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Emotion Processing in Persons at Risk for Schizophrenia

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Evidence suggests that individuals with schizophrenia demonstrate emotion-processing deficits. However, the nature and extent of emotion abnormalities in individuals considered at risk for schizophrenia have not been previously summarized. This article provides a review of the recent literature pertaining to emotion processing in 3 at-risk populations: those at familial high risk, those with schizotypal characteristics, and those in the putative prodrome to psychosis. Studies are reviewed across the components of emotion perception, experience, and expression. Further, we discuss investigations into psychophysiology, brain structure, and brain function that employ emotion probes. Review of the literature suggests that individuals at high risk demonstrate similar abnormalities to those with schizophrenia but at an attenuated level. The most robust findings in at-risk groups are in the areas of reduced emotion perception, self-reported anhedonia, and increased negative affect. We conclude with an agenda for future research.

Key words: high risk/schizophrenia/emotion/review

Introduction

From the earliest descriptions of schizophrenia, disturbance of affect and aberrant emotion processing have been considered core features. Expressions of apathy and fear were central elements of Kraepelin's[1] description of dementia praecox. In Bleuler's conceptualization,[2] delusions and hallucinations were considered to be secondary to "the four A's," which included disturbed affect. Bleuler also emphasized that individuals with schizophrenia may experience powerful affects despite reduced overt expression and that oversensitivity to emotion is often reported at the beginning of the onset of disease.[2]

Researchers have debated whether emotion abnormalities in schizophrenia are merely a reaction to living with a debilitating illness or, instead, intrinsic components of the pathophysiology of the disorder. More recent theoretical views describe hypohedonia (or "anhedonia"), an inability to experience pleasure, as core to schizophrenia.[3] Meehl suggested that anhedonia stems from genetic factors and is integral to schizotypy, the basic predisposition to schizophrenia. Modern theoretical conceptualizations of schizophrenia continue to include descriptions of emotion disturbances. The most recent edition of the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (*DSM-IV-TR*) contains numerous references to emotion disturbance in schizophrenia, including affective flattening, inappropriate affect, anhedonia, depression, anxiety, and anger.[4] Indeed, individuals with schizophrenia have now been shown to demonstrate abnormalities in emotion perception, emotion experience, emotion regulation, and emotional expression (articles in this issue). Generally, individuals with schizophrenia exhibit impaired emotion perception, intact experience of emotion in the laboratory, reduced self-reported positive experiences, and reduced emotion expression.[5] In addition, individuals with schizophrenia demonstrate abnormal cognitive biases in the context of emotional information. More specifically, individuals with positive or disorganized symptoms exhibit a bias associated with negatively valenced information in the cognitive domains of attention,[6,7] interpretation,[8] memory,[9–11] and language output.[12,13] These emotional processing deficits impact social behavior.[14,15] Thus, substantial evidence points to emotion abnormalities as being intrinsic to the origin of the illness.

Over the past 2 decades, investigation into emotion processing in schizophrenia has been extended to include at-risk groups. However, the extent to which these emotion-processing abnormalities are found in individuals considered at high risk (HR) for schizophrenia has not been systematically reviewed, in contrast to the many reviews of cognition in HR individuals. Research aimed at measuring HR for schizophrenia includes a number of possible populations and experimental approaches.[16,17] As will be evident in this review, in certain domains,

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the abnormalities in those at HR resemble the performance of individuals with schizophrenia; while in others, those at risk demonstrate only attenuated abnormalities or performance comparable to that of healthy controls. The inclusion of HR groups adds insight into the pathophysiology of schizophrenia. By examining performance among different HR groups, constellations of abnormalities might emerge as vulnerability markers or predictors of subsequent onset of schizophrenia. Moreover, studies of HR persons avoid confounds that bedevil schizophrenia research (ie, effects of medications, psychosis, chronicity, and other environmental adversities) and help identify traits that are presumably core parts of the liability to the disorder.

We follow an organizational framework suggested for the study of emotion processing in schizophrenia (eg, Kring[5] and Berenbaum and Oltmanns[18]) that includes sections on emotion perception, emotion experience, and emotion expression. While research suggests that impairment in the processing of one emotion component may be independent of other areas of emotion processing (ie, experience and expression),[19] it is possible that certain instances of emotion abnormality impact the integrity of other forms of emotion processing. Thus, tasks may measure more than one area of emotion processing. Whenever apparent, this overlap will be highlighted.

We review evidence of emotion-processing abnormalities in 3 populations who are at risk for schizophrenia: (1) nonpsychotic individuals (who may or may not be symptomatic) selected on the basis of a family history (FH) of schizophrenia (Persons with an FH of schizophrenia are considered to be at genetic HR because they are presumed to carry some of the same susceptibility genes for the illness as their affected biological relative.); (2) individuals from the general population who demonstrate relatively high levels of schizotypy or signs that resemble attenuated symptoms of schizophrenia; and (3) treatment-seeking individuals in the putative prodrome to schizophrenia, who are displaying early clinical signs of possible psychosis. Finally, we present an agenda for future research and highlight possible targets of intervention.

Articles included in this review were acquired through Medline searches that included terms relevant to emotion and risk for psychosis, such as "high risk," "sibling," "schizotypy," "prodrome," "emotion," "affect," "valence," "arousal," "psychophysiology," "fMRI," and "MRI." Bibliographies in the selected articles also were reviewed for relevant publications. The period of search ended with articles published in June, 2007. Articles were excluded if they did not include reference to emotion and/or include emotion probes as part of the methods.

