disposition to draw conclusions more quickly than non-delusional individuals, a tendency which Bentall (2004) describes as "epistemological impulsiveness" and which has come to be called the "jumping to conclusions bias" (Garety et al. 1991; Freeman and Garety, 2014).

The use of a reasoning task to investigate a "jumping to conclusions bias" was introduced into the literature on psychosis by Huq et al. (1988) who compared the performance of 15 individuals diagnosed with schizophrenia and experiencing delusions, with 10 non-deluded patient controls, and 15 individuals with no psychiatric diagnosis on the "beads task". In this version of the task, participants were presented with two jars. One jar contained 85 green beads and 15 pink beads; the other had the same proportions but the colors inverted (85 pink, 15 green). Beads were then "drawn" from the jars as though at random and shown to participants in a sequence, which the researchers had actually predetermined. In the simplest condition of the task, participants were required to decide which jar they thought the beads were coming from, but could "draw" as many beads as they wished before they decided. Three other conditions were also included; requiring participants to rate the probability of a particular color being next (condition 2), rate the probability that a given bead came from a particular jar (condition 3), and a combination of both of these latter (condition 4). The dependent variable was the number of beads drawn before the jar was decided upon ("draws to decision"). The "deluded" group in this study showed an average of 1.22 "draws to decision", while controls had an average of 2.60. This group difference was significant.

This study introduced the notion of a specific deficit in the evaluation of evidence to form beliefs. Huq et al. (1988) concluded that delusions could be formulated as a failure of Bayesian

belief updating, with participants demonstrating insufficient caution before drawing a conclusion. The precise nature of the JTC bias remains somewhat controversial, with various accounts of whether the demonstrable difference between delusional and non-delusional individuals on the "beads task" is best considered to arise from a deficit in memory (i.e. a difficulty holding information about multiple beads in mind and so "giving up" more quickly), a greater "need for closure", or even from a tendency to imbue each piece of information (i.e. each bead) with a greater sense of significance, and thereby reach a conclusion more quickly (Fine et al. 2007). Another important issue is whether performance on the beads task is indicative of an underlying bias in evidential reasoning (as proponents have claimed), or a result of the diverse range of cognitive deficits present in schizophrenia.

Huq et al. (1988) did not check for the potential confound of behavioral impulsivity, though they did compare delusional subjects to psychiatric controls, to control for non-delusion specific cognitive deficits that may be associated with mental illness. Subsequent examinations of JTC and impulsivity have tended to suggest it does not account for performance on the beads task.

Dudley et al. (1997) administered two versions of the beads task (the original 85:15 version and a harder 60:40 version) to three groups: patients with delusions, patients with depression and healthy controls. They found that, although the delusions group still drew fewer beads than the other groups across conditions (replicating previous work), they also drew significantly more beads on the harder version (finding later replicated by Garety et al. 2013). Dudley et al. took this to suggest that the delusion group was demonstrating a data gathering bias rather than simply acting impulsively by responding after a set number of beads. This result speaks against the suggestion that impulsivity drives the JTC effect, but it does not rule out the

possibility; it may be that the extra difficulty of the 60:40 version counteracts some degree of impulsivity in individuals with delusions, but that this is still what drives the effect. More compellingly, Lunt et al. (2012) administered the beads task to a group of individuals with frontal lobe damage, a group with ADHD and a group of healthy controls. Although the frontal lobe damage group demonstrated a data gathering bias relative to the other two groups, the ADHD group did not differ from the healthy controls, a finding which Lunt et al. took to suggest that impulsivity is unrelated to the data gathering bias. Furthermore in a factor analysis which examined various social and neurocognitive tasks in psychosis, van Hooren et al. (2008) found performance on the beads task to be correlated only weakly with performance on the Trail Making Task (r=0.19), but not correlated with the Stroop test or semantic fluency.

2.3.5. JTC in People with delusions

Since Huq et al.'s initial study, the presence of a JTC bias in samples of people with delusions has been replicated multiple times and been subject to a number of reviews (e.g. Garety and Freeman, 1999; Freeman and Garety, 2014). The dependent variable in the task has increasingly been dichotomously defined in the terms of the presence or absence of a JTC-bias, defined by the selection of two beads or fewer before making a decision. In a systematic review of the literature on persecutory delusions Freeman (2007) suggested that the unusual robustness of the effect across 10 reviewed studies made the JTC bias a rare phenomenon in the context of psychosis research.

Fine et al. (2007) conducted several meta-analyses to test competing explanations of the JTC bias, and determined that comparisons between schizophrenic groups with and without delusions suggest a reliable association with this positive symptom. This suggests that the bias cannot be accounted for simply in terms of being an "epiphenomenon" of the neurocognitive deficits (i.e. vigilance, sustained attention, Green, 2001) which are associated with

schizophrenia. Specifically, Fine et al. concluded that the 12 studies they analyzed supported the theory that a JTC bias is driven by a tendency to make a decision on the basis of less evidence, rather than a tendency to ignore disconfirmatory evidence. Studies which specifically examined the use of disconfirmatory evidence (i.e. sequencing beads so that they suggested one jar initially and then a different jar, making it rational to change one's mind) found that delusional individuals expressed significantly greater uncertainty than non-delusional individuals under such circumstances. Thus, it is not that delusional individuals are more stubborn about their conclusions, but rather they are quicker to draw them. Fine and colleagues also tested the suggestion that, rather than being a causal factor in the generation of delusional beliefs, the JTC bias might be a result of general cognitive deficits associated with schizophrenia. They aggregated the results of studies which compared schizophrenia patients with and without delusions, and which examined the bias in a group with delusional disorder vs. psychiatric controls. These approaches control for the possibility that the bias might be an epiphenomenon of schizophrenia per se by ensuring that the difference between control and experimental groups is limited to the presence of delusions and does not also include broad cognitive deficits. If a JTC bias were an epiphenomenon of psychosis per se, this specific association with delusions would not be expected, hence Fine et al. rule out what they call the "strong epiphenomenon hypothesis" ("that the JTC effect is purely a consequence of schizophrenic symptomatology unrelated to the presence of delusions per se"). However, they were not able to rule out what they call the "weak epiphenomenon hypothesis", that schizophrenic symptomatology makes a contribution to the presence of the JTC bias, because they found the effect to be stronger in deluded participants diagnosed with schizophrenia than in non-deluded, schizophrenia-diagnosed controls.

A recent meta-analysis (Malcolm-Ross et al. 2015) found slightly less encouraging results in terms of strength of the JTC bias in people with clinically significant delusions compared to healthy controls. These authors examined all studies in which the Jumping to conclusions bias had been used in samples which were also assessed with the Peters Delusions Inventory PDI; Peters et al., 1999). The authors found that the association between the bias (operationalized by a smaller number of "draws to decision") and a high score on the PDI is robust but small (Cohen's d = 0.03). The effect was most stable among the subgroup of studies that had examined it in non-clinical samples. When they took the subgroup of studies which had examined the bias in people with current delusions, the aggregated effect was not significant. This study has been the first to suggest that the association between the JTC bias and delusions is not as strong as has been thought. However, two important caveats should be noted about this result. First, Malcolm-Ross and colleagues suggest that their result could be due to the low statistical power of subgroup analysis. Second, by only examining studies which have deployed the PDI, Malcolm-Ross and colleagues exclude a number of studies such as Huq et al. (1988) and Garety et al. (1991) which first established the presence of the effect among delusion positive samples. A planned systematic review and meta-analysis of all JTC like tasks (Taylor et al. 2014) will better reveal the extent of any effect.

2.3.6. JTC in at Risk States

To date only one study has examined the jumping to conclusions bias in a sample of people clinically assessed as being "at risk" for psychosis, a group which may be critical for understanding how psychotic symptoms first emerge. Broome et al. (2007) administered three versions of the task (an "easy" one with an 85:15 ratio of beads; a harder version, with a 60:40 ratio and a hardest version with three jars, with ratios of 44:28:28) to 35 individuals with an "at risk mental state" (ARMS) and 23 healthy controls. They found that draws to decision among the

ARMS averaged 8.5, compared to 13.4 in the controls on the 60:40 version of the task and 12.5 compared to 17.5 on the 44:28:28 version. These differences were significant. However, unlike the majority of studies which have examined the phenomenon in people with full blown delusional states, they did not find a significant effect for the 85:15 version[4]. The authors suggest this may be due to the 60:40 version being harder, and therefore more sensitive to the presence of an attenuated version of the JTC bias in groups of people who have not developed full-blown symptoms. It may also be a result of the fact that Broome et al.'s experimental group was defined in terms of individuals meeting criteria for an "at risk mental state" and not in terms of the presence of delusion-like experiences per se (thus diluting the effect in an essentially heterogeneous group). Nonetheless this result points to the presence of a JTC bias in people who are at risk of developing psychosis, a finding which ought to be replicated in a larger sample. Furthermore, while Broome et al.'s study can be taken as tentative evidence for the presence of a reasoning deficit in people at risk of developing psychosis, it does not examine how this putative factor might interact with other factors to produce full-blown psychotic symptoms. Thus further research is required to confirm the presence of a JTC bias alongside attenuated psychotic symptoms, and to clarify what the role of this bias might be in concert with other factors that are postulated to contribute to psychosis.

2.3.7. Sensitivity and the "beads task"

Multiple versions of the beads task appear in the literature, with the most frequently varying element being the ratio of the differently colored beads. The original task used a ratio of 85:15, though this is now commonly referred to as the "easy" version of the task, with a 60:40

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[4] The authors do not state whether the order of these tasks was counterbalanced. This raises the possibility of task-sequencing effects such that performance on one of the "versions" of the task is systematically altered in virtue of having been preceded by practice on the other.

ratio regarded as a more difficult task. The results of Broome et al. (2007), who found a group difference between "at risk" individuals and controls on the hard version but not the easy, suggest that the "easy" 85:15 version of the Jumping to Conclusions task may be insufficiently sensitive to differences between two groups not actively experiencing delusions. This makes it important to include an easy version in the proposed study, which focuses on a sample that closely resembles Broome et al.'s.

2.4. Aberrant Salience and Jumping to Conclusions as distinct "factors":
Cognition is known to be altered in psychosis, with numerous studies and multiple reviews confirming the presence of a range of deficits in populations with schizophrenia (Fioravanti et al., 2005; Fatouros-Bergman et al., 2014), and in individuals at clinical "high risk" (Bora et al., 2014). These deficits range across the domains of perception (Green et al., 2011); working memory (Lee & Park, 2005); attention and vigilance (Elvevåg et al., 2000) and executive function (Fioravanti et al., 2005).

Whether aberrant salience and the JTC bias can be viewed as distinct constructs, and thus as good candidates for the "first" and "second" factors of Coltheart et al.'s (2011) model, depends on whether performance on tasks which set out to measure them can be shown not to result from such cognitive deficits. Furthermore, it is theoretically important to show that aberrant salience and the JTC bias themselves are distinct cognitive processes rather than merely epiphenomena of the same underlying process.

In terms of the first question, the JTC bias has been examined in the context of several neurocognitive processes, with a strong suggestion that memory deficits play a role in the bias. Garety et al. (2013) performed the largest study of this nature, and found that the JTC bias is associated with poorer working memory, a finding which was also present in Broome et al.

(2007). Additionally, when Menon et al. (2006) performed a version of the beads task in which each drawn bead remained visible as a memory aid to the participant, no difference was found between deluded and non-deluded patients with schizophrenia. No other cognitive deficit has been reliably associated with the beads task, though the role of impulsivity has been examined (see above) and executive functioning (as measured by rule-extraction tasks) has been shown in one study to be associated with beads task performance (Garety et al., 2013).

Aberrant Salience has been less widely assessed than the JTC bias. In theory this experience ought to be expected to arise not from a disrupted neurocognitive impairment, but from a disorder of neuromodulation (i.e. the "mood" which is bestowed on subjective experience, Kapur, 2003). However, the experimental assessment of aberrant salience (the SAT) draws on processes of memory, attention and inhibitory control, and so differences in performance between psychosis and non-psychosis groups are vulnerable to confounding by these cognitive factors. Schmidt and Roiser (2009) assessed the divergent validity of the SAT by administering it concurrently with measures of working memory, IQ, probabilistic reward learning, learned irrelevance and sensitivity to probability. They performed a factor analysis with variables from all these measures and discerned five distinct factors; "operant/explicit learning", "general cognitive ability", "cognitive speeding", "implicit aberrant salience" and "attentional vigilance". Schmidt and Roiser took the emergence of a distinct "implicit aberrant salience" factor to be particularly strong evidence of good construct validity, and also found that measures of working memory and IQ loaded onto separate factors from their outcome variables of interest from the SAT. In subsequent studies, Roiser and colleagues have administered the SAT and in one study found only explicit adaptive salience to be positively correlated with a proxy measure of IQ (the Weschler Adult Reading Test) and the forwards and backwards versions of the digit

span task (Roiser et al, 2009). In a second study, no such correlations were found, leading Roiser at al. (2013) to conclude, "elevated aberrant salience scores in UHR individuals were unlikely to be secondary to some general cognitive deficit" (p.1331).

In terms of the second question, several lines of evidence tentatively suggest that the aberrant salience and the JTC bias can be viewed as distinct constructs: a. It has been shown that pharmacological treatments which impact on dopamine functioning (and thus should also impact on salience regulation) do not impact on the JTC bias. b. Studies which have examined the JTC bias in detail have not found evidence to suggest that the JTC bias is driven by dysregulated salience and c. Studies which have compared the JTC bias across multiple "levels" of delusional ideation.

2.4.1. Pharmacological Studies

The two components of psychosis described above have started to be examined together. Andreou et al. (2013) performed a randomized double blind trial in which 36 healthy participants (age 18-40) with no history of mental illness or treatment with psychotropic drugs were divided into three groups and administered L-DOPA (a promoter of dopamine synthesis), Haloperidol (a drug which blocks the impact of dopamine by occupying receptors) or a Placebo. Using a double dummy experimental design to ensure testing began at the maximum serum concentration for each drug, experimenters gave participants a version of the beads task (the fish in lakes version) and a procedure that tested their confidence for memories. There was no impact of dopamine related substance on draws to decision. However, participants administered Haloperidol showed significantly less overconfidence than either the L-DOPA or placebo groups on incorrect responses to the false memory task. The authors suggest that this could be due to the separation of two factors, aberrant salience and JTC-bias, and that it is plausible that these would interact to

give rise to delusional beliefs. Like Broome et al. (2007), the authors suggest that the 60: 40 beads task is better than the 85:15 version for discriminating among healthy subjects.

