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Cognitive and Neural Models of Threat Appraisal in Psychosis: A theoretical integration

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Abstract

Cognitive models of psychosis propose that maladaptive appraisals of anomalous experiences contribute to distress and disability in psychosis. Attentional, attributional and reasoning biases are hypothesised to drive these threat-based appraisals. Experimental and self-report data have provided support for the presence of these biases in psychosis populations, but recently there have been calls for neurobiological data to be integrated into these findings. Currently, little investigation has been conducted into the neural correlates of maladaptive appraisals. Experimental and neuroimaging research in social cognition employing threatening stimuli provide the closest equivalent of maladaptive appraisal in psychosis. Consequently, a rapprochement of these two literatures was attempted in order to identify neural networks relevant to threat appraisal in psychosis. This revealed overlapping models of aberrant emotion processing in anxiety and schizophrenia, encompassing the amygdala, insula, hippocampus, anterior cingulate cortex, and prefrontal cortex. These models posit that aberrant activity in these systems relates to altered emotional significance detection and affect regulation, providing a conceptual overlap with threat appraisal in psychosis, specifically attentional and attributional biases towards threat. It remains to be seen if direct examination of these biases using neuroimaging paradigms supports the theoretical integration of extant models of emotion processing and maladaptive appraisals in psychosis.

Keywords:

Psychosis, neuroimaging, cognition

Introduction

In recent years there have been calls for a re-evaluation of psychosis as a unitary construct with clearly defined diagnostic boundaries (Keshavan et al., 2011). This comes in the light of evidence from multiple fields of inquiry including genetics, neuroscience, epidemiology, and cognitive psychology (Kaymaz and van Os, 2010). Notable among these findings is that several major psychiatric disorders, including schizophrenia and bipolar disorder, show overlapping genetic risk (Serretti and Fabbri, 2013; Williams et al., 2010). This is particularly significant as the evidence is derived from large-scale genome-wide association studies, using the very techniques biological psychiatrists employ to bolster the categorical view.

In addition to undermining diagnostic boundaries, epidemiological studies show a continuity of psychotic experiences extending from clinical patients to the general population, with recent meta-analyses finding a much higher prevalence rate for subclinical psychotic experiences in the general population than the incidence rate of clinical psychotic disorder (Linscott and van Os, 2013; van Os et al., 2009). Sub-threshold experiences are generally associated with distress and impairment (DeVylder et al., 2015; Kelleher et al., 2015), and increase the risk of developing a psychotic disorder (Dominguez et al., 2011). However, a minority of individuals in the general population report persistent psychotic experiences without distress or help-seeking behaviour, and remain high functioning (Peters et al., 2016). The persistent experiences in this group are indistinct phenomenologically (Daalman et al., 2011; Heriot-Maitland et al., 2012) and at the level of brain activity (Barkus et al., 2007; Diederen et al., 2012) from clinically relevant psychotic symptoms, implying that these experiences are not in and of themselves pathological.

What constitutes a ‘need for care’ may therefore be determined by factors secondary to psychotic experiences, such as resulting distress and disability. Indeed, related distress, as well as the frequency, duration, and negative emotional valence of auditory hallucinations, has been found to provide greater predictive ability for distinguishing clinical patients from non-need for care

individuals than topographical features such as loudness, location or personification (Johns et al., 2014). Similarly, associated distress and preoccupation, rather than degree of conviction, would appear to affect the clinical outcome of delusions (Lincoln, 2007; Peters et al., 1999; Sisti et al., 2012).

According to cognitive models of psychosis (Bentall et al., 2001; Bentall et al., 2007; Garety et al., 2007; Garety et al., 2001; Morrison, 2001), a key influence in the distress experienced by 'need for care' individuals is the negative interpretation or 'appraisal' of anomalous experiences. Clinical groups tend to endorse maladaptive appraisals characterised by perceptions of external, personalised threat, in contrast to the benign or even positive appraisals reported by non-need for care groups (Brett et al., 2007; Lovatt et al., 2010; Ward et al., 2014), which in turn are predictive of less distress (Brett et al., 2014).