Overview of HR Approaches

The HR approach implies that certain groups of individuals are considered more vulnerable than others for developing a disorder. By virtue of their genetic relationship, first-degree relatives of individuals with schizophrenia are considered at familial high risk (FHR), regardless of whether or not symptoms or signs are apparent. Individuals at clinical high risk display attenuated signs and symptoms of schizophrenia and can be divided into (1) individuals who report high scores on psychometric measures of schizotypy or who have a *DSM-IV* diagnosis of schizotypal personality disorder (SPD) and (2) those identified to be potentially already on a pathway to psychotic illness, in a putative "prodrome" phase of incipient psychosis.[20,21] Conclusions are complicated by the fact that these 3 groups are not discrete. Individuals who are at FHR may score high in schizotypal characteristics or reach "prodromal" levels of impairment. Similarly, individuals may meet criteria for SPD only or they may reach a threshold of criteria for being considered putatively prodromal. Importantly, being at HR by any set of criteria does not imply that one will definitely develop schizophrenia.[22]

Familial Risk

First-degree, biological full relatives of individuals with schizophrenia share approximately 50% of their genes with their ill relative and are at increased risk for developing the disease, with degree of risk associated with genetic proximity to ill relatives.[23] schizophrenia occurs more often in biological relatives of individuals with schizophrenia than in the general population (eg, Vollema et al[24] and Kremen et al[25]). While the prevalence of schizophrenia is approximately 1% in the general population, the prevalence in first-degree relatives is approximately 6%–13%.[26] Although the risk for developing schizophrenia is increased in those who share genes with an affected individual, only a subgroup of those are presumed to carry susceptibility genes. While the elevated risk of conversion is one feature of FHR for schizophrenia, others who do not develop schizophrenia may have milder versions of the illness such as schizotypal traits, neurocognitive abnormalities, etc.[27] In this article, we will replace the more traditional term "genetic high risk" with "familial high risk" because the field of molecular genetics has redefined the terrain, rendering the conventional terminology less accurate; persons without first-degree relatives with schizophrenia may still be shown to have genetic markers for the illness. Thus, they could be at genetic risk without affected relatives.

There are strengths and weaknesses of the FHR approach. Unlike patients with schizophrenia, or even those in the prodrome, biological relatives typically are neither treatment-seeking nor treated with antipsychotic medications or hospitalization. Thus, any identified impairment is not confounded by putative neurotoxic effects of psychosis or medications. Moreover, in contrast to the prodromal approach, the participants' risk for a specific form of psychosis (ie, schizophrenia vs affective psychosis) can be specified by diagnostically assessing the ill

relative (proband). The FHR approach has yielded many important insights over the past 40 years, and the study of cognition has been among the most fruitful, in which attention, memory, and executive dysfunctions have been robustly demonstrated (eg, Snitz et al[28]). The FHR model contributes to the literature by adding insight into pathophysiological mechanisms of the illness. However, a significant limitation of this method is that it yields low-positive predictive values and high rates of false positives for conversion to psychosis.[21] In addition, it is inefficient because predicting conversion to psychosis may take decades before participants become frankly psychotic. Finally, a large percentage of individuals who develop schizophrenia appear to have neither a first- nor second-degree relative with schizophrenia in their family; thus, the FHR risk method is only generalizable to individuals who have a genetic relationship with an individual with schizophrenia.[29]

Schizotypy

Schizotypal personality traits, such as social isolation, magical thinking, and suspiciousness, are considered subtle characteristics that resemble those that occur with schizophrenia.[30] Whether these signs occur along a continuum in nonclinical populations or whether they are taxonic remain under debate.[31] Schizotypal traits are examined through psychometric measures, including the *DSM-IV* and questionnaires such as the Schizotypal Personality Questionnaire (SPQ),[32] the Structured Interview for Schizotypy,[33] and the Chapman Scales (eg, perceptual aberration, magical ideation, revised social anhedonia scale, and revised physical anhedonia scales).[30,34,35]

Research suggests that schizotypy traits fall into a 3-factor organization, similar to that found in schizophrenia, consisting of: positive (eg, magical ideation, perceptual aberration), negative (eg, physical anhedonia, social anhedonia), and disorganized (eg, disorganized speech and behavior) symptom constellations.[36,37] In addition, subgroups of individuals with schizotypal characteristics exhibit a number of the cognitive abnormalities that occur with schizophrenia, such as in sustained attention, executive functioning, and attentional inhibition (eg, Lenzenweger et al[38]). Importantly, individuals with schizophrenia demonstrate a number of schizotypal characteristics. Higher physical anhedonia has been found in individuals with schizophrenia, as compared with controls, across time and clinical state. Positive schizotypal characteristics, such as magical ideation and perceptual aberration, have been shown to be consistently higher in those with schizophrenia across time and scores fluctuate with clinical state.[39]

The prevalence of SPD is approximately 3%,[4] and 10%–15% of relatives of persons with schizophrenia develop SPD (eg, Lenzenweger and Korfine[40] and Baron et al[41]). Further, schizotypal traits in relatives of individuals with schizophrenia predict conversion, and SPD and prodromal symptoms interact to raise the conversion rate.[22] In particular, social withdrawal, psychotic symptoms, and socioeconomic dysfunction predict future onset of schizophrenia.[42] In addition, individuals who score abnormally high on the revised Social Anhedonia Scale have been found to be at increased risk for developing schizophrenia spectrum illnesses.[43]

In summary, the psychometric HR method identifies persons who exhibit a number of personality and cognitive abnormalities that resemble those that occur with schizophrenia. In addition, like persons at FHR, higher levels of schizotypy predict future conversion to schizophrenia. Thus, investigations that incorporate individuals with schizotypy may be particularly fruitful toward greater understanding of the liability for schizophrenia.

Prodrome

Prodromal approaches typically focus on treatment-seeking individuals who have subthreshold, psychotic-like positive symptoms but who do not meet criteria for unambiguous psychotic disorder.[20,21,44,45] Conversion rates to psychosis after 1 year range from approximately 20%–40%.[22,46–48] With a lower rate of false positives relative to the FHR method, the prodromal method is believed to be a step closer toward early detection. The Personal Assessment and Crisis Evaluation Clinic, established in Melbourne, Australia, in 1994, is one of the first to implement this strategy, and similar approaches have been used by a number of different programs around the world.[22,42,45,47–50] Definitions of the prodrome-risk syndrome typically require at least one of the following 3 criteria: attenuated positive symptoms during the past year, brief experience of psychotic symptoms that have lasted no longer than a week and have spontaneously remitted, or having a significant decrease in functioning over the past year and either manifesting the diagnosis of SPD or having an FH of psychosis. Participants are typically between the age of 12 and 30 and have not experienced a previous psychotic episode.