There is evidence that antipsychotic treatment (which has been theoretically and experimentally linked to aberrant salience) does not reduce the JTC bias, suggesting that this component of delusional belief can be considered distinct, and potentially trait-like. Peters and Garety (2006), and So et al. (2012) conducted longitudinal studies in which the beads task was administered over multiple time points during a study of treatments. In these studies a JTC bias was found to be consistent, even while other measures of delusional intensity, and delusion related distress declined. This raises the possibility that antipsychotic medications act on a distinct "factor" in terms of their action on delusions Additionally, Menon et al. (2008) found that the presence of a JTC bias on an emotionally salient version of the task (in which individuals "draw" adjectives to form a conclusion about whether they describe the self or another person) moderates the effectiveness of antipsychotic treatment. Individuals who demonstrated the bias showed less improvement in positive symptoms over time. Menon et al. suggest that this result is consistent with the hypothesis that the JTC bias represents a distinct risk factor for delusions. However, this result was not found in a neutral (beads) version of the task. Their use of an emotionally salient version of the task potentially blurs the boundary between a cognitive "reasoning" factor and an emotionally-salient factor. Menon et al. may be measuring something other than "jumping to conclusions" reasoning per se. That they did not break down their results into different types of positive symptom and still found a moderating relationship provides tentative support for the role of some form of "jumping to conclusions" bias in all positive psychotic symptoms.

2.4.2. Detailed studies

In their meta-analysis examining the details of the JTC bias in psychosis, Fine et al.

(2007) considered the hypothesis that the JTC bias could be driven by emotional salience, i.e.

that the tendency to make fewer "draws to decision" could result from each draw being imbued

with heightened salience, and therefore feeling subjectively more important in determining

which jar it came from. They found that studies which had made beads (or, more frequently the

bead-equivalents in tasks which were superficially different, but structurally analogous to the

beads task) more emotionally salient did not exacerbate the strength of the difference in JTC bias

between delusional and non-delusional groups. They concluded that Kapur's aberrant salience

hypothesis could not explain the JTC bias, which presumably results from another psychological

mechanism unrelated to salience regulation. This finding supports the view that aberrant salience

and a JTC bias can be regarded as distinct factors.

2.4.3. Testing JTC across different "levels" of delusions

To date five studies have taken the approach of comparing the bias across more than two

levels of delusion (typically two "healthy" groups scoring "high" and "low" on a measure of

delusion proneness, and a clinical group with a diagnosis of a delusional disorder. Results have

been mixed. Van Dael et al. (2006) compared four groups of increasing risk; 40 patients with

schizophrenia diagnoses and delusions, 40 first-degree relatives, 41 "psychosis prone"

individuals and 53 healthy controls. The researchers defined the JTC bias as drawing just one

bead before making a decision. They observed a linear trend with increasing levels of psychosis

risk associated with an increasing percentage of participants showing the bias. They concluded

that there was a dose-response relationship between delusional intensity and level of JTC-bias.

Balzan et al. (2012) found a similar stepped increase over three groups of increasing risk.

However, three studies have found results which support a different interpretation. Warmans et al. (2007); Freeman et al. (2010) and Ho Wai So and Kwok (2015) all stratified participants into three groups, and found that the JTC bias was less prevalent among the "middle" group (delusion prone) than among the healthy controls. This pattern of results suggests that there may not be a straightforward linear relationship between increasing levels of delusional intensity and the jumping to conclusions bias. One potential explanation for this is that while the presence of a first factor may be sufficient to elevate a person's "delusion proneness", the presence of a second factor (i.e. a data-gathering bias) is required for the delusion to attain the full intensity required to cross over into clinical relevance. Under such circumstances we might expect "delusion-prone" individuals to manifest normal, or even enhanced inferential abilities. Such intact inferential capacity could act as protective; ensuring that people who are delusion prone in virtue of the presence of a first factor do not become fully delusional. This offers a potential hypothesis for the relationship between aberrant salience and JTC as interacting components of clinically significant delusions. If the absence of a second factor distinguishes clinical delusions from at risk states then we might expect to see a pattern where a candidate second factor (in this case JTC) moderates the relationship between a candidate first factor (in this case AS) such that an association between AS and clinically significant delusional ideation is present only when a JTC bias is also present.

2.5. Predictions and Hypotheses

The research and theory which has been reviewed here suggests that both aberrant salience and a "jumping to conclusions" bias may play a role in attenuated psychotic symptoms. These have never been investigated thoroughly in the context of the same study. Roiser et al. (2009) did include an "easy" 60:40 version of the beads task in their examination of the SAT, finding no association between experimentally assessed aberrant salience and a jumping to

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conclusions bias. However, their study also failed to replicate the well-established JTC bias in schizophrenia patients relative to controls, so it could be that their small sample size lacked the power to detect such an effect. It thus remains unknown precisely in what manner aberrant salience and hasty decision-making might be expected to relate to psychotic symptomatology as distinctive "factors" in a multifactorial process.

Previous research suggests that aberrant salience and the JTC bias are both associated with attenuated psychotic symptoms, with the JTC bias also associated more specifically with delusions (Garety et al., 2013), and with "delusional intensity" in an "at risk" group (Broome et al., 2007). Thus the simplest possible outcome of the present study is that these two variables make an independent contribution to psychotic symptoms, i.e. both aberrant salience and the JTC bias will be associated with a high level of attenuated positive psychotic symptoms, but aberrant salience and JTC will not be correlated with each other.

However, the two factor theory would predict that aberrant salience and the JTC bias could interact with one another such that the contribution of aberrant salience will be necessary but not sufficient to generate attenuated psychotic symptoms. Thus the association between aberrant salience and attenuated psychotic symptoms would be expected to be stronger under conditions where the jumping to conclusions bias is also present than when it is not. The stability of performance on non-emotionally salient versions of the beads task, combined with its apparent immunity to antipsychotic treatment, suggests the possibility that the jumping to conclusions bias is a trait-like feature of reasoning in comparison to the more state like experience of aberrant salience, thought to be influenced by dynamic changes in neuromodulation.

These alterative possible relationships give rise to the following specific predictions and hypotheses:

HYP 1: Individuals who display a high number of attenuated positive psychotic symptoms will demonstrate a high degree of aberrant salience and a "jumping to conclusions" bias relative to control participants who display a lower number of such symptoms.

HYP 2: Individuals high in attenuated psychotic symptoms will show greater levels of aberrant salience, but this will be moderated by a "jumping to conclusions" style of reasoning, such that the positive association between high aberrant salience and attenuated psychotic symptoms will be stronger for individuals with high levels of JTC than individuals with low levels of JTC.

Chapter 3: Method

3.1. Overview

      The present study was a quasi-experimental, between group procedure, comparing the performance of a "high PQ" group and a "low PQ" group (see below for definitions of these groups) on measures of aberrant salience and jumping to conclusions bias. To control for the possibility that behavioral measures of aberrant salience are confounded by a difficulty with cognitive fluidity and task switching, the Trail Making Task was also administered.

3.2. Participants

      The Prodromal Questionnaire (PQ) had been administered to a large sample of undergraduates as part of an ongoing longitudinal study examining distressing attenuated positive psychotic symptoms (DAPPS) in the context of a range of social and demographic factors. The PQ provides a continuous outcome variable (the absolute number of attenuated symptoms endorsed), but his sample can also be separated into two groups; one of "high" scoring and one of low scoring individuals on the PQ. Conventions have not been established for determining how to divide samples using this measure, but a sensitivity and specificity analysis performed by Loewy et al. (2005) suggested that endorsing 8 items or predicted at risk status with 90% sensitivity and 49% specificity. Thus the "high" scoring group in the current study was defined in terms of anyone endorsing 8 or more distressing positive symptom items. The "low" scoring group was defined in terms of anyone endorsing fewer items than the sample mean PQ-items endorsed. 32 participants were recruited from the former group and 30 from the latter.

3.3. Materials

3.3.1. Aberrant Salience Inventory (ASI)

      The Aberrant Salience inventory is a 29-item measure which assesses subjective experiences of aberrant salience attribution. Cicero et al. (2010) reported good overall internal

consistency for their scale (Cronbach's alpha = 0.89) and, in terms of construct validity, found positive correlations with other psychotic-like experiences scales; the Magical Ideation Scale (r=0.55), the Perceptual Aberration Scale (r=0.47), the Referential Thinking Scale (r=0.41). In contrast to these convergences, Cicero et al. found a relatively low correlation between their measure and the Social Anhedonia Scale (r=0.17) which they took to indicate that the ASI also demonstrated good divergent validity. Further construct validation was pursued by dividing participants into high and low groups on existing psychosis proneness measures (the Magical Ideation Scale or the Perceptual Aberration Scale) to determine whether membership of a psychosis proneness group, defined by high scoring on these, also predicted ASI scores. They found that the psychosis proneness group had far higher scores on the ASI than either a healthy control group, or a "social anhedonia" group (defined by high scores on a measure of non-positive schizotypal symptomatology). Every affirmative answer on the ASI added a 9% increase in the odds of being in the psychosis proneness group. Cicero et al. derived 5 factors from the ASI, which they labeled Increased Significance (e.g. item 10: "Do you ever feel the need to make sense of seemingly random situations or occurrences?"); Senses Sharpening (e.g. item 12: "Do you sometimes feel that you can hear with a greater clarity?"); Impending Understanding (e.g. item 17: "Do you sometimes feel like you are on the verge of figuring out something really big or important, but you aren't sure what it is?"); Heightened Emotionality (e.g. item 20: "Do you go through periods in which you feel overstimulated by things or experiences that are normally manageable?"), and Heightened Cognition (e.g. item 25: "Do you sometimes feel like the world is changing and you are searching for an explanation?").

The ASI yields a total score out of 29 (a higher score corresponds to greater degree of aberrant salience) derived from yes/no responses to 29 statements. The current study confirmed the high internal consistency of this measure (Cronbach's alpha=0.91).

3.3.2. Salience Attribution Test (SAT)

The SAT (Roiser, 2009, Schmidt and Roiser, 2009) is an implicit learning paradigm in which participants are shown a series of trials. In each trial a fixation cross appears briefly, followed by an image at the top and bottom of the screen. The images they see are of household objects or of animals, and they can be blue or red, providing four "dimensions" (red; blue; household object; animal) which will be the "task relevant" dimension on any given trial. The images stay on screen, but after a variable time delay (between 1000 and 2000 milliseconds) a probe image (a black square) appears (for a variable time, clustering around a mean times which is equal to participants' average reaction time during a brief preliminary practice trial), upon which participants have to press a single response key ("space") as quickly as possible. They are told in advance that on some portion of the trials there is a financial reward for this response, and that this will vary with the speed with which they can make it, but they are not told on which trials this financial reward occurs. In Roiser et al.'s original version, this financial reward accrues to a real payment given to participants at the end of the test. Local ethics considerations mean that in the present study participants were told that they were accruing a reward, but in reality they were given the same (maximally possible) amount of $20 for participation. In any given block of the experiment (each participant completes two blocks of 64 trials), one of these dimensions (e.g. "red") is financially rewarded 87.5% of the time while the other (e.g. "blue") is rewarded 12.5% of the time. The dimension being rewarded varies from block to block. Participants' reaction times in response to the black-square probe are recorded. The expectation

is that participants learn implicitly which dimension (e.g. "redness") is being rewarded and show a faster response to "task-relevant" (e.g. red) objects during that block.

At the end of each block, participants are asked to use a sliding scale to rate the percentage likelihood of a reward for each different type of object (i.e. they are asked "on what percentage of trials were you rewarded for blue objects/red objects/animals/household objects?") They are given a sliding scale for each to rate the likelihood, this scale yields a continuous outcome measure of 1-100.

The Salience Attribution Test thus yields two forms of data, implicit (reaction time) data, and explicit (visual analogue scale) data. These in turn are used to calculate four outcome variables on which groups can be compared:

1. Implicit (Reaction Time) adaptive salience. This is attained by calculating the absolute difference in reaction time between rewarded and non-rewarded trials. Roiser et al. (2009) do not report a normative optimal "score", but if a significant difference arises between groups on this variable, it is indicative that (a) group(s) with a lower degree of implicit adaptive salience is not relatively "speeding" toward the financially rewarded trials as much as (an)other group(s).

2. Explicit (sliding scale-rating) adaptive salience. This variable is derived in a very similar way to implicit adaptive salience, by calculating the absolute difference in percentage ratings (as opposed to reaction times) given on the visual analogue scale between rewarded and non-rewarded trials. As with implicit adaptive salience, it allows for groups to be compared in terms of their sense of which dimension of objects came to have a "significant" feeling through their association with reward, but instead of being measured through "speeding" in reaction times, is measured through subjective judgments of how often rewards were provided.

3. Implicit (Reaction Time) aberrant salience. This variable is the putatively pathological counterpart to implicit adaptive salience, representing instead the tendency to assign salience inappropriately to objects. It is attained by calculating the difference in average reaction times between the different non-rewarded trials, which ought to be approximately equal. If a positive value is found for the difference in reaction times between types of non-rewarded domain (i.e. if the person shows a specific pattern of speeding to "household" objects vs. "animals" on trials where a color, "redness", or "blueness" is being rewarded) then aberrant salience can be said to be present. Groups can then be compared in terms of the degree of aberrant salience they demonstrate relative to comparison groups.

4. Explicit (sliding scale) aberrant salience. This variable is derived in a directly analogous way to implicit aberrant salience, by calculating any absolute positive difference between levels of the task-irrelevant stimuli. (i.e. does a participant person rate "blue" as more highly likely to be rewarded than "red" when in fact neither is rewarded for that block?) However, unlike implicit aberrant salience, which is derived by calculating any difference between reaction times, explicit aberrant salience is obtained by examining differences between visual analogue scale ratings given by participants to these task-irrelevant stimuli at the end of each block.

Roiser et al. (2009) did not find any significant group differences in reaction time between controls and medicated schizophrenia patients, though there was a non-significant trend in this direction. This finding suggests that a group difference in reaction time is unlikely in the case of a less severe psychological disorder.

3.3.3. Jumping to Conclusions Bias (The "Beads Task")

In order to examine the presence of a hasty inferential style (or a "jumping to conclusions bias"), in the present study participants completed the easy and difficult versions of the computerized beads task (Garety et al., 2013). Participants are shown a picture of two jars containing 85 beads of one color and 15 of another (easy version) or 60 of one color and 40 of the other (difficult version). They are then told that one of the jars has been chosen at random and that now beads are going to be drawn from it. Each bead will be replaced, so the proportions will remain the same. Participants are told that their job is to decide which jar the beads are coming from, and that they can see as many beads as they like before deciding. As beads are shown, the previously drawn sequence of beads is also visible at the bottom of the page to act as a memory aid. Following most studies using this measure, the presence of a JTC bias was defined by requesting two or fewer beads. To control for potentially confounding practice effects, the order of presentation of difficult and easy versions was counterbalanced within groups in the present study.

3.3.4. Prodromal Questionnaire (PQ)

A range of psychometric and structured clinical interview measures exist to diagnose high risk states, many of which were developed to facilitate enhanced clinical care of this population. However, as Loewy et al. (2005) note, these have often been time consuming to deploy, and have limited the speed with which new research can be produced. In order to address this, Loewy and colleagues developed a 92-item self-report scale, the Prodromal Questionnaire (PQ), adapting questions from existing measures of schizotypy, and structured clinical interviews for high risk states (the PQ is regarded as having "descended from" Raine's, 1991, Schizotypal Personality Questionnaire and McGlashan et al.'s, 2010, SIPS, by having integrated information from these measures, Daneault et al., 2013). 113 participants completed the PQ and the Structured Interview for Prodromal Syndromes (SIPS). It was found that the positive symptom

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subscale successfully predicted the presence of a SIPS-diagnosed prodromal syndrome, suggesting that the PQ has convergent validity with a "gold standard" (Loewy et al., 2005) diagnostic instrument. On the basis of these results, Loewy et al. concluded that the presence of 8 or more "attenuated positive psychotic symptoms" (APPS) on the PQ was a sensitive measure of "high risk" state. Subsequent work has yielded a briefer version of the PQ (Loewy et al. 2011), and this has been subsequently shown to also have good sensitivity in follow up studies (Kline et al., 2015).