Reasoning, attentional, and attributional biases are thought to shape these threat-based appraisals (Garety et al., 2001). While the 'jumping-to-conclusions' (JTC) bias and attributional style in psychosis have been extensively studied (For a review, see Garety and Freeman, 2013), other biases remain relatively under-researched, with two recent questionnaires having been developed to help address this gap (Peters et al., 2014; van der Gaag et al., 2013). Pertinently, a recent review of the cognitive underpinnings of paranoid psychosis highlighted potentially applicable interpretation and information-processing biases that have previously been associated with affective disorders (Savulich et al., 2012). It was noted that while these biases have considerable supporting evidence within the affective literature, few experimental studies have been conducted linking them to psychosis.

In contrast, complementing the clinical literature is a considerable body of experimental and neuroimaging data on threat processing in anxiety and psychosis (Green and Phillips, 2004). Studies investigating social cognition and the neuroscience of threat have revealed findings which echo cognitive accounts of appraisal in clinical research, even employing analogous terminology (Tone and Davis, 2012).

Altogether this demonstrates the need, as has been recently articulated (Garety et al., 2007; Howes and Murray, 2014), for a rapprochement of clinical, cognitive, and neurobiological approaches to threat appraisal in psychosis by integrating experimental and neuroimaging data from these multiple literatures. Additionally, bearing in mind the mounting evidence for psychosis lying on a continuum, it would be beneficial for research to focus on aetiologically relevant but non-disorder specific cognitive mechanisms in the pathway to psychotic illness. In this review, an attempt will be made to integrate multiple literatures on the cognitive and neural mechanisms underlying threat appraisal, relating them to psychosis. In order to better define the expansive term "appraisal", literature from several cognitive domains will be reviewed, including attention, reasoning, and interpretation. Subsequently, neurobiological models potentially relevant to the biases underlying threat appraisal will be outlined.

1. Need for care and appraisal in psychosis

As stated earlier, cognitive models of the positive symptoms of psychosis have in common the proposal that a principal factor in the transition to a 'need for care' is the cognitive 'appraisal' of the content and meaning of anomalous perceptual experiences. More specifically, Garety et al's model (Garety et al., 2007; Garety et al., 2001) suggests that individuals who appraise anomalous experiences as externally located, uncontrollable, and personally significant in nature, are more likely to experience distress and disability. Longitudinal studies of children and adults support these claims, indicating that the temporal relationship between hallucinatory experiences and patient status is cognitively mediated by negative beliefs and a perceived lack of control (Escher et al., 2002; Krabbendam et al., 2004; Krabbendam et al., 2005).

1.1. Defining appraisal

In considering research on appraisal across different literatures, a clear definition will aid in limiting the scope of summarised findings to only the most relevant data. The term 'appraisal' is in part derived from clinically-oriented, self-report data, and perhaps ill-suited to a strictly cognitive, experimental approach.

A more parsimonious definition established within the social cognitive literature states that appraisal is the classification of stimuli in terms of their emotional-motivational significance, which then gives rise to emotional responses (Roseman and Smith, 2001). Beyond emotional valence, appraisal establishes the personal relevance of a stimulus according to the individual's goals and needs (Ellsworth and Scherer, 2003). It is possible that in the case of patients with psychosis, anomalous perceptual stimuli have been evaluated as personally relevant to the goal of maintaining safety. Indeed, maladaptive appraisals often result in behaviours designed to nullify the perceived threat to one's safety (Dudley et al., 2012; Freeman et al., 2001; Gaynor et al., 2013).

1.1.1. Assessing appraisal

A particularly fruitful method of examining the role of appraisal in contributing to a need for care has been to compare patients with non-patient groups reporting psychotic symptoms. These non-patient groups are composed of individuals who report first-rank symptoms or psychotic-like experiences but have never sought nor required treatment, and cannot be considered prodromal (Bak et al., 2003; Linscott and van Os, 2013).