In summary, these 3 strategies offer considerable insight into the pathophysiology of schizophrenia. A review of emotion in HR populations offers a window into the roots of emotional dysfunction in schizophrenia, apart from disease-related confounds.

Overview of Neural Circuits Relevant to Emotion Processing in Healthy Individuals, schizophrenia, and Its Risk

Emotion processing has been conceptualized and parsed in multiple ways. For example, emotion processing has been theorized to involve: (1) cognitive appraisal and perception, (2) expressive behavior, (3) physiological arousal, and (4) subjective experience.[51] In this review, we describe each of these components in the context of risk for psychosis. Attention is paid to the processing

of discrete emotions, such as Ekman's (1992) 6 prototypical emotions of anger, disgust, fear, joy, sadness, and surprise. Equal consideration is given to emotion conceptualized as a 2-factor motivational system, composed of valence and arousal. This system is theorized to be driven by 2 motives, appetitive (consummatory, sexual, and nurturant) and aversive (protective, withdrawing, and defensive), and these motivations can be activated at low or high levels of arousal.[53] Abnormalities in emotion processing in those at risk for schizophrenia can be seen in reference to both the discrete and dimensional views of emotion.

The brain circuits involved in emotion are complex and are believed to include multiple highly intertwined structures. Two neural systems, a ventral and a dorsal, are integral to emotion processing. The ventral system is involved in identification of the emotional significance of a stimulus, production of affective states, and automatic regulation of an emotional response. Its component structures that are relevant to this review are the amygdala, anterior insula, ventral anterior cingulate cortex, orbital prefrontal cortex, and ventrolateral prefrontal cortex. The dorsal system is thought to be involved in the effortful regulation of affective states and related behaviors. Relevant structures include the hippocampus, dorsal anterior cingulate gyrus, and the dorsolateral prefrontal cortex (DLPFC).[54] Abnormalities in the connections between these 2 systems are associated with abnormalities in emotion perception and identification, emotion experience, and emotion expression (eg, Phillips et al,[55] Williams et al,[56] and Grace[57]).

Emotion Processing in Those at FHR

Emotion Perception

Investigations of emotion perception in those at FHR consist of measures of facial affect identification, recognition of emotion from nonverbal audio and visual scenes, and a questionnaire designed to measure alexithymia. While individuals with schizophrenia consistently demonstrate impaired face emotion judgment,[58] their relatives do not. Various studies have suggested that individuals at FHR have no impairment in facial affect identification regardless of the method (eg, choose 1 of 7 emotion labels that match the emotion of the face; free response format of emotion identification that was later rated by independent judges) or emotion (happiness, sadness, fear, anger, surprise, disgust, and neutral).[59,60]

On tasks that involved more subtle or rapid presentations of stimuli, group differences emerged between those at FHR and healthy controls. On a facial emotion-morphing task, those at FHR performed intermediate between those with schizophrenia and healthy controls, while there were no group differences on a gender-morphing task.[60] In addition, relatives performed most like individuals with schizophrenia when the emotion expression was subtle and resembled the controls in conditions of higher intensities of emotional expression.[61] Group differences between FHR and controls were also found through the profile of nonverbal sensitivity index, consisting of a video of nonverbal audio and visual scenes depicting emotional and social behaviors.[60] In this task, nonverbal cues included video clips of faces, parts of the body, and vocal soundtracks that were either scrambled or electronically filtered so that the content was unclear and presented for relatively brief periods of time. Participants were asked to choose descriptions of everyday life situations that best matched the segment heard or viewed; eg, "jealous anger" or "admiring nature." Finally, similar to male individuals with schizophrenia, males at FHR have demonstrated increased levels of alexithymia, a multidimensional construct that involves both emotion perception and emotion expression.[62,63] More specifically, alexithymia refers to impairment in the inability to accurately perceive, or identify, and verbalize one's own feelings.[62,63] Males at FHR endorsed questionnaire items such as "I find it difficult to verbally express my emotions.[62]"

In summary, rather than demonstrating abnormalities pertaining to specific discrete emotions, deficits are observed in individuals at FHR across different affective expressions when tasks involve more subtle expressions. In addition, individuals at FHR appear to be generally able to navigate within their social environment effectively, except in more subtle and complex social interactions. Future work might benefit from including stimuli in multiple modalities (eg, faces, emotional prosody, and postures) in order to more precisely determine the specificity of emotion perception deficits. Further, stimuli that span a range of affective intensity and subtlety are essential to detection of group differences.

Emotion Experience

Studies that assess emotion experience of individuals at FHR include self-report questionnaires, ratings of emotion experience while viewing emotional slides, and experience-sampling methods. On self-report measures of physical and social anhedonia, individuals at FHR reported anhedonia as compared with controls[64,65] but significantly less anhedonia compared with their ill relatives.[64] In the rating of emotion experience while viewing slides, similar to findings among individuals with schizophrenia, relatives rated their experience (rated how positive or negative the slides made them feel) during positive pictures as less positive relative to controls and did not significantly differ from those with schizophrenia.[66] This finding of altered experience, on the part of those with schizophrenia, is in contrast to the robust findings concerning intact experience of emotion within the laboratory and may also be an exception in the case of those at FHR. Additional studies that employ stimuli in a range of modalities (eg, pictures, film clips, words), as well as

stimuli that are rated on valence and arousal, are necessary to clarify the nature of emotion experience in those with schizophrenia and individuals at FHR.

Through experience-sampling methods, individuals at FHR demonstrated equivalent experience of positive and negative emotions to that experienced by controls.[67] In contrast, in response to everyday activities, an FHR group reported subtle psychotic experience (eg, hallucinations, preoccupation, suspicion, feeling unreal) that was intermediate between the patients and controls.[67] In summary, individuals at FHR report anhedonia and rate slides as being less positive as compared with ratings by controls; however, those at FHR report intact levels of positive and negative affect through experience-sampling methods.