3.3.5. Trail Making Task

Participants completed the Trail Making Task from the Delis-Kaplan Executive-Function System (DKEFS, Delis et al., 2001) to control for the possibility that performance on the SAT is a function of an individual's capacity for task switching. Participants completed a number of different conditions. In condition 2, participants trace a pencil line as quickly as possible connecting 16 circles labelled one to 16 while ignoring distractors. In condition 3 participants trace a pencil line as quickly as possible connecting 16 circles labelled A to P while ignoring distractors. In condition 5, participants follow a similar procedure, tracing a line to join circles in a sequential order, but are required to switch between circles labelled with letters and circles labelled with numbers. It has been shown that the TMT provides a valid index of an individual's capacity to deploy executive functioning in the service of task switching (Arbuthnott and Frank, 2000).

3.4. Procedure

Data collected as part of an ongoing study of distressing attenuated positive psychotic symptoms (DAPPS) were reviewed. Participants who fell into the "low" and "high" PQ-defined groups (see section on participants, above) were contacted by phone to participate in an experimental procedure. Participants were briefed and asked to sign a consent form. They then

completed the Salience Attribution Test on a computer, the Trail Making Task, and a computerized version of the beads task. The entire procedure took around 90 minutes to complete. The Salience Attribution Test included a tutorial element, with three short blocks of learning trials (following the instructions provided by Roiser et al., 2009) to prepare participants for the task.

3.5. Data Analysis: Testing the Hypotheses

HYP 1: Individuals who display a high number of attenuated positive psychotic symptoms/high levels of delusional ideation will demonstrate a high degree of aberrant salience and a "jumping to conclusions" bias relative to control participants who display a lower number of such symptoms.

HYP 2: There will be a positive association between aberrant salience and attenuated psychotic symptoms, and this will be moderated by a "jumping to conclusions" style of reasoning, such that individuals with high levels of JTC will show an association between high aberrant salience and attenuated psychotic symptoms. Individuals with low levels of JTC will show less of an association between aberrant salience and attenuated psychotic symptoms.

To test these hypotheses participants in the "high" and "low" scoring group on the PQ and were compared in terms of their scores on the measures of aberrant salience and jumping to conclusions. Multiple t-tests allowed the comparison of these two groups on the main variables of interest. Logistic regression allowed for the investigation of the contribution of the main variables for predicting membership of the low and the high groups, and also for the examination of any potential interaction between aberrant salience and jumping to conclusions.

Chapter 4: Results

This study sought to examine the relationship between aberrant salience, a probabilistic reasoning ("jumping to conclusions") bias, and the presence of distressing attenuated positive psychotic symptoms (DAPPS). Specifically, it sought to examine whether there is a relationship between salience processing and attenuated positive psychotic symptoms and whether that association is moderated by a hasty reasoning style, such that the aberrant salience-DAPPS association is stronger when there is evidence of hastier style of reasoning.

4.1. Preliminary Analyses

4.1.1. Demographic Characteristics of the sample

Sixty-two undergraduate males and females aged 18 to 35 years participated in this study. This was a sample of racial/ethnic minorities that was predominately Asian and Hispanic, with a higher proportion of female than male participants. Just over 16% of the sample reported an ethnic background other than Asian, Black or Hispanic. This approximately reflects the demographic makeup of the urban public school system from which the sample was recruited.

Participants were recruited from a larger ongoing study and screened based on how many Distressing Attenuated Positive Psychotic Symptoms (DAPPS) they endorsed on the Prodromal Questionnaire (PQ) in that dataset. Individuals who endorsed four or fewer DAPPS were considered "low" scorers. Individuals who scored eight or more DAPPS were considered "high" scorers. There were initially 32 low PQ scorers recruited, and 30 high PQ scorers recruited to the present study.

Due to a problem with the computer program that ran the SAT, response times of 16/62 participants were only partially recorded, substantially biasing SAT data for these participants. This left a sample of 46 participants for whom full data were available. Because of the extent of SAT data lost, it was regarded as safer to exclude these participants altogether from analyses that

required this information, rather than impute missing data. As can be seen in Table. 1. the sample

for whom full SAT data was not available was demographically similar to the original group.

However Hispanic students were over-represented among those who were missing. It is not clear

why this is.

Table 1-Demographic Characteristics of the sample, including those with SAT data, compared with those missing SAT data.

	Sample with SAT data (N=46)	Group Missing SAT data (N=16)	Original Overall Sample (N=62)
Age Mean (SD) min-max	20.7 (3.4) 18-35	20.63 (2.94)	20.5 (3.33) 18-35
Male	21 (45.7%)	6 (37.5%)	27 (43.5%)
Female	25 (54.3%)	10 (62.5%)	35 (56.5%)
Race/Ethnicity N (%)			
Hispanic	16 (34.8%)	11 (68.75%)	27 (43.5%)
Black	8 (17.4%)	2 (12.5%)	10 (16.1%)
Asian	14 (30.4%)	2 (12.5%)	16 (25.8%)
Other	8 (17.4%)	1 (6.25%)	9 (14.5%)

4.1.2. Clinical characteristics of the sample

4.1.2.1. DAPPS and total "PQ Positive" score:
        This section presents detailed data about the average number of DAPPS endorsed by the

low and high PQ groups. In this study, a cut score of 4 or fewer was used to determine the low

group, and 8 or more was used to determine the high group. These scores are based specifically

on the number of distressing positive symptoms endorsed by participants. In the table below,

data are also provided on the mean total number of positive symptoms endorsed altogether ("total PQ positive), to provide further information about how many attenuated positive psychotic experiences (including those that were not identified as distressing) were reported by each group.

Table 2-Total number of DAPPS, and total number of attenuated positive psychotic symptoms (APPS) endorsed by the High and Low groups:

	High (n=32)	Low (n=30)
Mean Total DAPPS (SD)	10.03 (5.5)	2.86 (4.19)
Mean Total Positive PQ (SD)	37.63 (22.45)	18.41 (19.63)

4.1.2.2. PQ/RT correlation and group TMT comparison

Dividing a sample based on a putative clinical characteristic raises the possibility of results being confounded by a systematic difference other than the variable of interest. It may be that a group that is elevated in terms of a clinical variable (in this case attenuated positive psychotic symptoms) is also different in terms of their overall reaction times, or in terms of their capacity to rapidly switch set. As these variables are potential confounds for the current study, they were examined prior to the main analyses.

Any systematic difference in reaction times, with the High group performing more slowly than the Low, might represent a confound in a measure involving group comparisons based on reaction time data. Bivariate Pearson correlations were conducted to assess whether slower reaction times to high validity SAT items was associated with higher levels of total attenuated positive symptoms, or with distressing attenuated positive symptoms. These analyses revealed extremely small correlations with none coming close to significance. Participants reporting

higher rates of attenuated positive symptomatology did not show any tendency to respond less quickly to high validity items than those reporting lower rates. These results are displayed in table. 3.

Table 3-Bivariate Pearson correlations between block 1 and block 2 reaction times, and Total number of DAPPS, and total number of attenuated positive psychotic symptoms (APPS):

	Total Attenuated Positive Psychotic Symptoms	*Distressing Attenuated Positive Psychotic Symptoms*
Block 1	*r=-0.105, n=46, p=0.489*	*r=0.108, n=46, p = 0.474*
Block 2	*r=-0.154, n=46, p=0.306*	*r=0.03, n=46, p = 0.842*

The SAT involves the capacity to switch effectively from responding to one rewarded stimulus in Block 1 to a new rewarded stimulus in Block 2. A specific cognitive deficit in the capacity to switch sets would thus present a potential confound. To control for this, High and Low groups were compared on their performance on Trail Making Test number 4 in the Delis–Kaplan Executive Function System (D-KEFS) battery. This specific subtest assesses for an individual's capacity to rapidly switch sets. No significant differences were found between low and high groups (67.8s and 58.23s respectively) in terms of their performance on Trail Making test (t [45]=1.35, p=0.18), suggesting that the groups' capacity to deploy executive functioning skills to shift set was not a confound for any group differences in terms of the SAT.

4.1.3. Descriptive data

4.1.3.1. Descriptive Salience Attribution Test (SAT) data:

If participants responded in less than 100ms this was considered a premature response and excluded from analysis, following the precedent set by Roiser et al. (2009). Examination of individual level reaction time distributions revealed a consistent pattern of positive skew. Following the procedure detailed by Field (2005), skewness data were divided by the standard

error of skewness to produce a z-score. Individual distributions all showed a value greater than 1.96, suggesting the presence of significant positive skew. To address this issue, all RT data were log transformed prior to analysis. Statistical analyses of RT data (presented in Primary Analyses section, below) are based on the log transformed data. However, for clarity untransformed mean RTs are presented throughout.

4.1.3.2 Summary descriptive SAT data, current and previous studies:
Descriptive results are presented for the salience attribution test, following the convention of Roiser et al. (2009). The 128 trials of the SAT are broken down into two blocks of 64, with different dimensions of the stimulus rewarded in each block. This division of the task into Block 1 and Block 2 provides a way to examine whether participants are able to effectively re-learn a new set of contingencies, and switch to a new pattern of salience attribution. First overall mean reaction times for the entire sample are presented in Table 6. Then summary RT data from previous published studies are presented to give context to the present data.

4.1.3.3. Implicit (RT) salience data broken down by block and low/high classification:
The following series of tables provides descriptive SAT data, broken down into low/high DAPPS group comparisons. In the first table, Mean and SD reaction time data are provided for the low and the high group in Block 1, Block 2 and overall.

Table 4-Reaction time data by group and block

	Low (n=26)		High (n=20)	
	Mean RT	SD	Mean RT	SD
Block 1	262.01	57.56	262.53	40.59
Block 2	264.51	57.45	260.65	42.64
Overall	261.59	55.60	261.59	40.13

These data are somewhat different from previous studies reporting SAT reaction times. The low group in the present study showed slower reaction times than previously reported control groups, and the high group showed quicker reaction times than previously reported schizophrenia groups (see Table 5).

Table 5-Summary reaction time data by group from previous studies:

	Control	Experimental (designation)
Schmidt and Roiser (2009)	233.86ms	(n/a)
Roiser et al. (2009)	252.9ms	283.35ms (DSM IV schizophrenia)
Abboud et al. (2016)	245.67ms	359.06ms (DSM IV schizophrenia & "persistent delusions")

In the following tables SAT reaction times for the entire sample are broken down by block (i.e., Block 1 = the first 64 trials, Block 2 = the second 64 trials) and by the different levels of stimulus "validity." High validity trials are those on which the stimulus was associated with a reward. Low validity trials are those on which it was not.

Table 6 -Summary reaction time data by group, block and stimulus validity:

	Mean RT (milliseconds)	Standard Deviation
Block 1 High Validity	261.70	49.96
Block 1 Low Validity	262.77	52.72
Block 2 High Validity	259.80	50.85
Block 2 Low Validity	265.87	55.30
Overall High Validity	260.75	48.26

Overall Low Validity	264.32	51.33

Stimuli were colored either red or blue, and were either animals or household objects. Out of these four stimulus features, one feature (e.g., animals) would be rewarded; while the other dimension (e.g., household objects) would not be. This yields reaction times to four different types of stimulus (red animals and blue animals; red household objects and blue household objects). From these reaction times, estimates of salience attribution can be derived. The reaction times are further broken down and presented in two further tables below, using the terminology coined by Roiser et al. (2009). This terminology is explained through an example.

In any given block, if red objects are rewarded, color is the relevant stimulus feature. Red objects are high validity stimuli, and blue objects low validity stimuli. Subtracting the former from the latter yields an estimate of implicit adaptive salience (a negative value would indicate no speeding toward rewarded stimuli, and thus an absence of adaptive salience). The "task irrelevant" dimension of the stimulus was the aspect of the stimuli that did not predict any reward (in this example, content-i.e. whether the stimulus was an animal or a household object). Any difference in reaction times between these two types of content (i.e. speeding toward animals relative to household objects) would indicate the presence of aberrant salience. This was assessed by averaging reaction times for the two different groups of task irrelevant stimuli and subtracting the lower number ("task irrelevant low") from the higher ("task irrelevant high"). Figure 1 (below) provides a key to the calculation of adaptive and aberrant salience

RTs to BLUE stimuli (Low Validity)	-	RTs to RED stimuli (High Validity)	=	Adaptive Salience
RTs to whichever task irrelevant stimulus feature was responded to most slowly (Task Irrelevant High)	-	RTs to whichever task irrelevant stimulus feature was responded to most quickly (Task Irrelevant Low)	=	Aberrant Salience

Figure 1-Calculating salience variables on the SAT.

In table 7, below, the data are further broken down by the different stimuli to which participants responded. Reaction times are presented by block and validity level, and by block and level of the task-irrelevant stimulus feature.

Table 7- SAT reaction time data by group, block and stimulus validity

	Low (n=26)		High (n=20)	
	Mean RT	SD	Mean RT	SD
Block 1 High Validity	263.03	55.94	259.98	42.32
Block 1 Low Validity	260.99	60.90	265.09	41.14
Block 2 High Validity	261.73	55.79	257.30	44.91
Block 2 Low Validity	267.30	62.93	264.01	45
Block 1 Irrelevant High	270.59	65.33	271.21	48.89
Block 1 Irrelevant Low	252.24	61.99	260.82	41.92
Block 2 Irrelevant High	268.25	57.86	272.07	50.81
Block 2 Irrelevant Low	266.76	76.14	255.66	48.86
Overall High Validity	262.38	53.59	258.64	41.57
Overall Low Validity	264.14	58.69	264.55	41.32

These differences allow for the calculation of the two forms of salience the SAT attempts to measure (described above), which are presented in table 8, below.

Table 8-Implicit salience data by group and block

		Low (n=26)	High (n=20)
Block 1	Implicit Adaptive Salience (ms)	-2.03 (20.47)	5.11 (19.42)
	Implicit Aberrant Salience (ms)	18.34 (35.01)	10.38 (37.7)
Block 2	Implicit Adaptive Salience (ms)	5.57 (30.68)	6.7 (28.48)
	Implicit Aberrant Salience (ms)	1.49 (47.93)	16.4 (41.97)

4.1.3.4. SAT VAS Rating data:

In addition to reacting with a key press across 128 trials, participants are asked, at the end of each block of 64 trials, to provide a subjective probability rating of how often they received money for different types of stimuli (red/blue/animal/household object) on a visual analog scale (VAS). Average VAS ratings for each group are presented in the tables below. VAS ratings were made on a percentage scale, and thus ranged from 0-100.