Assessing appraisals in these non-clinical individuals requires a measure appropriate for non-clinical contexts. The Appraisals of Anomalous Experiences Interview (AANEX, Brett et al., 2007) is a semi-structured tool that probes for psychotic experiences without recourse to clinical terminology, and is thus suitable for interviewing non-clinical populations. In line with cognitive models, 'non-need for care' participants have been found to be differentiated from their clinical counterparts by their appraisals: clinical participants, in addition to reporting externalising attributions, endorse significantly more personalising appraisals, regarding their experiences as more distressing, and caused by an agency posing a personal threat (Brett et al., 2007). In contrast, 'non-need for care' participants were primarily characterised by normalising, psychological, and spiritual appraisals with benign or positive emotional valence, although interestingly they also viewed their experiences as externally caused.

Additional research using semi-structured interviews, as well as a handful of studies employing experimentally-induced anomalous experiences, have since corroborated these findings, showing that 'need for care' individuals endorse significantly more 'maladaptive' appraisals of anomalous experiences than those without a need for care (Daalman et al., 2011; Lovatt et al., 2010; Taylor et al., 2013; Ward et al., 2014). A creative approach to measuring appraisals experimentally has been to use virtual reality (Freeman et al., 2008a; Freeman et al., 2003; Valmaggia et al., 2007). By simulating a train ride, Freeman et al. (2010) were able to compare patients and non-patients' perceptions of hostility from computer-generated people with neutral facial expressions. Consistent with the continuum view of persecutory delusions, the clinical and non-clinical high paranoia groups were differentiated from their non-paranoid counterparts by their degree of persecutory attributions and accompanying worry.

Overall this suggests that maladaptive appraisals are indicative of a general information processing style present in 'need for care' individuals in which neutral or ambiguous stimuli are interpreted as threatening. In fact, delusions have been shown to exist in the absence of anomalous experiences (Bell et al., 2008), implying that maladaptive appraisals reflect a way of interpreting experiences, anomalous or otherwise, that persists over time. This potential dissociation between the aetiology of biased cognition and anomalous perceptual experiences in psychosis underlines the comparability of similar research in other disorders, facilitating their integration into a common literature.

1.1.2. Cognitive biases underlying maladaptive appraisals

Bearing in mind the extensive evidence demonstrating that cognitive deficits are associated with psychotic disorder (Tandon et al., 2008), differences in appraisals between those with and without a 'need for care' may simply reflect differing levels of cognitive impairment. Typically patients with psychosis display deficits in multiple domains, including attention, working memory and executive functioning (Lee and Park, 2005; Riley et al., 2000), which may or may not be impacted by antipsychotic medication (Fusar-Poli et al., 2013; Hutton et al., 2002; Moncrieff, 2011; Radua et al.,

2012). Additionally, clinical groups are consistently found to have lower IQ than non-clinical groups with psychotic symptoms (Brett et al., 2007; Peters et al., 2016). Nevertheless, while cognitive deficits may impair functioning at the global level, cognitive biases independently relate to the selective processing of information leading to the maintenance and severity of threatening appraisals (Savulich et al., 2012). The association between neuropsychological functioning and cognitive biases such as the JTC bias has been investigated, finding only a weak relationship (Woodward et al., 2009), apart from patients with delusions of high conviction, in which an association has been observed (Garety et al., 2013).

In early research on cognitive processes in delusions (Bentall et al., 1994; Garety and Freeman, 1999), an externalising attributional bias and the JTC bias were considered crucial to the maladaptive appraisals in 'need for care' individuals, alongside personalising appraisals (Kinderman and Bentall, 1997). The JTC bias, the most widely researched of biases in cognitive models of psychosis (Fine et al., 2007), describes the phenomenon whereby delusional individuals require less information before accepting a hypothesis as correct (Freeman et al., 2008b). This is principally measured via a task requiring participants to estimate the distribution of coloured beads in a jar(Garety et al., 1991). For example, delusional intensity has been found to negatively correlate with the amount of information participants require before making their decision (Menon et al., 2008).