Expression

Studies on emotional expression in those at FHR have included analysis of emotional facial expression in home movies of families that include an individual who later developed schizophrenia, from measures of emotion expression within the laboratory, and a questionnaire designed to tap alexithymia. Through home movies, it was found that female children, who later developed schizophrenia, demonstrated a reduced proportion of joy expressions as compared with other emotional expressions and relative to their siblings who did not develop schizophrenia.[68] In addition, as compared with their siblings who did not develop schizophrenia, both male and female children who later developed schizophrenia demonstrated increased negative affect. No comparisons were made between relatives who did not develop schizophrenia and healthy controls; thus, one can only conclude a difference in expression between those who later develop schizophrenia and those at FHR.[68] However, in a different study of adults, in which emotional expression evoked during a clinical interview was later coded, nonpsychotic male and female relatives of male probands demonstrated more flat affect than male and female relatives of female probands.[69] As mentioned above, similar to male individuals with schizophrenia, males at FHR have demonstrated increased levels of alexithymia as compared with healthy controls.[62,63]

In summary, those at FHR as a group do not demonstrate impairment in facial expression, though the subgroup of relatives of male probands demonstrated increased flat affect as compared with relatives of female probands. In addition, male relatives demonstrate alexithymia relative to controls, suggesting that sex differences might mediate certain emotional difficulties in HR individuals and may occur independent of disease factors.

Psychophysiological Reactivity to Valenced Information

Little work has been devoted to the psychophysiological response of individuals at FHR to emotion information. As mentioned above, and similar to those with schizophrenia, those at FHR rated positive slides as less positive. However, startle eye blink methods revealed that, like individuals with schizophrenia, those at FHR have intact modulation of the startle eye blink in response to affective pictures (equivalent to healthy controls).[66] These findings suggest a disjunction between reported experience and psychophysiological response.

Neuroimaging Studies

Structural and functional brain dysfunctions associated with emotion processing that are found to be altered in those at familial risk include the prefrontal cortex,[70] amygdala, the amygdala-hippocampal complex (AHC),[71,72] and the hippocampus.[73] Thus far, a meta-analysis of structural magnetic resonance imaging studies demonstrates that the strongest familial link is with the hippocampus, especially on the left side.[73] Certain FHR designs, such as those studying obligate carrier siblings, identify more substantial impairment than in nonobligate carriers. Obligate carrier siblings are nonpsychotic siblings who are assumed to possess heightened genetic liability as defined by the pattern of conversion within 2 or 3 generations of a family. In the only study using this design, noncarrier siblings had intact temporal and frontal lobe whole-brain volumes, whereas the AHC of the obligate carriers and those of their relatives with schizophrenia did not differ from each other and were reduced relative to their unaffected noncarrier siblings.[74] These findings suggest that AHC volume abnormalities may be related to a familial liability but that full manifestation of the disease requires an additional environmental influence or neurodevelopmental process. These studies, while identifying regions of interest associated with emotion, have not directly evaluated the degree to which brain abnormalities mediate emotional differences in those at FHR.

Functional magnetic resonance imaging (fMRI) studies of FHR individuals have demonstrated abnormal activity within multiple brain areas that are relevant to emotion processing, including: the prefrontal cortex, anterior cingulate cortex, and the amygdala.[17,75–78] Although there has been a rapid escalation of fMRI studies of relatives of persons with schizophrenia in the last 5 years,[70] only one of the 20 published studies (which focus on cognitive domains—working memory, episodic memory, procedural memory, cognitive control, and language) has directly addressed emotion.[79] During a sad mood induction, in which participants viewed happy and sad facial expressions, male patients and their brothers demonstrated less activity in the amygdala, relative to members of a control group. The decreased activity was specific to the sad condition. While the controls showed a correlation between subjective ratings of mood through the Positive and Negative Affect Schedule

(consisting of labels of positive and negative affects in which participants are asked to rate items on degree to which the emotions were felt during the last week) and brain activity, neither the individuals with schizophrenia nor the relatives demonstrated this relationship. The healthy relatives were, on average, beyond the age of risk for schizophrenia; thus, the authors explain that there is likely a mechanism that compensates for the reduction in amygdala activity that protects these individuals from developing schizophrenia. Suggested candidate compensatory regions that might regulate emotion mechanisms, in the face of amygdala abnormality, include the orbitofrontal, temporal, and posterior cingulate cortices.[79]

In summary, individuals at FHR for schizophrenia demonstrate some structural and functional abnormalities in circuitry relevant to emotion processing. These differences are apparently part of the neural substrate of vulnerability; however, an additional factor must occur in order for schizophrenia to develop. However, only one functional imaging study has specifically examined areas of brain function during an emotional probe, and activity was not associated with subjective experience in those at risk. Similar to data gathered through psychophysiological methods, this finding demonstrates a disjunction between self-report and that found through biological indices. Nevertheless, because this area of research is relatively new, additional imaging studies that involve emotional stimuli are warranted to clarify brain activation associated with emotion processing in those who are at FHR.

Emotion Processing in Schizotypy

As stated above, participants in studies that investigate schizotypy are identified through *DSM-IV* diagnosed SPD and by questionnaires designed to tap schizotypal characteristics. Although there are proposed variations to the factor structure of schizotypy, symptoms often are subdivided into cognitive-perceptual (magical thinking, unusual perceptual experiences, ideas of reference, paranoid ideation), interpersonal (no close friends, constricted affect, undue social anxiety, paranoid ideation), and disorganized features (odd/eccentric behavior, odd speech).[80] These 3 subtypes resemble the positive, negative, and disorganized subtypes of schizophrenia,[36,37] and performance on emotion processing tasks often varies by subtype.