Table 9-Overall VAS rating data by block and stimulus validity

	Mean VAS Rating	Standard Deviation
Block 1 High Validity	63.80	15.79
Block 1 Low Validity	28.04	19.53
Block 2 High Validity	64.26	16.43
Block 2 Low Validity	35.17	18.06
Overall High Validity	64.03	11.53
Overall Low Validity	31.60	13.65

Explicit salience ratings can be derived from these figures in a manner analogous to the derivation of implicit salience ratings. Subtracting average Low Probability ratings from average High Probability ratings yields a measure Roiser et al. (2009) term explicit adaptive salience. Subtracting average ratings for one level of the task irrelevant stimulus from the other yields a measure of explicit aberrant salience. These derived salience figures are presented in the tables below.

Explicit (VAS Rating) Behavioral Salience data for the SAT:

Table 10-VAS rating and explicit salience data by group, block and stimulus validity.

		Low (n=26) Mean (SD)	High (n=20) Mean (SD)
Block 1	VAS High Probability	61.12 (16.28)	67.3 (14.8)
	VAS Low Probability	25.88 (16.51)	30.85 (23.03)
	VAS irrelevant "high"	59.62 (12.74)	56.05 (13.09)
	VAS irrelevant "low"	40.54 (14.56)	40.6 (12.81)
	Explicit Adaptive Salience	35.23 (27.42)	36.45 (30.88)
	Explicit Aberrant Salience	19.07 (12.28)	15.45 (16.14)
Block 2	VAS High Probability	62.77 (17.53)	66.20 (15.1)
	VAS Low Probability	33.92 (19.09)	36.80 (16.96)
	VAS irrelevant "high"	51.69 (17.81)	56.10 (17.88)
	VAS irrelevant "low"	37.23 (17.56)	39.05 (17.95)
	Explicit Adaptive Salience	28.84 (33.79)	29.4 (25.43)
	Explicit Aberrant Salience	19.30 (22.02)	26.45 (21.55)

To assess whether the reward contingencies of the Salience Attribution Test had been successfully learned by participants, paired samples t-tests were conducted on the difference between overall High Validity reaction times, and overall Low Validity reaction times.

Participants tended to respond more quickly to rewarded than to unrewarded stimuli, however, this overall group difference in mean reaction times was not significant (t=-1.32 [df=45] p=0.19).

As expected, participants' assigned significantly higher VAS ratings to rewarded stimuli than to unrewarded stimuli. This difference was significant, t=11.02 (df=45) p < 0.001. This pattern of results suggests that participants did not respond notably faster to rewarded stimuli than unrewarded, and that reaction time ("implicit") measures derived from the SAT in this study may be insensitive to variations in salience attribution. However, despite this, participants appear to have been reliably subjectively sensitive to which stimulus dimension was being rewarded. Thus, the measures of explicit salience used in the following analyses can be regarded as valid.

4.2. Primary Analyses

4.2.1. Hypotheses:
This study sought to examine two hypotheses. The first was that individuals who display a high number of attenuated positive psychotic symptoms would demonstrate a high degree of aberrant salience and a "jumping to conclusions" bias relative to control participants displaying a lower number of such symptoms. The second was that there would be a positive association between aberrant salience and attenuated psychotic symptoms, and this would be moderated by a "jumping to conclusions" style of reasoning, such that individuals with high levels of JTC would show an association between high aberrant salience and attenuated psychotic symptoms. Individuals with low levels of JTC would show less of an association between aberrant salience and attenuated psychotic symptoms.

4.2.2. Testing the Hypotheses
To explore whether group membership had any impact on salience processing across time (i.e., whether participants in one group showed a tendency toward improved learning of the contingencies relative to the other group), transformed reaction time data were entered into a

mixed ANOVA, with Block (1 vs. 2) and Validity (High vs. Low) as within subjects factors, and DAPPS high/low group as the between subjects factor. There were no significant main effects and no significant interactions, suggesting that there were no systematic differences between the groups, either in terms of how they implicitly learned the contingencies, or the extent to which they improved over time.

To explore differences between the task-irrelevant levels of the stimulus over time (i.e., changes in aberrant salience), reaction time data were entered into another mixed ANOVA model, with Block (1 vs. 2) and Mean RT to the two validity levels of the task-irrelevant stimulus (High vs. Low) as within subjects factors, and DAPPS group as the between subjects factor. There were no main effects but there was an interaction with significance ($F=6.131$, 1, 44, $p = 0.01$).

In order to understand the nature of the interaction, aberrant salience reaction time patterns were graphed for high and low DAPPS groups and presented in Figure 1. The graphed interaction between task irrelevant high and low reactions times for Block 1 and Block 2 were graphed for high and low DAPPS groups. The pattern suggests a difference in the degree to which high and low DAPPS groups assigned aberrant salience over time. Namely, these graphs reveal that low PQ individuals showed a tendency toward responding equally quickly to both levels of the task-irrelevant stimulus over time suggesting a decrease in aberrant salience (i.e., a tendency to display less aberrant salience by not responding faster to one unrewarded stimulus feature than another). However, the high PQ or DAPPS group did not show this pattern, and showed a consistent difference in how quickly they responded between the two levels of the category that was not being rewarded over time. This finding represents preliminary evidence for

an improvement in learning in the low group that was not found in the high group, which may represent improved salience processing in the former.
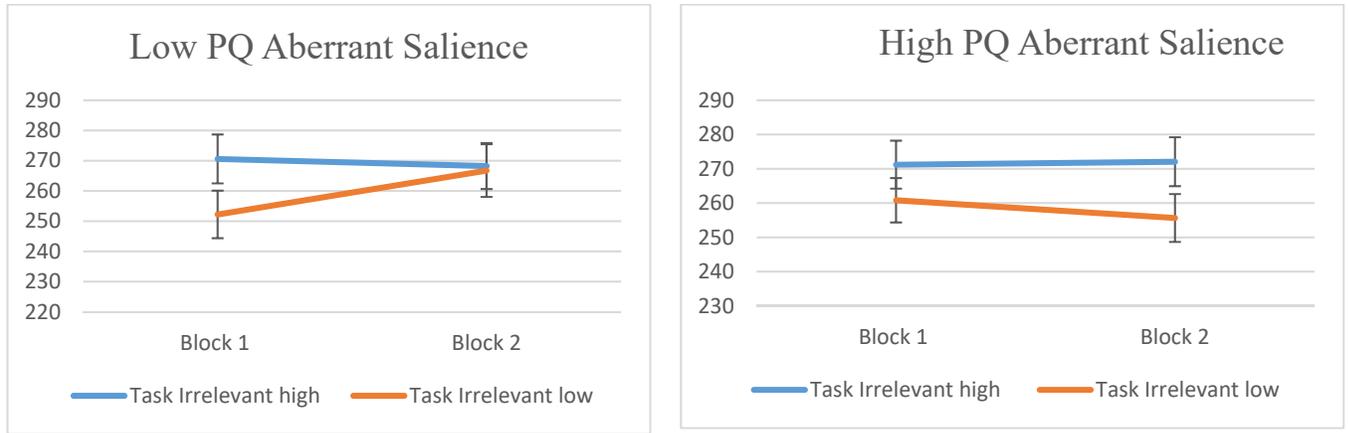
Figure 2-Reaction time data for implicit aberrant salience

To explore whether there were differences between rewarded and unrewarded trials, and whether these were larger among the High DAPPS than the Low DAPPS participants, VAS rating data were entered into a mixed ANOVA, with Block (1 vs. 2) and Validity (High vs. Low) as within subjects factors, and group as the between subjects factor. There was a significant main effect of block ($F=4.86$, 1,44, $p=0.03$), and validity ($F=117.39$, 1,44, $p<0.01$). Examination of the low and high groups' VAS ratings graphed by, block and validity (Figures 3 and 4) suggest that both DAPPS groups consistently and correctly rated high validity stimuli as more likely to have been rewarded relative to low validity trials, and that this accounts for the significant main effect of validity. The significant main effect of block was explored with post-hoc paired sample t-tests examining VAS ratings across DAPPS groups. Low Validity ratings for block 1 and Block 2, and High Validity ratings for block 1 and Block 2 were compared in two paired samples t-tests. In neither case was the difference across blocks significant. However, when Low and High VAS ratings are averaged together to create two overall (Block 1 and Block 2) VAS ratings variables, there was a significant difference between blocks ($t=2.33$, $df=45$, $p=0.02$). Overall, participants'

ratings increased from Block 1 (mean VAS 45.92, sd=10.50) to Block 2 (mean VAS 49.71, sd=8.43). Examination of figure 2 below suggests that this effect was mainly driven by an overall tendency toward rating low validity stimuli as more frequently rewarded on the second block than on the first. The resultant slight narrowing of the gap between high and low validity VAS ratings from block to block suggests a decrease in adaptive salience. This probably results from participants having to switch to learning a new set of contingencies in the second block (i.e. learning that a different stimulus characteristic was being rewarded). There were no significant interactions.
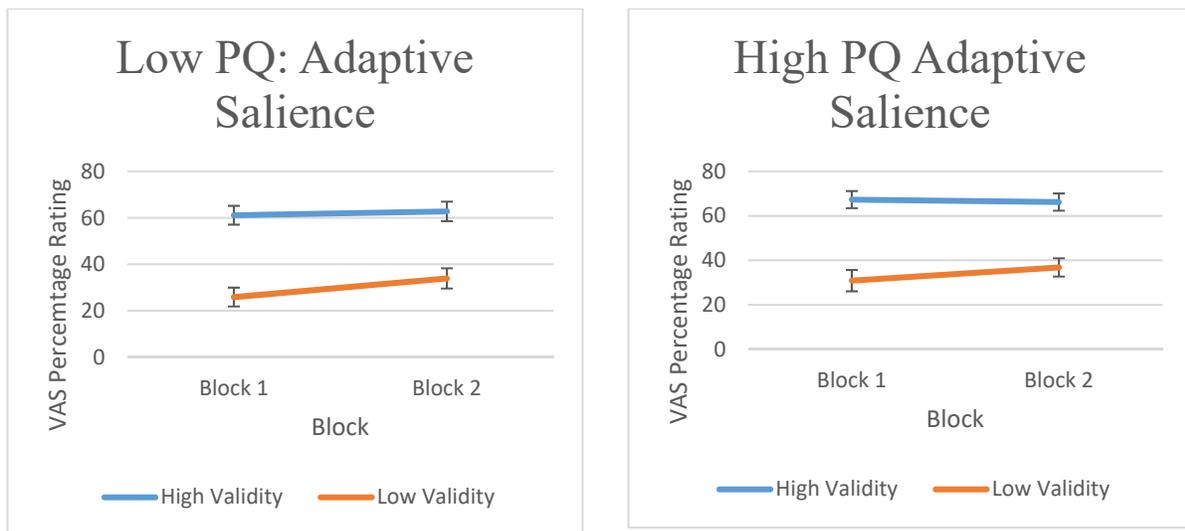
Figure 3-VAS Rating data for explicit adaptive salience

To explore differences in explicit ratings between the task-irrelevant levels of the stimulus from Block 1 to Block 2 (i.e. changes in explicit aberrant salience), reaction time data were entered into another mixed ANOVA model, with Block (1 vs. 2) and VAS ratings to the two levels of the task-irrelevant stimulus (High vs, Low) as within subjects factors, and DAPPS group as the between subjects factor. There was a significant main effect of Validity ($F=93.77, 1, 45, p < 0.01$). There were no other significant main effects or interactions. This result suggests that both groups showed some degree of aberrant salience (i.e. not showing the rationally optimal

pattern of rating both levels of the task irrelevant stimulus as equally likely to yield a reward.)

Examination of Figs. 3 below suggests that, while the low PQ participants' aberrant salience remained stable from block to block, the high PQ participants showed an increase in aberrant salience from Block 1 to Block 2. However, this effect falls short of significance ($F=1.96$, 1, 44, $p=0.28$), and appears to be at least partly accounted for by a virtual absence of aberrant salience in Block 1 among the High PQ participants.
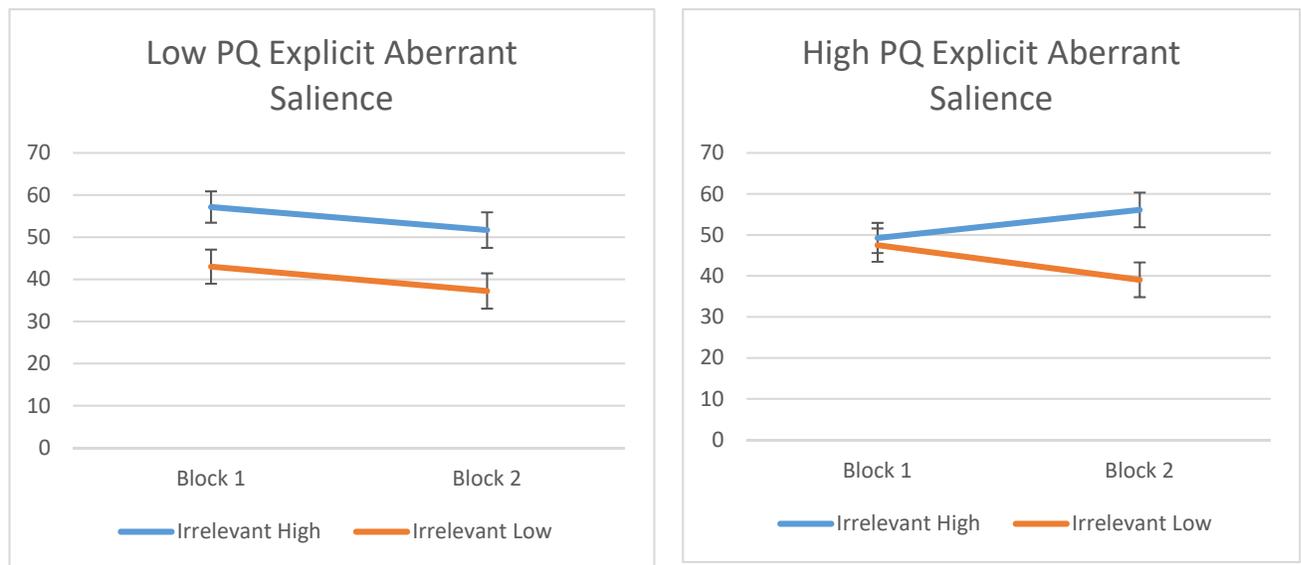
Figure 4-VAS Rating data for explicit aberrant salience

4.2.5. Self-Report Aberrant Salience Data

High PQ participants endorsed a mean of 16.75 out of 29 (SD= 7.8) items on the Aberrant Salience Inventory (ASI). Low PQ participants endorsed a mean of 10.88 (SD=6.3) items. This difference was statistically significant ($t=2.97$, $df=44$, $p=0.008$).

4.2.6. Probabilistic Reasoning Data

The second hypothesis of this study was that the positive association between aberrant salience and attenuated psychotic symptoms would be moderated by a "jumping to conclusions" style of reasoning. The outcome variable for the probabilistic reasoning (beads) task was the number of beads drawn before participants felt certain they knew which jar the beads were

coming from. Mean draws to decision for each group are presented in table 11. During the current study, additional qualitative observations were made of the approach participants took to completing this reasoning task. These observations raise some questions for the traditional interpretation of beads-task results, and are included in Appendix A.