Nevertheless, the JTC bias has also been reported in delusion-prone individuals (Colbert and Peters, 2002; Lim et al., 2012), as well as remitted psychotic populations (Peters and Garety, 2006). The exact causal role of the JTC bias in the formation of maladaptive appraisals has yet to be fully determined, having been recently criticised for lacking theoretical precision (Fine et al., 2007). It is thought that JTC is part of normal reasoning in the context of danger, as non-delusional participants will show a tendency to confirm threat-related conditional statements (Dudley and Over, 2003). Delusional participants, however, perceive danger where none exists, extending JTC to a non-threatening context, and thus displaying a JTC bias. In this sense, the JTC bias may not directly contribute to a 'need for care', since it may be secondary to the misattribution of threat to a neutral situation.

Similarly, while externalising biases have been shown to be an important cognitive underpinning of hallucinations in source-monitoring, self-monitoring and signal detection studies (Blackwood et al., 2004; Brookwell et al., 2013), evidence indicates that externality is not related to a 'need for care' per se, since 'non-need for care' individuals also report externalising appraisals for their voices (Daalman et al., 2011) and other psychotic experiences (Brett et al., 2007; Lovatt et al., 2010).

It would seem therefore that the persecutory, personalised nature of maladaptive appraisals is what best discriminates those with and without a 'need for care'. This implies that the cognitive biases most significant to a 'need for care' would be those informing threat-based appraisals. Looking at the original cognitive model of psychosis, personalising appraisals appear most applicable; indeed, as mentioned above distressed clinical participants report significantly greater personalising appraisals than non-clinical participants with psychotic symptoms, both of their own (Brett et al., 2007) and experimentally induced (Ward et al., 2014) anomalous experiences. A personalising appraisal can be defined as viewing one's anomalous experiences as being caused by an external agency, who in the case of clinical patients, appears to intend harm. While the pathway to such an appraisal may involve both an externalising bias and a JTC bias, it is the threatening, agential component that most significantly differentiates clinical and non-clinical groups. Therefore, in order to examine the cognitive biases informing threat-based appraisals specifically, it would appear necessary to look beyond Garety et al.'s model, as well as probe literature in other fields.

1.2. Social cognitive view of threat appraisal

With 'appraisal' taken to mean stimulus classification with regard to its emotional-motivational relevance, 'threat appraisal' therefore refers to classifying a stimulus based on its capacity for harming the organism (Britton et al., 2011). Applying this to maladaptive appraisals in psychosis, attributing anomalous perceptual experiences to a malign agency (Brett et al., 2007) can be seen as an aberrant outcome of this classification process, which then results in the negative emotions and distress observed in clinical participants (Taylor et al., 2011). This would echo Freeman's model

of threat anticipation (Freeman, 2007), which combines emotional beliefs, anomalous experiences, and cognitive biases.

Crucially though, the definition proposed here focuses solely on the cognitive underpinnings of threat appraisal and thus lends itself more readily to comparisons across other literatures, such as anxiety (Britton et al., 2011) and fear conditioning (Mechias et al., 2010). In this regard, a recent review attempted to integrate clinical, social cognitive and neuroscientific data on the cognitive biases informing anxiety and paranoia (Tone and Davis, 2012). In both these clinical conditions, as a consequence of variation in adaptive mechanisms that have evolved to facilitate effective threat detection (Green and Phillips, 2004), threat cues can take on excessive salience, resulting in a hyper-vigilance or attentional bias towards threat (Bar-Haim et al., 2007; Gotlib et al., 2004). For example, when asking participant groups with social phobia to identify facial expressions, angry faces require less intensity to be accurately identified than do happy or neutral ones (Joormann and Gotlib, 2006). Equally, this attentional bias has been observed in delusion-prone individuals (Green et al., 2003), and patients with psychosis in a range of studies (Green and Phillips, 2004; Moritz and Laudan, 2007).