Emotion Perception

Data on the emotion perception of individuals with schizotypy come from laboratory studies that investigate perception of: facial affect, emotional prosody, and emotions from body posture. Findings on facial affect perception are mixed and depend on the nature of the stimuli and method. One study that included individuals with SPD, which did not differentiate performance by symptom subtype, demonstrated that deficits are specific to positive facial emotions.[81] Facial affect perception has been shown to be intact in healthy undergraduates high in schizotypy more generally[82] and in those with positive or disorganized schizotypy.[83] However, one study that employed a degraded facial task suggested that those with positive symptoms classify angry faces as happy, happy faces as angry, and happy faces as fearful.[84] Individuals with negative symptoms have demonstrated reduced facial affect perception, particularly with negative facial emotions.[83]

In the identification of emotion through tone of voice, undergraduates with positive schizotypy (as assessed by the SPQ) have shown impairment. Lastly, negative and positive symptoms have been associated with a deficit in the ability to perceive postural expressions of affect, as demonstrated through pictures of full-body shots of people displaying positive, negative, and neutral emotions.[82]

In summary, individuals with schizotypy demonstrate impaired emotion perception depending on symptom subtype (eg, negative, positive, disorganized), emotion type (eg, happy versus angry) of the stimuli, and the modality of the stimuli. Future studies should divide participants by subtype with attention to the possibility that methods for ascertaining samples may lead to varying results. Caution should be used in assuming that undergraduates high in schizotypy are representative of schizotypy in the general population. Community samples, as well as individuals with *DSM*-diagnosed SPD, may perceive emotions in unique ways. In addition, similar to the state of the research pertaining to studies that include those at FHR, studies that include individuals with schizotypal characteristics should incorporate a range of emotional stimuli (eg, faces, emotional prosody, body postures).

Emotion Experience

Studies on emotion experience in those with schizotypy include college undergraduate samples, divided by symptom subtype characteristics, and individuals with SPD. Emotion experience is most often examined through self-report questionnaires. Exceptions are 2 unpublished dissertation studies that examined emotion experience while participants viewed emotional film clips. Similar to those with schizophrenia, individuals with SPD reported similar experience of emotion to controls in the laboratory to emotional film clips;[85,86] however, they reported increased anhedonia on questionnaires.[86] Undergraduates with positive schizotypal characteristics have endorsed items that suggested higher levels of experienced emotion as compared with controls, in the form of increased emotionality, affective intensity,[87] and increased negative affect.[88] Similarly, scores on the Launay-Slade Hallucination Scale (used to investigate

differences between subjects who score high vs low in hallucinatory predisposition) correlated with emotionalizing—the degree to which someone is emotionally aroused by emotion-inducing events.[84]

Like those who display higher levels of positive schizotypy, those with disorganized schizotypy report increased emotionality on self-report. This includes increased emotional confusion (low clarity of emotions), increased ambivalence to emotions (Schizotypal Ambivalence Scale; eg, ''My thoughts and feelings always seem to be contradictory''), as well as increased neuroticism, which has been suggested to be related to trait negative affect.[36] Thus, individuals with disorganized schizotypy experience intense emotions, particularly negative emotions, but may have difficulty understanding and organizing them.[36]

In contrast to positive and disorganized schizotypy, negative schizotypy is associated with decreased reported emotionality and increased emotional confusion. Undergraduates with negative schizotypal characteristics report experiencing emotions of reduced intensity[36,89] and have trouble identifying the experienced emotion.[36] It has been speculated that decreased emotionality might be due to a limited number of cognitive interpretations that would often lead to a generation of emotion and an increase in emotion intensity.[36] In an unpublished dissertation, it was found that female undergraduates with social anhedonia demonstrated lower state baseline positive affect relative to controls, and while viewing positive film clips.[90] Lastly, socially anhedonic undergraduates have reported higher perceived stress and trait negative affectivity, as compared with controls.[91]

In summary, data suggest that individuals with schizotypy report increased negative emotion and reduced positive emotion; however, there are subtle differences in experience that depend on schizotypal symptom subtype. Because studies of emotion experience in this at-risk group are questionnaire based, one must consider the possibility of response bias in many of these studies. Individuals may endorse items according to what is most socially acceptable. In addition, responses may be influenced by memory biases. To avoid these confounds, additional laboratory work using experimental methods with emotion probes are warranted. Further, published studies that examine emotion experience include college undergraduates only. Accordingly, similar to the area of emotion perception, one must take into consideration that findings to date may not generalize to all individuals with schizotypy.

Emotion Expression

Investigations of emotion expression in those with schizotypy include measures of facial affect while a participant views emotion eliciting film clips or slides and questionnaires pertaining to alexithymia. Individuals with SPD and those with anhedonia have demonstrated no difference in expression from controls while watching positive and negative film clips[85,86]; however, participants reported that they felt as if they were generally less emotionally expressive.[86] When only those with social anhedonia were included, participants in an unpublished dissertation study displayed reduced facial expression in response to film clips relative to controls,[90] and males with physical anhedonia demonstrated fewer and briefer facial expression to emotion slides.[89]

Higher ratings on schizotypy, across all subtypes (positive, negative, and disorganized), correlated with alexithymia.[84] However, when individuals with negative anhedonia were identified through measures of physical vs social anhedonia, differing results emerged. College students who scored higher on social anhedonia demonstrated alexithymia[92] in the form of a reduced capacity to communicate emotion.[93] In contrast, those who scored higher on physical anhedonia did not demonstrate this reduced ability.[93]

In summary, individuals with negative schizotypal characteristics, but not positive, demonstrate reduced expressiveness in the laboratory. Through questionnaires, individuals with schizotypy report reduced dispositional expressivity. Reduced expression is likely associated with the alexithymia that is demonstrated by individuals with schizotypy. In particular, as in all investigations that examine schizotypal characteristics, future work should divide participants by symptoms subtype.

Psychophysiological Reactivity to Valenced Information

Psychophysiological studies that include individuals with schizotypy have incorporated measures of skin conductance and startle modulation. Unpublished dissertation data revealed that people with SPD show a greater number of nonspecific skin conductance responses only during a sad film clip (and not fear/disgust, happiness, neutral).[86] In terms of symptom subtypes, individuals with elevated positive schizotypal characteristics demonstrated exaggerated heart rate to aversive stimuli, a finding interpreted as suggesting that they find negative stimuli more aversive than those without positive schizotypy.[94] Across a number of studies, individuals with negative schizotypal symptoms, particularly anhedonia, demonstrated psychophysiological hyporesponsiveness to positive emotional stimuli.[89,94] In contrast, college students higher in social anhedonia demonstrated normal startle modulation.[92]

In summary, individuals with schizotypy have demonstrated increased nonspecific skin conductance responses to sad clips. Those with positive schizotypy show increased reactivity to negative stimuli, whereas those with negative schizotypy have demonstrated reduced reactivity but intact modulation of the startle response.