Table 11-Mean Draws to Decision (DTD) for "high" and "low" groups:

	High (n=33)	Low (n=29)
85:15 mean DTD (SD)	7.5 (4.3)	6.4 (3.7)
60:40 mean DTD (SD)	10.7 (3.7)	9 (3.2)

Participants were administered the two versions of the beads task, the standard 85:15 version and the more difficult 60:40 version. The latter is harder because it requires participants to make a discrimination about a less obvious difference in quantities of beads. Both versions were administered because the 60:40 version is regarded as sensitive to less marked differences between groups (Broome et al. 2007). Very few participants in this sample displayed the JTC bias drawing 3 beads or fewer and there were no statistically significant differences between the high and low DAPPS groups on mean DTD.

4.2.7. Group differences and interaction effects between the two factors

To assess for DAPPS high vs low group differences on the test variables, multiple independent t-tests were conducted to compare group (high vs. low) means for VAS adaptive salience block 1, VAS adaptive salience block 2, VAS aberrant salience block 1, VAS aberrant salience block 2 the ASI, the 85:15 version of the beads task and the 60:40 version of the beads task. A Bonferroni correction was applied for multiple (7) comparisons, so that the threshold for

a significant finding was a p-value of 0.007. Results of multiple comparisons are shown in table

6 below.

Table 12-Multiple t-tests of group mean differences on five test variables:

Variable	t-value	p-value
ASI Mean score	2.97 (df=44)	0.008*
Beads (85:15)	.867 (df=60)	0.38
Beads (60:40)	1.407 (df=60)	0.16
VAS adaptive Salience B1	0.142 (df=44)	0.89
VAS aberrant Salience B1	.866 (df=44)	0.39
VAS adaptive Salience B2	0.61 (df=44)	0.95
VAS aberrant Salience B2	1.1 (df=44)	0.27

*=significant at p=0.007.

The only significant difference between groups was on mean total ASI score, suggesting

that the groups here did not differ in terms of their draws to decision performance or their

aberrant salience attribution during a probabilistic learning task.

To test for the possibility that probabilistic reasoning moderates the association between

aberrant salience and DAPPS, two logistic regression analyses were completed, using ASI

aberrant salience and draws to decision for the two different versions of the beads task as

predictors. Self-reported experiences of aberrant salience were associated with increased odds of

belonging to the "high" DAPPS group, confirming the first hypothesis of the present study.

Draws to decision was not reliably associated with increased odds of belonging to the high

DAPPS group for either version of the beads task. To examine the interaction between aberrant

salience and performance on the beads task, a third variable was computed to represent the

multiplicative term of aberrant salience and draws to decision on the beads task. The interaction

for both models was non-significant, suggesting that performance on the beads task does not

moderate the relationship between aberrant salience and DAPPS.

Table 13-Logistic regression predicting High/Low DAPPS status using Aberrant Salience (ASI) and 85:15 Beads Task results:

	OR	95% CI	b (SE)	P
Aberrant Salience (ASI)	1.12	1.02-1.23	0.12 (0.48)	0.01*
Beads 85:15	1.15	0.62-2.11	0.14 (0.31)	0.65
ASI*Beads 85:15	1.06	0.9-1.23	0.05 (0.07)	0.46

Table 14-Logistic regression predicting High/Low DAPPS status using Aberrant Salience (ASI) and 60:40 Beads Task results:

	OR	95% CI	b (SE)	P
Aberrant Salience (ASI)	1.12	1.02-1.23	0.12 (0.48)	0.01*
Beads 60:40	1.45	0.66-3.14	0.37 (0.39)	0.34
ASI*Beads 60:40	1.075	.935 - 1.235	0.07 (0.07)	0.31

This pattern of results suggests that probabilistic reasoning did not moderate the

association between aberrant salience and DAPPS in this sample. This finding is inconsistent

with the second hypothesis being examined here.

4.3. Secondary Analyses

4.3.1. DAPPS Instability

The results of this study show few significant differences between low and high DAPPS

participants on the measures of interest. This may partly result from an unexpected degree of

instability in DAPPS over time. There were initially 32 low PQ scorers recruited, and 30 high PQ

scorers recruited to the present study. The PQ was administered to the current sample of participants anywhere between two months up to a year prior to commencement of recruitment for the present study. Given this time lag, all participants were administered the PQ a second time at present study commencement to provide a current assessment of attenuated positive psychotic symptomatology. Sixteen of the participants' PQ scores at this second administration led to different low/high classification, suggesting a degree of instability in attenuated symptoms for around a quarter of participants.

As a result of this change, PQ status at the point of recruitment did not always reflect PQ status at the point of the experiment. Given this fact, it was decided to explore, in secondary analyses, whether there were differences between participants based on other more specific derivations of PQ status that accounted for the time lag between recruitment and study commencement. Two additional ways of classifying these participants in terms of PQ status are possible. One is based on a simple re-classification, based on their most recent PQ score. Under this classification, 29 participants reported four DAPPS or fewer when tested again at the point of the experiment, falling into the "low" group (mean: 1.45 S.D: 1.52). Twenty-seven reported eight or more DAPPS at the point of the experiment, falling into the "high" group (Mean: 12.44 SD: 4.33). 6 individuals fell into neither of the two a priori determined groups, scoring an average of 6 DAPPS (SD: 2).

A second way to reclassify participants based on PQ status involves a longitudinal consideration of an individual as being either stably-low, stably-high, or variable. Most participants who moved, did so clearly from one category to another and were thus classified as variable (and excluded from analyses). However, two participants endorsed eight or more

DAPPS at time one, and seven or more at time two. To accommodate some minimal variability, these were classified as stably high.

Table 15-Participants whose group status changed:

	DAPPS at recruitment	DAPPS at testing	Direction of change	Functional Status
1	13	0	High to Low	Variable
2	15	0	High to Low	Variable
3	8	4	High to Low	Variable
4	12	3	High to Low	Variable
5	8	2	High to Low	Variable
6	10	4	High to Low	Variable
7	10	3	High to Low	Variable
8	9	7	High to Middle	Stable High
9	10	7	High to Middle	Stable High
10	9	6	High to Middle	Variable
11	2	7	Low to Middle	Variable
12	4	7	Low to Middle	Variable
13	2	16	Low to High	Variable
14	0	13	Low to High	Variable
15	2	9	Low to High	Variable
16	0	10	Low to High	Variable

The analyses presented in the main body of this results section are based on PQ status at the point of recruitment. However re-analyses for alternative groupings were also performed to assess whether these different groupings had an impact on findings. Even with the division of the sample into different low/high configurations, the results remained the same, with no significant group differences in terms of the SAT salience variables, or draws to decision on the beads task. The finding of a significant difference in self-report aberrant salience (ASI) was stable for each of the other two possible configurations of low/high grouping. For the results pertaining to these alternative groupings, see Appendix. B.

4.3.2. PQ/ASI divergent validity

To examine the convergent and divergent validity of the PQ and ASI, and explore the extent to which they are different but related constructs, Pearson correlations between total number of DAPPS and total ASI score across the entire sample were carried out. The number of DAPPS correlated significantly with total ASI score ($r=0.35$, $p=0.006$). The total number of PQ positive symptoms and the total ASI score also correlated significantly with total ASI score ($r=0.34$, $p=0.009$). These correlations are significant, but only medium in terms of effect size. This result suggests a robust association between these measures. However the association is less than the 0.85 threshold suggested by Campbell and Fiske (1959) in their discussion of divergent validity. This provides some tentative support for the hypothesis that the positive symptom scale of the PQ and the ASI measure different underlying constructs, and is consistent with the moderately sized correlations between the ASI and psychosis proneness measures examined in Cicero et al. (2010). However this should be regarded as an exploratory and suggestive finding. Further work is required to establish the divergent validity of the ASI.

4.3.3. Exploratory SAT/ASI convergent validity

This is the first study to employ the two extant measures specifically designed to assess

aberrant salience attribution (the ASI and the SAT) and thus affords an opportunity to examine

their convergent validity. A correlation between two measures in such different domains (self-

report vs. experimental) would provide support for the assumption, present in the extant

literature, that they are both measuring the same phenomenon. To examine this aspect of

convergent validity, bivariate correlations were performed between Block 1 VAS Aberrant

Salience, Block 2 VAS Aberrant Salience, and Total ASI score. Block 1 VAS Aberrant Salience

actually correlated negatively with total ASI, though this effect was small and not statistically

significant ($r=-0.178$, $n=46$, $p=0.236$). However, Block 2 VAS Aberrant Salience showed a small

positive, and statistically significant correlation with total ASI ($r=0.385$, $n=46$, $p=.008$).
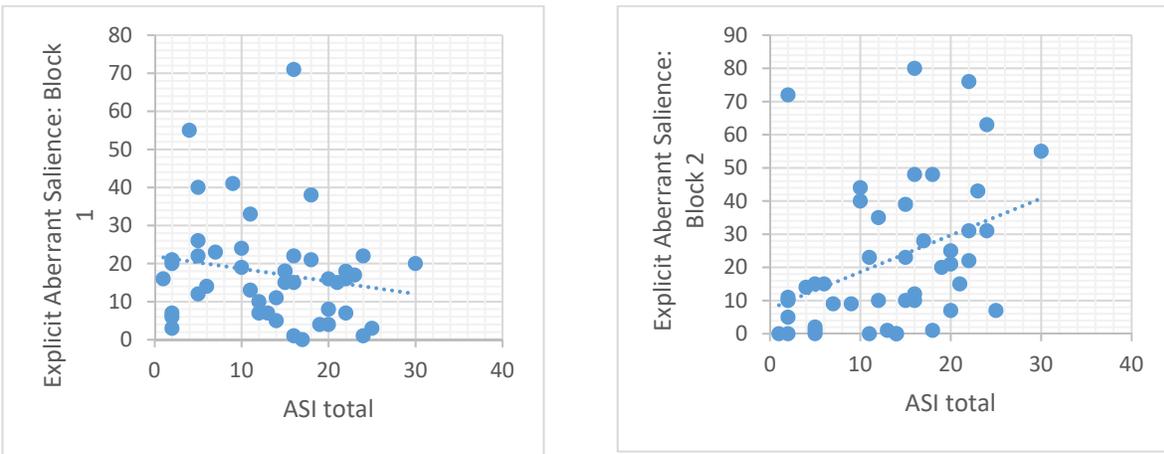
Figure 5-Scatterplots showing self-report aberrant salience (ASI) plotted VAS aberrant salience for Block 1 (left) and Block 2 (right)

Chapter 5: Discussion

The present study sought to investigate the relationship between two cognitive factors, aberrant salience and the jumping to conclusions bias, and their relationship to clinically significant attenuated positive psychotic symptoms. This was the first study to examine aberrant salience using experimental and self-report methods, and the first to do so in a non-treatment seeking population. Additionally it was the first study to examine aberrant salience experiences and probabilistic reasoning together in the context of a multifactorial theory of psychosis. It was hypothesized that individuals self-reporting a clinically significant number of positive psychotic-like symptoms would be more likely to exhibit the tendency to place salience on irrelevant stimuli. This was supported in that high scoring individuals on a prodromal questionnaire scored higher on an inventory of aberrant salience. Furthermore, using experimental methods, it was found that self-reported, subjective feelings of sharpened senses and enhanced awareness correlated with aberrant salience attribution on a rating scale during a behavioral task, in the context of attenuated positive psychotic symptoms.

5.1. Summary of findings

The main finding from the present study was that individuals who endorse elevated levels of distressing attenuated psychotic symptomatology tended to also report experiences of elevated salience dysregulation than a group who reported only average levels of such symptoms. This finding is consistent with Hypothesis one, and provides support for the proposed link between psychosis and aberrant salience. However, contrary to previous studies that have deployed the Salience Attribution Test in populations with psychotic symptoms or high risk states, and contrary to what was hypothesized, this study did not find any associations between DAPPS and any of the SAT outcome variables. The failure to find any such association is novel, and appears

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to contradict the aberrant salience hypothesis. Reasons for such a failure to replicate are explored further below.

Contrary to one of this study's main hypotheses, individuals with elevated attenuated psychotic symptoms did not show a tendency to select fewer beads before drawing a conclusion about which of two jars the beads were coming from, i.e., they did not show evidence of any tendency towards a jumping to conclusions bias. Although this finding was not predicted, it is consistent with an interpretation of the two-factor model, as will be discussed below in the section Findings in Context. The lack of an association between DAPPS and draws to decision on the beads task also meant that the third major hypothesis of the study was not confirmed: there was no moderation of the relationship between aberrant salience and DAPPS by number of beads drawn. Drawing fewer beads did not yield a stronger relationship between aberrant salience and DAPPS.

5.2. Interpretation of findings

Overall the results discussed here are consistent with (but not strongly corroborative of) a model in which distressing attenuated positive psychotic symptoms are associated with aberrant salience; an inappropriate sense of subjective significance which may contribute to the development of experiences like having a delusional belief, or seeing/hearing things which aren't there. However, the evidence is mixed. While the significant difference between experimental groups on the self-report salience measure (the ASI) supports this interpretation, the absence of any such difference on the experimental/behavioral measure (the SAT) does not. The mixed pattern of findings regarding salience is open to several potential interpretations.

First, it may be that the ASI provides a more sensitive measure of salience processing than the SAT, and that it is thus able to detect relatively small differences between the two

groups examined here. In favor of this interpretation is the fact that the ASI relies on self-reported subjective experiences. The experiences in question are generally quite subtle in character (e.g. "has your sense of taste ever seemed quite acute?"). It is prima facie plausible that such subtle alterations in subjectivity could be present in non-clinical manifestations of attenuated psychosis, without the additional presence of more pronounced cognitive distortions of the sort that would give rise to differential performance on an experimental task. This interpretation is also supported by the fact that the subjective VAS ratings in the SAT did show a reliable difference between rewarded and unrewarded stimuli.

A second interpretation is that the implementation of the SAT in this study was flawed in some way. In terms of reaction time, the overall sample did not show a tendency toward more rapid responding to rewarded items, and did not show a pattern of "implicit adaptive salience." Such a finding limits the applicability of the reaction time results for understanding aberrant salience, and may account for why there was no group difference in terms of implicit aberrant salience. However, against this interpretation the rating scale results (explicit salience) did yield a clear pattern of higher likelihood ratings for rewarded items, indicating successful attribution of explicit adaptive salience among all participants, as expected. This suggests that, despite the failure of the task to detect speeding toward rewarded stimuli, participants could reliably judge which stimuli were being rewarded. The failure to detect a group difference in terms of explicit aberrant salience on this measure is thus interpretable in terms other than the simple failure of the SAT to accurately detect salience attribution.

A third interpretation is that the failure to find group differences on the SAT is a result of Type-II error, as the sample size limited the power of the experiment to find any such effect. This possibility (also discussed in the section on Limitations, below) cannot be corroborated or

refuted. Even with the loss of power that resulted from the data loss, the sample size here is similar in size to previous SAT studies that have found positive results.

The self-report and experimental rating-scale measures of aberrant salience were found to be correlated (i.e. self-report aberrant salience correlated with Block 2 Explicit aberrant salience, salience). This result provides some tentative support for the hypothesis that they are measuring the same construct. The use of two approaches to measuring salience attribution represents a strength of this study. No work has yet been conducted to examine subjective experiences of aberrant salience while also investigating experimental attribution of salience. Future studies could fruitfully set out to more explicitly examine the construct validity of aberrant salience by examining the covariation of these alternate forms of assessing it.