Moreover, it has been found that psychotic patients experience strong aversive emotion when processing social stimuli considered to be neutral (Cohen and Minor, 2010). Rather than an impairment for neutral or positive emotion recognition, this misattribution may reflect an interpretative bias where ambiguous or neutral stimuli come to be regarded as negative and threatening. For instance, paranoid schizophrenia patients have been found to over attribute anger to neutral faces (Pinkham et al., 2011), and adults with persecutory delusions often report greater attributions of hostility and aggression than controls when presented with ambiguous social situations (Combs et al., 2009). It is possible that a hyper-vigilance to threatening stimuli in turn leads to the development of this attributional bias. Certainly, training healthy participants to develop an attentional bias towards threat has been found to then bias their interpretation of ambiguous stimuli in a threat-related manner (White et al., 2011).

There is some overlap between the misinterpretation of neutral faces and the biases underlying maladaptive appraisals discussed in cognitive models of psychosis. Freeman et al.'s virtual reality train ride experiments also demonstrate an attributional bias toward threat, as hostile interpretations of virtual passengers' neutral facial expressions were reported by delusion-prone individuals (Freeman et al., 2010; Valmaggia et al., 2007). This attributional bias may also link to the observed preference amongst psychotic patients for attributing ambiguous stimuli as personally relevant. The personalising appraisals reported in response to experimentally-induced anomalous experiences by those with a 'need for care' (Ward et al., 2014), may reflect a consequence of a misattribution of hostility triggering feelings of self-relevant persecution.

Taken together, these findings in social cognition suggest that core to threat appraisals are two cognitive biases, namely an attentional bias and a misattributional bias towards threat. The following sections will explore different models proposing the possible neural basis of these biases.

2. Neurobiology of threat processing

Substantial data for the neural mechanisms of threat processing can be found in fields outside of psychosis, such as anxiety research. Bishop (2008) recently proposed a model of anxiety which describes the neural correlates of a selective attention to threat. This model proposes negatively or anti-correlated activity between 'lower-order' brain areas such as the amygdala, implicated in the detection and evaluation of stimulus salience, and 'higher-order' regions including the lateral prefrontal cortex (PFC) and the anterior cingulate cortex (ACC), thought to control post-perceptual attention and cognitive processing. These lower and higher-order regions correspond to what are often called 'bottom-up' and 'top-down' cognitive processes (Whalen et al., 2013). Bottom-up processes are driven by stimulus characteristics, forming an initial, often unconscious impression (Schiller et al., 2009; Willis and Todorov, 2006). For example, although the amygdala response to threat stimuli is not wholly automatic, it does not require conscious awareness to occur (Bishop et al., 2004; Pessoa et al., 2006). Top-down processing on the other hand is more volitional, integrating contextual

information and changing the meaning of a stimulus such that an initial response can be re-appraised or modulated.

In Bishop's model (Bishop, 2008), it is the interaction between these types of processing that determines state anxiety: a threatening stimulus amplifies the bottom-up amygdala response to a detected threat, which in turn disrupts the top-down attentional control and executive functions of the ACC and lateral PFC (Bishop, 2007). In fact, recent studies have shown that the structural and functional connectivity between these regions is a more robust predictor of emotional response than the activity of each region separately (Kim et al., 2011; Kim and Whalen, 2009).

Excessive threat salience in anxiety disorders may therefore relate to aberrant activity in this amygdala-prefrontal cortex circuit. Evidence from multiple studies indicate that the PFC and related structures down-regulate activity in the amygdala during fear extinction learning (Myers and Davis, 2006; Quirk et al., 2006), and conversely that training in emotional 're-appraisal' of aversive stimuli leads to increased PFC activity and reduced amygdala activity (Eippert et al., 2007; Kim and Hamann, 2007). Hence it is thought that abnormality in the attentional control exerted by the PFC likely corresponds with difficulty in disengaging from threat cues.

Indeed, scanning patients with an anxiety disorder while viewing negative emotional expressions has revealed exaggerated amygdala responsivity coupled with a diminished response in the medial PFC (Shin et al., 2005). Further studies have replicated this pattern of differential activity while exposing adolescent patients and non-patients to negative facial expressions (Monk et al., 2006; Telzer et al., 2008).