Neuroimaging Studies

Early research suggested that individuals with SPD, unlike those with schizophrenia, did not typically manifest abnormalities in the medial temporal lobe.[95] However, other work suggests the contrary,[96] and a recent study has shown hippocampal volume reduction in females with SPD.[97] Findings to date suggest that individuals with SPD do not demonstrate the frontal lobe abnormalities that are found in schizophrenia.[96,98]

Individuals with schizotypy have evidenced a range of functional abnormalities in areas of the brain integral to emotion processing. Reduced frontal activation is found, similar to that occurring in schizophrenia[99]; however, this group appears to recruit alternative regions to compensate for the reduced frontal activity.[96,100] During an emotional Stroop task, increased right and decreased left activity was found in the DLPFC,[101] and greater prefrontal activity was found in those with positive schizotypy while processing negative vs neutral words.[102] Individuals with schizotypy have also demonstrated reduced activity in the nucleus accumbens and increased activity in the amygdala and hippocampus during an emotional Stroop task.[101]

In summary, to this date, research on medial temporal lobe abnormality in persons with schizotypy is mixed as positive findings thus far have been reported only in females, whereas no group differences have been noted in frontal lobe volumes. However, in fMRI studies, individuals with schizotypy have demonstrated reduced as well as increased frontal activation. Increased activity, in response to an emotion probe, in the temporal areas has also been found. The studies, while promising, are too few to be conclusive and are largely characterized by modest sample sizes. Considering the striking behavioral variation by subtype, it is also essential that imaging studies that investigate emotion include symptom subtype as factor. Neuroimaging studies that include persons with schizotypy are not numerous, and as a result, conclusions are quite tentative.

Emotion Processing in the Prodrome to Psychosis

Emotion Perception

One study has addressed emotion perception ability of individuals in the prodrome. Approximately one-quarter of individuals considered to be in the prodrome to psychosis endorsed ''decreased capacity to discriminate between different kinds of emotions,'' based on an interview using the Bonn Scale for the Assessment of Basic Symptoms.[103] Thus, to date, there is a subgroup of individuals in the prodrome who report impaired emotion perception.

Emotion Experience

Emotion experience in the prodrome has been studied through questionnaires and clinical interviews. Close to the time of onset of psychosis, individuals have displayed heightened emotionality and anxiety.[103] In a study that included participants considered prodromal and ''at imminent risk for psychosis,'' the most common *DSM-IV* diagnoses of study participants were depression, anxiety not otherwise specified, and social phobia.[104] Depression, anxiety, and worrying were among the 10 most frequent early signs of schizophrenia described by patients who had recently experienced their first episode of psychosis.[105] Through the use of the Bonn Scale for the Assessment of Basic Symptoms, items measuring stress intolerance were endorsed by individuals in the prodrome to psychosis. In all, 60% endorsed ''impaired tolerance to certain social situations,'' 50% endorsed ''impaired tolerance to unusual, unexpected demands or specific novel demands,'' and 30% endorsed ''impaired tolerance to everyday stress or routine work.[103]'' Interestingly, individuals who reacted with especially negative emotional states to their initial experience of psychosis were found to be more likely to develop exacerbation of psychosis later.[106] In summary, prior to the onset of a first episode of psychosis, individuals report increased emotionality, often in the form of depression and anxiety. In addition, large subgroups of individuals in the putative prodrome report increased emotion experience. Future work might incorporate emotion probes in a range of modalities as well as concomitant psychophysiology.

Emotion Expression

Questionnaire methods have also been the primary method of assessing emotion facial expression, prosody, and gestures conveying emotion, in persons in the prodrome to schizophrenia. Responses to the Interview for the Retrospective Assessment of the Onset of Schizophrenia suggest that flat affect may precede onset of psychosis.[105] Through the Bonn Scale for the Assessment of Basic Symptoms, it was found that approximately a quarter of individuals considered prodromal endorsed ''disturbances of emotional responsiveness as characterized by a decrease in facial expression, intonation, and communication gestures.[103]''

A related finding comes from a study previously described in which it was found that female children who later developed schizophrenia demonstrated, on home movies, a reduced proportion of joy expressions as compared with other emotional expressions and relative to their siblings who did not develop schizophrenia. In addition, compared with their siblings who did not develop schizophrenia, both male and female children, who later developed schizophrenia, demonstrated increased negative affect.[68]

In summary, at least a subgroup of individuals in the prodrome demonstrates reduced emotion expression. As children, those who later developed schizophrenia have demonstrated reduced positive facial expression and increased negative affect. Reduced emotion expression

Table 1. Key Findings

	No Impairment	More Impaired	Most Impaired
Perception			
Facial emotion-morphing task[61]	Controls	FHR	schizophrenia
Profile of nonverbal sensivity[60]	Controls	FHR	
Facial affect[82]	Controls; Neg schizotypy	Pos schizotypy	
Emotional prosody[80]	Controls; Neg schizotypy	Pos schizotypy	
Body posture[82]	Controls	Pos schizotypy; Neg schizotypy	
Questionnaire item[103]		Prodrome	
Experience			
Anhedonia[64]	Controls	FHR	schizophrenia
Anhedonia[103]		Prodrome	
Positive slides[66]	Controls	FHR; schizophrenia	
Negative slides[66]	Controls; FHR		schizophrenia
ESM positive affect[67]	Controls; FHR		schizophrenia
ESM negative affect[67]	Controls; FHR		schizophrenia
Psychotic to everyday activities[67]	Controls	FHR	schizophrenia
Emotionality[85,87]	Controls	Pos schizotypy higher; Neg schizotypy lower	
Negative affect[36,88,92]	Controls	Pos schizotypy; Disorg schizotypy; Neg schizotypy	
Negative affect[103–105]		Prodrome	
Positive affect[92]	Controls	Neg schizotypy—reduced	
Affect intensity[36]	Controls	Disorg schizotypy	
Emotion confusion[36]	Controls	Disorg schizotypy	
Expression			
Facial[69]	Controls; FHR		
Facial[103]		Prodrome	
Facial to film clips[85,86]	Controls, schizotypy		
Facial to film clips[90]	Controls	Neg schizotypy	
Emotional prosody[103]		Prodrome	
Emotional gestures[103]		Prodrome	
Alexithymia[62,a]	Controls		schizophrenia males; FHR males
Alexithymia[92,93,a]	Controls; Physical anhedonia	Social anhedonia	
Psychophysiology			
Startle to slides[66,92]	Controls, GHR, Neg schizotypy, SCZ		

Note: FHR, familial high risk; schizophrenia, schizophrenia; Pos, positive; Neg, negative; Disorg, disorganized; ESM, experience sampling method; SCZ, schizophrenia
[a]Alexithymia is conceptualized as involving a combination of emotion perception and emotion expression.

appears to predate onset of psychosis; however, replication of these findings is necessary as they are relatively new.