In terms of incautious reasoning, the lack of a group difference on the beads task is consistent with an interpretation on which high levels of attenuated positive psychotic symptoms (which have not crossed the threshold into "full blown" psychosis) are not associated with more hasty reasoning. In fact, the results here show a trend towards more beads being drawn by the High PQ group on both variations of the task, a finding which runs contrary to that which was expected. This null result is most parsimoniously interpreted as indicating the lack of any difference in probabilistic reasoning between groups who are defined solely in terms of attenuated symptomatology. Such a finding is consistent with an interpretation under which probabilistic reasoning is not a relevant factor in determining whether people experience attenuated psychotic symptomatology. Rather, such symptomatology may represent early disturbances in perception and subjective self-experience, which are nonetheless still capable of being "managed" by intact reality testing. This theoretical formulation is made explicitly by Beck and Warman (2004), who suggest that cognitive insight is essential to the distinction

between anomalous experiences and full blown psychosis. These authors place probabilistic reasoning at the center of their view of insight, saying that this construct is "impeded by premature closure ("jumping to conclusions") and overconfidence in the rightness of [...] inferences" (p.85). This two-factor interpretation is also supported by previous studies, which have found significant differences in neurocognitive performance between individuals who are in an "at risk" state and individuals who have developed a full blown psychotic illness (Pukrop et al., 2005). However there is also a substantial body of evidence to suggest that neuro-cognition assessed longitudinally over the development of psychosis reveals no pattern of decline from prodromal status to full blown illness (Bora and Murray, 2014). Such a pattern, when combined with evidence for the stability of the JTC bias in deluded patients over time (Peters and Garety, 2006) suggests that differences in performance on such tasks may distinguish between individuals likely to go on to develop psychosis and individuals who do not. Broome et al. (2012) examined this directly by following up after two years with a small sample of at risk individuals who had completed the 85:15 and 60:40 versions of the beads task at the start of the study. They found no significant difference between those who had and those who had not converted to psychosis, but their relatively small sample (28 individuals, five of whom had developed psychosis) limits the strength of the conclusions that can be drawn from their research. More research is needed on this question.

Considered alongside other similar findings with the beads task specifically, the present result is consistent with the possibility that an "epistemological impulsivity" (Bentall, 2004) associated with the jumping to conclusions bias could be an important factor in the development of more severe forms of psychotic symptomatology. Qualitative examination of the experiences of prodromal individuals is consistent with this suggestion. Investigators have suggested that the

prodrome can entail preoccupation with analyzing the reality of overvalued ideas, suggesting a degree of epistemic caution (the opposite of a Jumping to Conclusions bias) among these individuals (Møller et al., 2000). For example, one of Møller et al.'s participants reported "I had to define and analyze everything I was thinking about." (p.222). In a more anecdotal vein, Aviv (2010) said of a young patient that "she seemed to have come closer to psychosis than any other patient I interviewed there, but she used a few shreds of logic to tether herself to reality." (p.46). A recent qualitative examination of the experiences of psychosis (Jones et al. 2015) also drew attention to the apparently deliberate quality that psychosis can involve, and the importance of applying deliberative reasoning to keep it in check. This experience should be explored in greater detail in more rigorous qualitative studies. The possibility that beads-task performance is better among "high risk" populations than in either psychotic or "low risk" samples is discussed further below, in the section Results in Context.

5.3. Current Findings in Context

Previous studies of aberrant salience and probabilistic reasoning have largely treated these factors individually. Although both variables (especially the latter) have been consistently associated with various forms and degrees of psychotic experiences, they have not been explored in combination with one another. Understanding how they might interact is of particular interest for two reasons. The first is that they have each been incorporated into broad, multifactorial theoretical models of psychosis which require multifactorial empirical testing. The second is that the extent to which they are theoretically distinct remains poorly understood. It is possible that aberrant salience and probabilistic reasoning are two sides of the same coin. For example, aberrant salience attribution might lead to a premature cessation of bead selection because beads are imbued with subjective explanatory significance before the point at which it is rational to stop viewing them. However they may also represent unrelated cognitive abilities. This issue

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needs to be far better understood before the psychology of psychosis can be fully explicated. The current findings potentially shed some light on the interplay of these two variables in the production of attenuated psychotic symptoms, and their role can be even better understood by comparing the present study to previous findings in the same field.

In this section, the current results are considered in the light of relevant previous findings. The present finding of no group difference in SAT performance between low and high scorers on the PQ is inconsistent with experimental studies that have found Aberrant Salience in "at risk" type populations. Roiser et al. (2012) found that an Ultra High Risk (UHR) for psychosis group scored significantly higher than controls on explicit aberrant salience as measured by the SAT. This result stands in contrast to the present study. This inconsistency may reflect differences in the respective samples. A clear difference between this study and that of Roiser at el. is in the earlier study's use of individuals who were (1) seeking mental health treatment, and (2) diagnosed as being "high risk" by the Comprehensive Assessment of At Risk Mental State (CAARMS) criteria. This measure involves the use of a structured clinical interview to establish who is at risk, setting a substantially higher threshold for inclusion in the at risk group. This higher threshold for the "at risk" group might account for the difference between those and the present results. However, it is also worth noting that two (out of 18) of Roiser et al.'s participants had previously taken psychiatric medications, and that their engagement with mental health services may be indicative of other differences in social/mental functioning that might have contributed to their results. The use of psychiatric medications may have an impact on processing speed and thus make experimental reaction times generally slower and more erratic. The presence of clinically significant psychiatric symptomatology may be associated with group

differences in attention or other executive functions. These might be expected to impact performance in a task that draws on sustained vigilance, set shifting and working memory.

Haslegrove et al. (2015) examined aberrant salience in a college population that bore more similarities to the present sample, and their findings would be expected to be similar to those reported here. Haslegrove et al. assigned undergraduates to high/low groups on the basis of their scores on a self-report measure of schizotypy, and administered tasks to assess for latent inhibition, blocking, and learned irrelevance, three attentional learning phenomena that the researchers posited were associated with salience regulation. While low schizotypy participants demonstrated an attentional bias towards stimuli that were predictive of trial outcome, and faster responses toward stimuli with predictive validity, high schizotypy participants did not show such an effect. Although they did not employ the SAT, Haselgrove et al.'s study suggests that non-medicated, non-helping seeking individuals who score high on measures of schizotypy do show evidence of aberrant salience. This stands in contrast to the current study, lending support to the possibility that the absence of a significant group difference in aberrant salience represents Type-II error.

Moving to previous studies that have looked at self-reported aberrant salience, the present results fit with other literature using the same measure. In multiple studies, its authors have found that self-reported aberrant salience is associated with elevated rates of psychotic like experiences. (Cicero et al., 2010, 2013) The present results thus represent a modest replication of these findings, adding to a picture in which aberrant salience plays an important role in early or sub-clinical psychotic experiences.

In terms of the role of probabilistic reasoning (beads task performance), the present results stand in contrast to several studies that have found an association between sub-clinical

psychotic experiences and the jumping to conclusions bias (Broome et al. 2007, Bensi et al., 2010, Cafferkey et al., 2014). However, they are also consistent with a small emerging literature discussed in the Introduction that has examined beads task performance across the psychosis spectrum (Warmans et al., 2007; Freeman et al., 2010; Ho Wai So and Kwok, 2015). One possible role for probabilistic reasoning as a second factor in psychosis, is that it provides a check on anomalous experiences, to prevent them from being interpreted in a way that leads to the development of delusional or hallucinatory experiences. If this is an accurate characterization, we might expect to see a distinct pattern when we compare individuals across the psychotic spectrum. Specifically, we might predict the least cautious reasoning style to be shown by individuals with frank psychosis (who do not have anomalous experiences "reigned in"), and the most cautious reasoning style to be seen in individuals with sub-clinical psychotic experiences (who do have such experiences "reigned in" or reality tested). Individuals without elevated levels of sub-clinical psychotic experiences might be expected to show probabilistic reasoning that is intermediate between these extremes, or indistinguishable from sub-clinical participants. As was outlined in the introduction to this study, this is precisely the pattern that has been shown in the four previous studies that have examined this phenomenon. It is this pattern that is consistent with the current results. The non-clinical group of psychosis-prone individuals studied here did not demonstrate any tendency to "jump to conclusions" in a simple reasoning task, despite displaying elevated levels of self-reported aberrant salience and distressing attenuated positive psychotic symptoms. This pattern of results suggests a growing picture in which clinically significant psychosis is distinguishable from psychotic-like phenomena by the absence of probabilistic (reality testing) reasoning processes that act to protect an individual from losing touch with reality.

The nature of the sample in the current study is an important consideration when trying to understand departures from previous studies. In contrast to many studies of undergraduate populations, which draw on a predominantly white sample, the current study was predominantly non-white and drawn from a population of first-generation college students from immigrant families of lower socio-economic status. This may play a role in understanding why the present administration of the SAT did not detect a difference in terms of reaction-time based adaptive salience. However, it is also interesting to note that some of the outcomes in this study were replications of previous findings. This extends these results into new terrain, with a demographically broader sample.

5.4. Implications of the current findings

The finding that non-help seeking individuals who are high in DAPPS demonstrate elevated levels of aberrant salience replicates previous work (Cicero et al., 2010, 2013, Haslegrove et al., 2015) and provides further tentative support for the aberrant salience theory of positive psychotic symptoms. The fact that this association is seen in a group of undergraduates who were not recruited on the grounds of a clinical diagnosis or decline in social functioning supports the putative specificity of the relationship between attenuated psychotic phenomena and aberrant salience. This is not an association that is driven by incidental factors that have to do with being clinically psychotic or taking psychiatric medications that target dopaminergic neurons. Kapur's theory predicts that aberrant salience should be present from early on in the development of psychotic experiences, and that is corroborated by the current findings.

The findings in the current study provide some tentative support for a multi-factorial theory of psychosis. The apparent lack of any association between the number of beads drawn, and the presence of elevated levels of aberrant salience is concordant with a proposal that these

two components are important contributors to the development of psychosis, but not sufficient in isolation. Under the two-factor model, aberrant salience would provide experiential evidence that something new and strange was happening, and would lead to the early, attenuated experiences of oddness and difference that characterize prodromal or "psychosis-prone" states. A separate deficit in evaluating evidence in an appropriately cautious way would contribute to the acceptance or "incorporation" (e.g. Gerrans, 2014) of this evidence into a person's view of reality, in the form of accepting delusional beliefs or coming to believe that heard voices are separate from oneself.

It is also consistent with an interpretation under which the contributions of aberrant salience and probabilistic reasoning biases are distinct components. This runs contrary to single factor models of psychosis such as the predictive coding framework (Griffin and Fletcher, 2017) in which the deficits and symptoms of psychosis are explained by a generalized deficit in the hierarchical prediction processes that allow the brain to make inferences about and update its working model of reality. Under this latter framework, the experience of aberrant salience arises from unresolved prediction error arising in neural perceptual and motor feedback systems.

5.5. Limitations

The current study suffers from a number of limitations. The most significant limitation was the ultimate sample size of the study. An original sample of sixty-two participants was reduced to forty-six by a programming error that led to a loss of data. The change in sample size represents a loss of statistical power. To some minor extent, the issue of power is addressed by the fact that multiple analyses, dividing the groups in different ways, all found similar results. These re-analyses cannot stand as replications as they draw from the same sample, but the lack of variation from analysis to analysis does suggest that the present findings are not merely driven

by idiosyncratic extremes within the data set. More encouragingly, many of the results here are consistent with previous studies, and make theoretical sense. However, the limited sample size means that the study is potentially under-powered and that its results should be regarded as preliminary and suggestive. The absence of significant group differences on salience attribution may be the result of Type-II error.

Local ethics requirements meant that the financial reward component of the SAT in the current study had to be implemented differently than in previous uses of the task. Previously published studies using this measure have provided a financial reward to participants that is determined by their performance on the task. The ethics committee that oversaw the current study determined that the use of variable financial rewards was unethical. As an alternative, participants were informed that their financial compensation would be determined by SAT performance, but then all were provided with the same reimbursement. This difference should not have impacted participant SAT performance, as remuneration was provided after the completion of the task. However, participants were debriefed to determine whether this deception had been successful. Eleven out of forty-six reported that they had definitely not fallen for the deception, and three reported that they had questioned it but not reached a firm conclusion. When asked why the deception had not worked, three participants reported that it had been due to misunderstanding the recruitment call (which had stated the possibility of receiving up to $20) to mean that participants would definitely receive $20. One stated that he felt psychology "had a reputation" for deceiving people. Two reported that they did not think the computer (an ordinary PC laptop) was capable of calculating a financial reward on the basis of

reaction times. The remaining five were not able to provide a reason for the failure of the deception, but reported feeling that they had "just figured it out," or that "it didn't seem right".[5]

It is not clear what impact this difference had on SAT performance. It is unlikely that it accounts for the failure to observe adaptive salience in the sample, as only a minority reported that they hadn't fallen for the deception, and of these, four spontaneously reported that they had still put forth their best effort into the game as they had not felt the money to be important (participants were not systematically asked whether they had put forth their best effort). However, it is possible that the inability to genuinely yoke SAT performance to financial reimbursement had some impact on participant engagement with the task in a way that impacted performance.

One final consideration is worth examining when evaluating the absence of group differences seen in the current sample; the nature of the measure by which the groups were defined. During recruitment the PQ was deployed to distinguish a group that was meaningfully "high" in sub-clinical psychotic experiences from a group that was meaningfully low in such experiences. The cut score for a "low" group member was based on the mean number of Distressing Attenuated Positive Psychotic Symptoms seen in the broader sample from which these participants were drawn. However, the upper cut score (eight or more DAPPS to be included in the "high" group) was derived from a diagnostic study which administered the measure to a help-seeking sample attending a prodromal research clinic (Loewy et al. 2005). Thus the current study may have failed to divide people into theoretically meaningful groups.

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[5] One of the participants who had questioned the deception but not reached a firm conclusion stated "I sort of thought it was a deception, but then I didn't think you would do that!"

This study examined "high" vs. "low" scorers on a symptom measure administered to non-help seeking college undergraduates. Such an approach is by now reasonably well established within experimental psychopathology, and various different measures have been deployed to explore the characteristics of delusion/hallucination "prone" individuals, or individuals who experience attenuated symptomatology (e.g. Peters et. al, 2004, Freeman, 2006, Sommer et al., 2010, Reeves et al., 2014). However, it is possible that it yields "high" and "at risk" groups that are very different from clinical cases of psychosis. Additionally, there is likely to be variation between "at risk" groups between studies, depending on what type of symptom measure is used. Psychosis is a complex, multi-factorial phenomenon (Lincoln, 2007). To suggest that the difference between clinically significant positive psychotic symptoms and attenuated positive symptoms is only a matter of degree is to potentially misunderstand the phenomena. Individuals with psychosis also exhibit a range of neurocognitive deficits, (Saykin et al., 1994, Green, 1998, Choi et al., 2013), problems with social functioning (Dickerson et al., 1999, Green, 2000) and experiences of subjective strangeness that do not readily fall into the categories provided by mainstream descriptive psychiatry (see e.g., Sass, 1994, Sass and Parnas, 2003, Handest et al., 2015). The differences between an individual suffering from psychosis, and one reporting statistically elevated levels of attenuated psychotic symptoms may extend beyond the severity of the symptom present, making it difficult to draw reliable inferences about one by studying the other. Accordingly, any results from a study with this population should be interpreted cautiously.