Overall, these findings suggest that abnormal activity in various prefrontal regions relates to the development of biased attention towards and away from threat, supporting the assertion that perturbations in PFC activity underlie attentional threat bias by failing to down-regulate activity in the amygdala (Cisler and Koster, 2010). Although Bishop's model focuses explicitly on how aberrant threat processing may contribute to anxiety, it seems plausible that a comparable, if not similar model could apply to psychosis.

2.1. Neurobiology of emotion in the context of schizophrenia

Phillips et al (2003) proposed an intricate model of emotion perception, based on a range of structural and functional neuroimaging studies in schizophrenia, which describes interacting ventral and dorsal systems, rather than opposing frontal and subcortical networks. A ventral system implicating the ventrolateral PFC, the orbitofrontal cortex, the ventral anterior cingulate gyrus, the amygdala, insula, ventral striatum, and brainstem nuclei, is suggested to be responsible for the identification of the emotional significance of a stimulus, and is thought to be largely automatic. Separately, a primarily dorsal system composed of the dorsolateral and dorsomedial PFC, the dorsal anterior cingulate gyrus, and the hippocampus, is thought to be important for the regulation of resultant affective states.

Applying this model to the deficits in emotion perception characteristic of schizophrenia, Phillips et al propose that structural and functional abnormalities in the ventral system, particularly the amygdala, anterior insula, and ventral striatum, may result in anhedonia, flattened affect, and the misinterpretation of ambiguous or neutral stimuli as threatening. This is thought to be exacerbated by impairments in contextual processing and regulation of affective states, relating to abnormalities in the dorsal system, particularly the hippocampus and dorsal PFC regions (Phillips et al., 2003).

This more complex account of the functional neuroanatomy of emotion perception nonetheless bears similarities to Bishop's model, since there is a distinction between autonomic processing and effortful regulation of the ensuing response. Ultimately, in relation to threat appraisal in psychotic illness, both models imply abnormal functioning in regions responsible for the identification of the emotional significance of stimuli such as the amygdala and insula, coupled with a disruption of the regulatory function of regions such as the dorsal PFC, the hippocampus, and ACC structures. Phillips et al depart slightly from Bishop's model by claiming that the dysregulation of these systems accounts for an attributional bias towards threat owing to broader emotional and cognitive deficits such as restricted affect, and anhedonia. However, the attributional bias towards threat has been examined in other disorders such as anxiety, where cognitive deficits do not feature

(Savulich et al., 2012), implying that this bias does not emerge from broader deficits in psychosis. A recent integrative socio-developmental cognitive model of psychosis states that the relationship between psychosis and threat misattribution may be mediated by excess striatal dopamine (Howes and Murray, 2014), specifically in presynaptic dopamine terminals (Howes et al., 2012). Dopamine dysregulation may result in the misattribution of salience to peripheral or irrelevant stimuli, subsequently interpreted as threatening by various cognitive biases.

Currently, no studies have directly examined attentional and attributional threat biases in the context of psychosis using neuroimaging techniques. There is a body of literature examining brain structures important to self-referential processing (Northoff et al., 2006; Schmitz and Johnson, 2007), and their involvement in delusions of reference in schizophrenia (Menon et al., 2011). Aberrant referential ideation, such as the determination of ambiguous stimuli as self-relevant, may bear significance to the understanding of threat biases. However, an in-depth examination of the literature on self-relevance determination falls outside the scope of the current review.

Much of the available data relevant to Phillips et al.'s model, if not threat biases, typically employ facial emotion processing tasks. Our recent review (Underwood et al., 2015) of potential evidence for an attentional and attributional bias towards threat in psychosis employing these tasks suggested, despite various confounding factors and mixed findings, an emerging pattern of abnormal activity and connectivity within and between various regions implicated in the Phillips et al. model.