Neuroimaging Studies

Thus far, only one structural imaging study of individuals in the prodrome has been published. Prodromal individuals who later developed psychosis, relative to those who did not, demonstrated reduced gray matter in the right medial temporal, lateral temporal, inferior frontal cortex, and the cingulate cortex.[107] When those who later developed psychosis were rescanned, they demonstrated reduction in the left parahippocampal, fusiform, orbitofrontal, cerebellar cortices, and cingulate gyri. However, those who did not become psychotic showed differences in the cerebellum only at the time of the second scan.[107] Thus, to date, preliminary imaging of individuals in the prodrome demonstrates abnormalities in brain regions relevant to emotional function.

Summaries of Findings by Component of Emotion

Perception

Similar to individuals with schizophrenia, all the at-risk populations demonstrate emotion perception deficits to some extent; however, these deficits occur to varying degrees and differ by symptom constellation subtype

(see table 1). Individuals with schizophrenia demonstrate impaired emotion perception, particularly, in the areas of facial affect recognition and emotional prosody identification.[58] Similarly, individuals with schizotypy have demonstrated reduced ability to perceive affect in prosody and reduced perception of affect in body posture. Findings are mixed as to whether individuals with schizotypy demonstrate facial affect recognition impairments. A subgroup (25%) of individuals in the prodrome reported reduced emotion perception. In contrast, while individuals at FHR do demonstrate emotion perception deficits, these deficits only emerge in paradigms with more subtle facial expressions and social scenes. Thus, research to date suggests that emotion perception abnormalities are more striking in schizophrenia and schizotypy as compared with individuals at FHR or those in the prodrome. However, additional work is necessary in the prodrome as this is a new area of research, particularly using stimuli that require more rapid information processing.

Experience

Across all groups, emotion experience depends on the experimental methods. While individuals with schizophrenia, those at FHR, and those with schizotypy report increased anhedonia on questionnaires, their experienced emotion in the laboratory is relatively intact (for an exception, see Curtis et al[66,92]). Similarly, these 3 groups have shown intact modulation of startle.[66] Those with schizophrenia, with schizotypy, and those in the prodrome have demonstrated increased negative affect and reduced positive affect. Experience-sampling methods indicate that individuals at FHR report comparable experience to controls. When individuals with schizotypy are divided by subgroup, those with positive and disorganized schizotypal symptoms experience increased emotionality, while individuals with negative schizotypal symptoms report reduced intensity of emotions. However, each subtype has separately reported increased negative affect. Similarly, increased experience, particularly of negative emotion, is described by a subgroup of individuals considered to be in the prodrome and by people prior to their first episode of psychosis.

In summary, increased reported anhedonia occurs across all at-risk groups, though there are currently few studies of persons considered prodromal. Increased negative affect and reduced positive affect has been demonstrated in all groups other than those at FHR. Lastly, within the laboratory, generally intact experience occurs across groups.

Expression

Individuals with schizophrenia, those with negative schizotypy, and at least a subgroup of individuals in the prodrome have demonstrated reduced emotion expression. Individuals with schizophrenia demonstrate impairment in emotional expression in the form of reduced facial affect and emotional prosody.[108] However, one study demonstrates that individuals with schizophrenia express more subtle facial emotions and that it may take stimuli of a larger intensity to inspire a change in emotional expression.[108] Individuals across all subtypes of schizotypy have reported alexithymia as well as reduced dispositional expressivity in general. However, it is only those with negative schizotypy who have been found to be impaired in expression within the laboratory. In contrast, groups of persons at FHR have not demonstrated reduced expression, though males at FHR have been found to have difficulty verbally describing their emotions. A subgroup of individuals in the prodrome has endorsed items on questionnaires that indicate reduced expression. Thus, reduced expression appears to be an important factor for those with schizophrenia, those with negative schizotypy, and males at FHR.

Emotion-Processing Abnormalities Through the Premorbid and Prodromal Phases

In this section, we speculate briefly about the evolution of emotion dysfunctions that may precede schizophrenia. Individuals in the premorbid phase of schizophrenia may be vulnerable through a combination of emotion-processing abnormalities. Individuals at FHR report an increased stress response to events labeled as everyday activities.[67] In addition, in the premorbid phase, anhedonia is likely to be present as it is consistently described in at-risk groups. This reduced sense of positivity may make one more vulnerable through a reduction in remembered or salient positive experience, which might otherwise be a buffer against stress. Further, poor perception of subtle emotional and social nuances may lead to misinterpretation. This, in turn, may be associated with a heightened stress response and a reduced capacity for social relationships and lead to social withdrawal. In subgroups of persons at risk, such as males, increased difficulty understanding and reporting their emotions may be present. Finally, reduced amygdala-hippocampal volumes and abnormal functional activity in some brain areas pertinent to emotion may add increased vulnerability through impaired emotion regulation.

The transition from the premorbid to the prodromal phase may involve increased negative affect and reduced positive affect. This negative affect may evolve to take the form of a growing anxiety or mood disorder. Abnormal thinking, in the form of magical thinking, unusual beliefs, or subtle paranoia, may lead to social isolation and increased negative affect and stress. Increasingly abnormal emotion perception and expression may compound social difficulties. In addition, continued insufficient compensatory brain activity, particularly in prefrontal cortex, may contribute to vulnerability. Of course, these proposed emotional difficulties are likely to be only one component of a growing social disorder, also marked by neurocognitive

difficulties. The mechanisms of transition from a risk state to acute psychosis is as yet not well understood but is under active investigation in studies of the prodrome.