5.5.1. Does the SAT measure salience attribution?
Apart from specific limitations of this study, a broader potential limitation of the SAT became apparent over the course of data collection, which has implications for all studies which have deployed the measure. Because this issue has broader ramifications than the present study,

it will be discussed in some detail in the current section. The limitation in question pertains to the assumption that the Salience Attribution Test is a valid measure of the construct of salience. In this section I explore this assumption in the light of the present results and the rest of the extant literature. I will suggest that there are potentially serious flaws in the assumption, and that this leads to a need for further construct validation of the SAT in future research.

The SAT is a behavioral task which yields a series of reaction times and subjectivity judgements. How these are derived (and their names; "implicit/explicit, adaptive/aberrant salience") is outlined in the method section above. The theory is that each of the four main output variables pertain principally to salience attribution. However, an alternative interpretation is available. The task involves responses to reward, so it is possible that it measures (or contains interference from) a participant's subjective sense of pleasure and motivation pertaining to that reward, as opposed to the sense of significance the reward came to acquire. It is known that patients with a diagnosis of schizophrenia experience a range of motivational and hedonic deficits, which have been implicated in social functioning (Foussias et al., 2009). Furthermore, deficits in motivation have been shown to have a pervasive impact on cognitive task performance (Summerfeldt et al., 1991, Fervaha et al., 2014). Research using the SAT in schizophrenia patients is potentially vulnerable to misinterpretation. A closer examination of previous data using the SAT with this population is consistent with the possibility that anhedonia could be a confounding factor in interpreting its results. Both pleasure and salience processing have a well-established link to the mesolimbic dopamine system (Berridge & Robinson, 1998), so clarity about which construct is being tested is critical for theoretical consistency.

5.6. Future Directions

   Our understanding of what distinguishes individuals at risk for psychosis from those who have transitioned to full blown psychotic illness remains underdeveloped. Research examining the factors which predict conversion has recently been criticized for small sample sizes and poor methodological quality (Studerus et al., 2017). This is a field with substantial clinical significance. Psychosis is traumatic, socially and economically deleterious to individuals who experience it, and difficult to treat successfully. Preventing it depends partly on understanding what distinguishes those who do and those who do not transition. Cognitive interventions have targeted potential psychological mechanisms that may work to keep attenuated psychotic symptoms from developing into full blown psychosis (Moritz and Woodward, 2007). Understanding exactly which cognitive mechanisms distinguish those who do from those who don't transition can help to focus such interventions more precisely. Future work should continue to examine the inter-relations between cognitive processes associated with attenuated psychotic symptoms.

   The current study is among the first to explore the distinction between two factors that have been theoretically linked to psychosis, aberrant salience and incautious reasoning. It remains a live question how distinct these really are, and some accounts of the Jumping to Conclusions bias suggest that it is itself driven by salience processing (e.g. Speechley et al., 2010). One way to approach this question would be to recruit non-psychotic groups defined by cut-scores on the beads task (a jump to conclusions group, defined by a draw-to-decision score of two or less, and a group who draw an average or above average quantity of beads) and specifically compare them on various measures of saliency processing (including experimental and self-report/phenomenology measures). Such an approach would be better able to establish the extent of any overlap between salience processing and probabilistic reasoning, and rule out

the potential confound of their independent correlations with psychotic phenomena. Additionally, other characteristics of reasoning in such a specially recruited "jump to conclusions" group could ascertain precisely how this reasoning style could contribute to psychotic symptoms. Are healthy individuals who display the bias also prone to endorsing a wider range of beliefs on an instrument like the Cardiff Beliefs Questionnaire (Pechey and Halligan, 2010)? Alternatively, do such individuals show deficits in other forms of reality testing when compared with non-jump-to-conclusions participants?

The study of aberrant salience in psychosis remains underdeveloped, despite a significant influence on the theoretical literature. The present discussion suggests some significant limitations with the experimental approach to studying the phenomenon. However, self-reported aberrant salience (as measured by the ASI) captures an aspect of subjective experience that is of great importance to the theory. Two types of study could now significantly contribute to our understanding of the role of aberrant salience in the onset and development of psychosis. First, longitudinal self-report studies are required in order to discern whether experiences of aberrant salience genuinely precede the onset of full-blown psychosis, and thus whether they seem to play the role that has been theoretically assigned to them. Evidence that documented the onset of subjective feelings of elevated salience prior to the emergence of symptoms, and demonstrated an association between those experiences and symptoms, would lend stronger evidence to the supposition that salience dysregulation is an important causal mechanism. Second, more detailed studies are required to explore whether aberrant salience plays a role in all positive psychotic symptoms (as predicted by Kapur, 2003) or more so in some than in others. In the growing literature on specific psychotic symptoms, more weight is generally given to aberrant salience in theories of delusion formation (see e.g. Gurin and Blum, 2017) than it is in theories of auditory

hallucinations. Studies that compare groups with different sorts of positive psychotic symptoms (hallucinations vs. delusions) could provide evidence that bears on the relative importance of this experience in different symptomatic presentations.

Appendix A:
Beads Task: Behavioral Observations:

In the current study, participants were observed during administration of the beads task, providing some insight into how they approached it. This revealed the presence of some idiosyncratic reasoning processes in participants' approach to the task, which may have implications for how the results from the beads task are interpreted. It appears to be a general assumption that participants approach the task in an intuitive manner, without making calculations, just waiting for the feeling that they have seen enough beads to decide. If this assumption is incorrect, the reporting of the numeric "draws to decision" variable may not provide a consistent picture of the reasoning style used by participants. In the rest of this section I outline these apparent idiosyncrasies, and discuss their implications for the interpretation of the beads task.

As expected, the modal style of reasoning on the beads task in current participants did appear to be an attempt to get an imprecise, good enough sense of which of the two jars the beads were coming from. Participants seemed to wait until they had an intuitive feeling that they knew which jar was most likely. However, some participants approached the task in an idiosyncratic way. One participant (who was recruited as a "high" participant, but who endorsed only seven DAPPS on the day of the experiment) stopped the experimenter after hearing the instructions and before the beads were shown. He reported that he could tell me in advance that he would like to see eight beads on the 85:15 version and that he would decide after the eighth. On the 60:40 version he reported that he would like to see ten beads and that he would decide after that. Another participant ("high"; nine DAPPS) drew fewer beads than average in both conditions (four on the 85:15 version and seven on the 60:40 version), but requested at the start

of the procedure that the experimenter wait a moment as she would be able to work out how to calculate it. She also responded to the verbal instruction "only decide when you are certain" by saying "I'm never certain!"[6] When the experimenter asked how she was calculating, she replied that she was just trying to work it out, and did not mention a specific approach (e.g. applying Bayes' Theorem). These two (high scoring) individuals are reasoning unusually cautiously, but the number of beads they draw (lower than average) does not reflect this. It is unclear whether their reasoning style should be regarded as optimal (it is, after all, apparently informed by an arithmetic approach) or obsessive and inefficient. Interpreted within the theoretical framework of the two factor model, these participants' behaviors on the beads task could be taken as indicative of an exceptionally careful approach to reality testing. Such care could keep in check their unusually high level of distressing attenuated psychotic experiences. Their cautious precision may represent a coping style in the face of anomalous experiences, but this is not reflected in the sheer number of beads they drew.

Other participant behaviors also suggested the need for caution in interpreting the results of the beads task. One participant ("high"; endorsing nine DAPPS) may have misunderstood the task, drawing the maximum amount of beads (20) on the 85:15 ratio. When queried about her approach, she reported that she had been trying to wait until fifteen of one color had appeared and beads of that kind stopped being drawn, at which point she could have been sure the jar was mainly the other color. This approach seems to eschew the purely subjective feeling of certainty that beads task participants are theoretically proposed to rely on, and might be viewed as a highly cautious but hopelessly inefficient strategy. She drew 19 beads on the 60:40 version, and seemed

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[6] This verbal response also reveals the subjectivity of the instruction prompt. It is possible that this participant was distracted by a demand for certainty, which may have felt impossible to her, and could have influenced how she responded to the task.

to rely on a subjective sense of probability rather than using the elimination strategy from the 85:15 version. With the 60:40 version, such a strategy would have required the viewing of 40 beads. A "low" participant (two DAPPS) drew only one bead before deciding on the 60:40 version (which she saw first) and then five on the 85:15 version. When asked about her approach she reported that she had "just had a feeling" on the 60:40 version that the beads were coming from the mainly blue jar, but in retrospect wished she had seen more. Such an individual might be said to be "jumping to conclusions," but her behavior became paradoxically more conservative when presented with an easier version of the task. Her behavior on the 60:40 version may have represented a fleeting experience of certainty that did not generalize to the other version, or it may have represented a failure to understand the task. These observations were made by chance, and were not the result of a systematic exploration of how people reasoned, but they nonetheless reveal a potential flaw in the assumptions that underlie the use of the beads task to understand probabilistic reasoning.

Appendix B: Results with alternative groupings

In the following appendix, data are presented on the two alternative groupings discussed in the results section.

Table 1: Demographic characteristics of low/high participants by alternate groupings:

	Grouping 2		Grouping 3		Total Sample
	Low	High	Low	High	
Age Mean (SD)	21.4 (4.03)	19.8 (2.14)	21.5 (4.19)	20.17 (2.27)	20.5 (3.33)
Male n (%)	10 (17.85)	14 (25)	(37.5)	11 (45.8)	24 (42.85)
Female n (%)	19 (33.92)	13 (23.21)	15 (62.5)	13 (54.2)	32 (57.14)
Hispanic n (%)	6 (10.7)	15 (26.78)	3 (12.5)	14 (58.3)	21 (37.5)
Asian n (%)	11 (19.64)	5 (8.92)	10 (41.7)	5 (20.8)	16 (28.57)
Black n (%)	6 (10.7)	4 (7.14)	5 (20.8)	2 (12.5)	10 (17.85)
Other n (%)	6 (10.7)	3 (5.37)	6 (25)	2 (8.3)	9 (16.07)

Table 2. Average Distressing Attenuated Positive Psychotic Symptoms in low/high by alternate groupings:

	Grouping 2 (PQ status at experiment) (n=57)		Grouping 3 (Stable PQ status) (n=48)	
	High (n=30)	Low (n=27)	High (n=24)	Low (n=24)
Total DAPPS	12.92 (3.62)	1.41 (1.5)	12.29 (13.93)	1.16 (1.37)
Total Positive PQ	44.07 (20.74)	14.19 (14.47)	43 (22.2)	12.58 (3.9)

B.1. Reaction times broken down by block and low/high classification, for each of the three groupings:

In the following series of tables, descriptive SAT data is provided, broken down into low/high group comparisons. The data is provided separately for each of the two alternate sets of low/high groupings. For each grouping, three tables are included. In the first table, Mean and SD reaction time data are provided for the low and the high group in Block 1, Block 2 and overall.

In the second table, these data are further broken down by the different types of stimulus that participants responded to. Low and high validity stimuli refer to whether the stimuli were predictive of a reward or not (i.e. "high validity" stimuli are predictive of a reward). Stimuli were colored either red or blue, and were either animals or household objects. Out of these four stimulus dimensions, one dimension (e.g. animals) would be rewarded; other stimuli (e.g. household objects) would not be. The "task irrelevant" dimension of the stimulus was that aspect

that was not predictive of the presence or absence of reward (in this example, color). The "task-irrelevant" reaction times refer to the average reaction time to the different levels of the task irrelevant stimulus (RTs to red and blue objects). The terms "task irrelevant high" and "task irrelevant low" refer to whichever color participants responded more quickly to.

In the third table estimates of salience attribution are extracted from the reaction time data as follows. Subtracting High Validity reaction times from Low Validity reaction times at the group level provides a measure of the extent of speeding to rewarded trials. Roiser et al. (2009) term this differential "adaptive salience". It is implicit because it is derived from a behavioral measure. Subtracting reaction times to one form of task irrelevant stimulus (i.e. red animals on a trial when blue stimuli are being rewarded) from reaction times to the other form of task irrelevant stimulus yields a measure of aberrant salience. A totally rational participant in the SAT would not demonstrate speeding toward one or the other level of the task-irrelevant stimulus. An individual who assigns aberrant salience might be expected to show a pattern of speeding toward stimuli that are not being rewarded. Implicit salience data for Grouping 1 are shown in Table X. below.

Grouping 2:

Table 3. Grouping 2 reaction time data by group and block

	Low (n=25)		High (n=18)	
	Mean RT	SD	Mean RT	SD
Block 1	257.49	48.68	266.98	56.94
Block 2	265.51	57.98	255.43	42.79
Overall	261.50	51.92	261.20	48.99

Table 4. Grouping 2 reaction time data by group, block and stimulus validity

	Low (n=25)		High (n=18)	
	Mean RT	SD	Mean RT	SD
Block 1 High Validity	259.37	48.42	263.60	56.90
Block 1 Low Validity	255.61	51.06	270.35	58.67
Block 2 High Validity	262.71	56.82	251.95	42.29
Block 2 Low Validity	268.32	64.19	258.91	45.56
Block 1 Irrelevant High	262.71	56.82	280.23	64.82
Block 1 Irrelevant Low	248.94	54.06	261.01	57.31
Block 2 Irrelevant High	269.10	77.79	263.71	51.35
Block 2 Irrelevant Low	262.68	57.49	261.31	52.31
Overall High Validity	261.04	50.77	257.78	48.33

Overall Low Validity	261.97	54.90	264.63	51.02

Table 5. Grouping 2 implicit salience data by group and block

		Low (n=25)	High (n=18)
Block 1	Implicit Adaptive Salience (ms)	-3.75 (20.61)	6.74 (19.82)
	Implicit Aberrant Salience (ms)	15.65 (34.07)	6.41 (43.87)
Block 2	Implicit Adaptive Salience (ms)	5.61 (35.37)	6.95 (20.16)
	Implicit Aberrant Salience (ms)	19.22 (35.55)	2.39 (48.58)

Grouping 3:

Table 6. Grouping 3 reaction time data by group and block

	Low (n=22)		High (n=15)	
	Mean RT	SD	Mean RT	SD
Block 1	251.30	48.64	253.96	41.92
Block 2	258.61	56.84	249.07	36.76
Overall	254.95	51.60	251.51	38.59

Table 7. Grouping 3 reaction time data by group, block and stimulus validity

	Low (n=22)		High (n=15)	
	Mean RT	SD	Mean RT	SD
Block 1 High Validity	253.28	48.44	250.7	43.36
Block 1 Low Validity	249.32	51.10	257.22	43.09
Block 2 High Validity	254.23	54.16	244.17	36.39
Block 2 Low Validity	262.99	63.5	253.97	38.39
Block 1 Irrelevant High	259.29	56.85	266.32	51.37
Block 1 Irrelevant Low	241.69	52.92	250.04	41.44
Block 2 Irrelevant High	260.51	75.46	256.54	38.21
Block 2 Irrelevant Low	259.80	57.98	251.01	49.36
Overall High Validity	253.75	49.63	247.43	40.64
Overall Low Validity	256.16	54.85	255.6	41.92

Table 8. Grouping 3 implicit salience data by group and block

		Low (n=22)	High (n=15)
Block 1	Implicit Adaptive Salience (ms)	-3.95 (21.26)	6.5 (21.08)
	Implicit Aberrant Salience (ms)	17.60 (34.59)	16.27 (34.7)
Block 2	Implicit Adaptive Salience (ms)	8.76 (31.74)	9.8 (19.86)
	Implicit Aberrant Salience (ms)	0.7 (43.3)	5.5 (39.52)

B.2. SAT VAS Rating data:

In addition to reacting with a key press across 128 trials, participants are asked, at the end of each block of 64 trials, to provide a subjective probability rating on a Visual Analogue Scale (VAS) of how often they were received money for different types of stimuli (red/blue/animal/household object). Average VAS ratings for each group are presented in the tables below.