More specifically, an attentional bias toward negative social stimuli would appear to relate to abnormal functioning and reduced connectivity between ventral regions such as the amygdala and insula, and dorsal structures such as the dorsomedial PFC and hippocampus (Bergé et al., 2014; Das et al., 2007; Kumari et al., 2011; Li et al., 2012; Mukherjee et al., 2012; Satterthwaite et al., 2010; Williams et al., 2007). Still, it is unclear whether this excessive threat salience is due to over-recruitment of 'bottom up' ventral regions or under-recruitment of 'top-down' dorsal regions. Paranoia may partly explain variation in findings, as paranoid patients with schizophrenia show a different pattern of activity changes in many threat-relevant brain regions, including the amygdala,

when compared to non-paranoid patients (Russell et al., 2007; Williams et al., 2007; Williams et al., 2004); a conclusion also echoed by recent fMRI studies (not included in the review) of social cognition (Pinkham et al., 2008) and resting state (Pinkham et al., 2015).

Conversely, evidence for an attributional bias towards threat was clearer, indicating that increased activity (but not connectivity) in both ventral and dorsal streams appear to underlie the evaluation of neutral or ambiguous stimuli as hostile (Habel et al., 2010; Hall et al., 2008; Holt et al., 2006; Mier et al., 2014). Future research explicitly targeting these biases would need to employ paradigms specific to psychosis, such as adaptations of the virtual reality studies of paranoia, or experimental tasks that induce anomalous experiences. In addition, paradigms tapping into non-social threat (e.g. snakes) may provide differing results from those representing social threat, as suggested in a recent behavioural study (Pinkham et al., 2014).

3. Conclusions

Clinical and experimental evidence suggests that it is not the content of one's anomalous experiences but rather how this content is appraised that determines the distress and disability associated with psychotic illness. Evidence from studies comparing those with and without a need for care point to attentional and attributional biases towards threat playing a particularly prominent role in the transition to and maintenance of psychotic illness. Consequently, these biases should be investigated not as peripheral, but aetiologically relevant, directly contributing to the need for care in psychosis. Recent psychological interventions already target these biases directly, indicating a move in this direction within clinical practice (Garety et al., 2015; Moritz et al., 2011).

To date, much of the research into such biases has been conducted within literature pertaining to social cognition, neurobiology, and affective disorders. As a consequence, this review has examined findings across these different literatures, incorporating a parsimonious definition of appraisal as stimulus classification, which provides specificity yet integrates a multitude of approaches.

Viewing the literature in this manner reveals both a model of anxiety involving top-down frontal regions and bottom-up subcortical structures whose activity covaries negatively when processing threatening stimuli, as well as a nuanced model of emotion processing in schizophrenia, involving negatively correlated activity between a regulatory 'dorsal' system, and a 'ventral' emotional significance identification system, overlapping with the anxiety model. While conceptually it has been established in affective disorders that aberrant activity in this network relates to biased attention towards and away from threat, there is a small literature suggesting this may also be the case in psychosis.

Direct examination of these biases using neuroimaging techniques in psychosis populations is needed, with these models as guidance for interpretation of potential findings. It also remains to be seen if similar patterns of activation are observed when comparing patients and non-patients with psychotic experiences. It would be relevant to examine threat-response to experimentally-induced anomalous experiences in clinical and non-clinical groups, particularly since the literature to date has focused solely on studies of social cognition, which primarily employs emotionally aversive stimuli such as negative facial expressions or unpleasant images. Scanning those without a need for care while exposed to experimentally-induced anomalous experiences may reveal alternative or compensatory patterns of activity corresponding to benign or positive appraisals of those experiences.

Ultimately, elucidating the specific networks of activation relevant to threat appraisal in developing a need for care has the potential to increase the focus and efficacy of cognitive interventions designed to target maladaptive appraisals in psychosis.

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Highlights

- Maladaptive appraisals of anomalous experiences in psychosis are driven by attentional and attributional threat biases, and contribute directly to a need for care.
- These biases have been examined using neuroimaging techniques but only in related literatures such as anxiety and social cognition.

- Drawing these literatures together has helped identify neural networks relevant to threat biases in the context of maladaptive appraisals in psychosis