Grouping 2:

Table 9. Grouping 2 VAS rating and explicit salience data by group, block and stimulus validity

		Low (n=25)	High (n=18)
Block 1	VAS High Probability	62.40 (16.88)	68.89 (11.06)
	VAS Low Probability	26.40 (16.81)	28.44 (22.137)
	VAS irrelevant "high"	57.16 (14.12)	51.39 (11.40)
	VAS irrelevant "low"	45.80 (16.75)	46.44 (15.05)
	Explicit Adaptive Salience (%)	36 (28)	40.44 (28.76)
	Explicit Aberrant Salience (%)	11.36 (18.76)	4.94 (24.62)
Block 2	VAS High Probability	63.63 (18.05)	65.89 (14.01)
	VAS Low Probability	33.64 (20.18)	40.06 (13.22)
	VAS irrelevant "high"	38.96 (18.49)	37.11 (17.99)
	VAS irrelevant "low"	49.24 (19.13)	62.72 (10.02)
	Explicit Adaptive Salience (%)	30 (35.53)	25.83 (22.54)
	Explicit Aberrant Salience (%)	10.28 (27.70)	25.61 (25.61)

Grouping 3:

Table 10. Grouping 3 VAS rating and explicit salience data by group, block and stimulus validity

		Low (n=22)	High (n=15)
Block 1	VAS High Probability	60.59 (16.9)	69.2 (10.7)
	VAS Low Probability	27.14 (17.57)	30.73 (23.6)
	VAS irrelevant "high"	57.64 (14.85)	50.8 (12.06)
	VAS irrelevant "low"	44.55 (16.97)	48.73 (14.84)
	Explicit Adaptive Salience (%)	33.45 (28.61)	38.46 (30.34)
	Explicit Aberrant Salience (%)	18.9 (11.94)	17 (17.97)
Block 2	VAS High Probability	62.91 (18.78)	66.8 (14.63)
	VAS Low Probability	33.41 (20.44)	40.87 (13.67)
	VAS irrelevant "high"	51.18 (18.1)	62.93 (9.64)
	VAS irrelevant "low"	37.7 (18.25)	38.2 (18.52)
	Explicit Adaptive Salience (%)	29.5 (36.45)	25.93 (24)
	Explicit Aberrant Salience (%)	22.13 (22.13)	27.8 (22.69)

Grouping 2 & 3:

To explore differences between the task-irrelevant levels of the stimulus over time (i.e. changes in aberrant salience), reaction time data were entered into a mixed ANOVA model, with Block (1 vs. 2) and Mean RT to the two levels of the task-irrelevant stimulus (High vs, Low) as within subjects factors, and group as the between subjects factor. There were no main effects and no interactions.

B.4. Self Report Aberrant Salience Data:

      56 participants completed the Aberrant Salience Inventory, data for three participants was incomplete or lost. Group means for the remaining 53 participants are presented in table 3., organized into the three different PQ groupings.

Table 11: Self-Report Aberrant Salience Data by group:

	Grouping 2: PQ status at time of experiment		**Grouping 3: Longitudinal PQ status**	
	High (n=25)	Low (n=29)	High (n=22)	Low (n=24)
ASI mean (sd)	17.04 (6.4)	11.45 (7.6)	18.27 (5.9)	9.79 (5.9)

B.5. Probabilistic Reasoning Data:

62 participants completed the probabilistic reasoning (beads) task. The outcome for this task was the number of beads drawn before participants felt certain they knew which jar the beads were coming from. Mean draws to decision for each group are presented in table 23. The distributions of these draws to decisions are presented in graphs 1 and 2.

Table 12. Mean Draws to Decision (DTD) for "high" and "low" groups, across three groupings:

	Grouping 2: PQ status at time of experiment (n=57)		**Grouping 3: Longitudinal PQ status (n=48)**	
	High (n=27)	Low (n=30)	High (n=24)	Low (n=24)
85:15 mean DTD (sd)	6.81 (4.1)	6.27 (3.75)	7.33 (4.23)	6.08 (3.75)
60:40 mean DTD (sd)	10.3 (4.2)	9.40 (3.7)	10.75 (4.19)	9.29 (4.07)

B.6. Group differences:

To assess for DAPPS high vs low group differences on the test variables, multiple

independent t-tests were conducted to compare group (high vs. low) means for VAS adaptive

salience block 1, VAS adaptive salience block 2, VAS aberrant salience block 1, VAS aberrant

salience block 2 the ASI, the 85:15 version of the beads task and the 60:40 version of the beads

task. A Bonferroni correction was applied for multiple (7) comparisons, so that the threshold for

a significant finding was a p-value of 0.007. Results of multiple comparisons for Groupings two

and three are shown in tables 13 and 14, below.

Table 13-Grouping 2: Multiple t-tests of group mean differences on five test variables:

Variable	t-value	p-value
ASI Mean score	2.87 (df=41)	0.006*
Beads (85:15)	0.52 (df=55)	0.60
Beads (60:40)	1.84 (df=55)	0.40
VAS adaptive Salience B1	0.50 (df=41)	0.61
VAS aberrant Salience B1	0.22 (df=41)	0.82
VAS adaptive Salience B2	0.43 (df=41)	0.66
VAS aberrant Salience B2	1.31 (df=41)	0.19

*=significant at p=0.007.

Table 14-Grouping 3: Multiple t-tests of group mean differences on five test variables:

Variable	t-value	p-value
ASI Mean score	4.83 (df=44)	<0.001*
Beads (85:15)	1.08 (df=46)	0.28
Beads (60:40)	1.22 (df=46)	0.22
VAS adaptive Salience B1	0.51 (df=35)	0.61
VAS aberrant Salience B1	0.38 (df=35)	0.70
VAS adaptive Salience B2	0.33 (df=35)	0.74
VAS aberrant Salience B2	1.28 (df=35)	0.20

*=significant at p=0.007.

In both groupings, the only significant difference between groups was on mean total ASI score, suggesting that the groups here did not differ in terms of their draws to decision performance or their aberrant salience attribution during a probabilistic learning task.

To test for the possibility that probabilistic reasoning moderates the association between aberrant salience and DAPPS, logistic regression analyses were completed for Groupings two and three, using ASI aberrant salience and draws to decision for the two different versions of the beads task as predictors. Self-reported experiences of aberrant salience were associated with increased odds of belonging to the "high" DAPPS group, confirming the first hypothesis of the present study. Draws to decision was not reliably associated with increased odds of belonging to the high DAPPS group for either version of the beads task. To examine the interaction between aberrant salience and performance on the beads task, a third variable was computed to represent the multiplicative term of aberrant salience and draws to decision on the beads task. The interaction for both models was non-significant, suggesting that performance on the beads task does not moderate the relationship between aberrant salience and DAPPS.

Table 16-Grouping 2 Logistic regression predicting High/Low DAPPS status using Aberrant Salience (ASI) and 85:15 Beads Task results:

	OR	95% CI	b (SE)	P
Aberrant Salience (ASI)	1.13	1.02-1.24	0.12 (0.5)	0.01*
Beads 85:15	1.17	0.62-2.11	0.14 (1.6)	0.92

Table 176-Grouping 2 Logistic regression predicting High/Low DAPPS status using Aberrant Salience (ASI) and 60:40 Beads Task results:

	OR	95% CI	b (SE)	P
Aberrant Salience (ASI)	1.123	1.02-1.23	0.17 (0.5)	0.01*
Beads 60:40	0.00	0.00	-19.85 (0.)	1.00

Table 187-Grouping 3 Logistic regression predicting High/Low DAPPS status using Aberrant Salience (ASI) and 85:15 Beads Task results:

	OR	95% CI	b (SE)	P
Aberrant Salience (ASI)	1.21	1.06-1.38	0.19 (0.69)	0.05*
Beads 85:15	1.09	0.18-65.04	0.09 (2.08)	0.96

Table 198-Grouping 3 Logistic regression predicting High/Low DAPPS status using Aberrant Salience (ASI) and 60:40 Beads Task results:

	OR	95% CI	b (SE)	P
Aberrant Salience (ASI)	1.12	1.05-1.28	0.19 (0.69)	<0.01*
Beads 60:40	0.00	0.00	19.16 (>100)	0.00

Appendix C: Prodromal Questionnaire (PQ):

Indicate how often you have had the following thoughts, feelings and experiences on average, in the last month, by choosing the appropriate answer on the scale for each item. Do not include experiences while using alcohol, drugs or medications.

For any item response greater than 0, please indicate if that experience has been distressing to you. Please answer all of the questions, and if you are unsure, choose the answer that you think is best.

Indicate that you have read the above instructions: Yes or No
For each Question choose one of the following answers: 0-----1-2 times-----once/week-----few Times/week-----daily and distress Yes/NO

Question
In the last month:
i. Indicate that you have read the above instructions: Yes or No
1. I have been distracted by noises or other people talking.
2. The passage of time has felt unnaturally faster or slower than usual.
3. I have had difficulty organizing my thoughts or finding the right words.
4. When I looked at a person or at myself in a mirror, I have seen the face change right before my eyes.
5. I have noticed strange feelings on or just beneath my skin, like bugs crawling.
6. I have not gotten along well with people at school or at work.
7. Previously familiar surroundings have seemed strange, confusing, threatening or unreal.
8. I seemed to live through events exactly as they happened before (déjà vu).
9. I have smelled or tasted things that other people didn't notice.
10. I have had difficulty concentrating, listening or reading.
11. I have had troubles at school or work.
12. I have thought that other people could read my mind.
13. I have heard things other people couldn't hear like voices of people whispering or talking.
14. I have had difficulty expressing my feelings as well as I used to.
15. I have had difficulty expressing my feelings as well as I used to.
16. I have noticed a sense of not knowing who I am.
17. I have noticed that I am less interested than I used to be in keeping clean or dressing well.
18. I have heard unusual sounds like banging, clicking, hissing, clapping or ringing in my ears.
19. I have mistaken shadows for people or noises for voices.
20. Things have appeared different from the way they usually do (brighter or duller, larger or smaller, or changed in some other way).
21. I have been very quiet and have kept in the background on social occasions.
22. People have stared at me because of my odd appearance.
23. I have wandered off the topic or rambled on too much when I was speaking.
24. I have had experiences with telepathy, psychic forces, or fortune-telling.
25. I have thought that other people had it in for me.
26. My sense of smell has seemed unusually strong.
27. I have felt that I was not in control of my own ideas or thoughts.
28. I have felt unhappy or depressed.
29. Everyday things have affected me more than they used to.

30. I have thought that I am very important or have abilities that are out of the ordinary.
31. Other people have thought that I was a little strange.
32. My thoughts have seemed to be broadcast out loud so that other people knew what I was thinking.
33. I have had nothing to say or very little to say.
34. I have felt unusually sensitive to noise.
35. I have had superstitious thoughts.
36. I have heard my own thoughts as if they were outside of my head.
37. I have had trouble focusing on one thought at a time.
38. I have felt that other people were watching me or talking about me.
39. I have gotten very nervous when I had to make polite conversation.
40. People have commented on my unusual mannerisms and habits.
41. I have been less interested in school or work.
42. I have found it hard to be emotionally close to other people.
43. I have avoided social activities with other people.
44. I have felt very guilty.
45. I have thought that I am an odd, unusual person.
46. I have thought that things I saw on the TV or read in the newspaper had a special meaning for me.
47. My moods have been highly changeable and unstable.
48. I have felt unable to enjoy things that I used to enjoy.
49. My thinking has felt confused, muddled, or disturbed in some way.
50. I have felt suddenly distracted by distant sounds that I am not normally aware of.
51. I have been talking to myself.
52. I have had the sense that some person or force was around me, even though I could not see anyone.
53. I have been in danger of failing out of school, or of being fired from my job.
54. I have engaged in some eccentric (odd) habits.
55. I have been worried that something may be wrong with my mind.
56. I have felt that I didn't exist, the world didn't exist, or that I was dead.
57. I have been confused whether something I experienced was real or imaginary.
58. People have found me to be aloof and distant.
59. I have tended to keep my feelings to myself.
60. I have experienced unusual bodily sensations such as tingling, pulling, pressure, aches, burning, cold, numbness, shooting pains, vibrations or electricity.
61. I have thought about beliefs that other people would find unusual or bizarre.
62. People have said that my ideas were strange or illogical.
63. I have felt worthless.
64. I have felt that parts of my body had changed in some way, or that parts of my body were working differently than before.
65. My thoughts have been so strong that I could almost hear them.
66. I have not been very good at returning social courtesies and gestures.
67. I have seen special meanings in advertisements, shop windows, or in the way things were arranged around me.
68. I have picked up hidden threats or put-downs from what people said or did.
69. I have used words in unusual ways.

70. I have felt angry, easily irritated or offended.
71. I have felt like I was looking at myself as in a movie, or that I was a spectator in my own life.
72. I have been less able to do usual activities or tasks.
73. I have not been sleeping well.
74. I have felt that some person or force interfered with my thinking or put thoughts into my head.
75. I have had experiences with the supernatural, astrology, seeing the future or UFOs.
76. People have dropped hints about me or said things with a double meaning.
77. I have been concerned that my closest friends and co-workers were not really loyal or trustworthy.
78. I have had little interest in getting to know other people.
79. I have seen unusual things like flashes, flames, blinding light or geometric figures.
80. I have been extremely anxious when meeting people for the first time.
81. I have felt like I was at a distance from myself, as if I were outside my own body or that a part of my body did not belong to me.
82. I have found that when something sad happened, I was no longer able to feel sadness, or when something joyful happened, I could not feel happy.
83. I have been crying.
84. I have seen things that other people apparently couldn't see.
85. I have felt unable to carry out everyday tasks because of fatigue or lack of motivation.
86. Everyday things have been more stressful than before, like school or work, social situations, deadlines or changes in a schedule.
87. I have avoided going to places where there were many people because I get anxious.
88. I have felt more nervous or anxious, and have found it hard to relax.
89. I have felt uninterested in the things I used to enjoy.
90. People have found it hard to understand what I say.
91. I have had trouble remembering things.
92. People have said that I seemed 'spacey' or 'out of it.'
93. I have felt like I had lost my sense of myself or felt disconnected from my life.
94. I have felt afraid.
95. In the past month I have received counseling or mental health services, or sought out help for emotional/psychological difficulties.

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