Mechanisms of Emotion Abnormalities in At-Risk Groups

As has been demonstrated in this review, emotion-processing abnormalities in those at risk are beginning to be delineated. However, theories on their underlying mechanisms are not well developed. For an explanation of emotion-processing abnormalities across certain at-risk groups and schizophrenia, including reduced emotion perception, increased negative emotion experience, and reduced emotion expression, we briefly look to theories pertaining to emotion dysfunction in schizophrenia. Impaired recognition of fear in schizophrenia is associated with reduced activity in the amygdala and regions to which this structure projects.[56] In addition, individuals with schizophrenia allocate less attention to the eyes in facial expressions,[109] which has been proposed to be important for the evaluation of fearful information and for activation of the amygdala.[110] Thus, functional imaging with emotion probes and eye-tracking studies may provide insight into whether similar mechanisms are at work in those at-risk as in persons with schizophrenia and whether compensatory neurocognitive processes can mitigate these abnormalities.

In the domain of experience, heightened negative affect in schizophrenia has been proposed to occur as a result of disconnected or dysregulated activity between cortical and subcortical structures. Specifically, reductions in amygdala and medial prefrontal activity are associated with increased autonomic response to fearful information. As a result, inappropriate appraisal of this excessive somatic response to fear may occur.[57] A similar theory proposes that there is a disruption of cortical regulation of subcortical dopamine systems, which leads to an exaggerated influence of the amygdala. Instead of being guided by a balance between the hippocampus and the amygdala, an overactive amygdala signals a threat where it does not exist, and increased negative affect ensues.[57] Other theories propose an underactive amygdala coupled with an underactive prefrontal cortex, leading to the processing of social information without regulation by the prefrontal areas.[111] Finally, in the area of expression, patients exhibit facial muscle expressiveness that is overtly unobservable but which occurs in the expected directions.[108] As stated above, it has been suggested that individuals with schizophrenia may have a higher threshold at which facial expressions become observable to the naked eye and that they only show expression during intense emotional experience.[108] Thus, although expression may appear to be restricted in subgroups of individuals with schizophrenia, expression is exhibited in the expected directions in HR individuals, simply to a subtler degree.

As stated above, studies involving all 3 at-risk groups have begun to show abnormal brain activation in regions relevant to emotion, although it is not often the case that the tasks are emotional in content. In addition, the effect of this abnormal activity on behavior is unclear as there may be compensatory mechanisms at work. Thus far, research suggests abnormality in areas of the brain integral to emotion processing, which may be associated with the abnormal behavioral responses discussed in the literature on at-risk populations. While promising, this field is relatively uncharted in HR groups, and additional work is necessary to clarify structural, functional, and cognitive abnormalities relevant to emotion, particularly in prefrontal-limbic interaction. The degree to which "top-down" (regulatory) or "bottom-up" dysfunctions are present has to be identified.

Implications and Future Directions

Individuals with schizophrenia exhibit widespread emotion deficits, including impaired emotion perception, self-reported anhedonia, increased negative affect, and reduced expression of emotion. Increasing data suggest that individuals at HR demonstrate similar abnormalities at an attenuated level. The most robust findings are in the areas of reduced emotion perception, reported anhedonia, and increased negative affect. Studies on individuals at FHR and with schizotypal characteristics are steadily increasing; however, little work on emotion processing has been devoted to those in the prodrome as this field is relatively newly established. In addition, imaging and psychophysiology methods that employ emotion probes are necessary to identify the brain mechanisms associated with these abnormalities. A number of other factors need to be addressed in order to clarify the nature and implications of abnormal emotion processing in at-risk groups. These include the effects of demographic factors, adequate control tasks, and a broader range of more externally valid emotional stimuli. In addition, future work is warranted toward investigating whether emotion-processing abnormalities might serve as markers of prediction and avenues of treatment.

Demographic Factors

Studies on emotion processing in at-risk individuals is in such a preliminary stage that few studies have explicitly addressed demographic factors, such as gender, age, education, ethnicity, and socioeconomic status as variables of possible influence. Regarding age, it is important to note that many of the findings pertaining to schizotypy include undergraduate populations only. Moreover, HR individuals such as relatives who have passed through the age of peak risk for schizophrenia (>age 30) allow the evaluation of components of the syndrome that are independent of psychosis. The study of younger relatives (<age 30) provides an opportunity to identify the differences present prior to typical onset of schizophrenia

in a subset of relatives. Younger relatives are likely to comprise a mixture of future cases and noncases, and therefore, the effect sizes here may be larger than in older samples where onset of illness is unlikely. Studies of young family members can contribute to prediction of illness. Thus, use of homogeneous samples on age may increase the precision of HR studies.

Some gender differences have been found, particularly in those at FHR, suggesting that males may have more salient dysfunctions. While no group differences were found in facial expression in some studies between those at FHR and healthy controls, it was observed that relatives of male probands demonstrated reduced expression as compared with relatives of female probands. It was concluded that relatives of female probands may be protected by their increased range of affect as compared with the relatives of male probands. Another study suggested that reduced joy expressions, particularly in female children, was predictive of future schizophrenia; reduced positive expression was not a factor in men. Lastly, similar to men with schizophrenia, men at FHR have demonstrated alexithymia. Thus, gender differences emerge in the domain of emotional expression, in regard to facial affect expression and ability to verbalize one's feelings. In order to adequately and explicitly test hypotheses regarding sex differences, large enough samples must be collected to obtain sufficient statistical power and also to match within sex as well as across diagnostic groups.

Adequate Control Tasks and Groups

In order to investigate which emotion-processing deficits are independent of other areas of dysfunction associated with HR status, such as cognitive deficits, it is essential to use adequate control tasks that match on level of complexity and salience and which incorporate measures of other areas of cognition. Many studies did include well-matched control tasks and provide evidence for emotion-processing deficits beyond more general cognitive deficits (eg, Toomey et al[60]). However, the extent to which cognitive impairment found robustly in HR populations contributes to emotion-processing abnormalities is not well studied to date and is an important area of continued investigation. In addition, in many studies, comparison groups are healthy controls and individuals with schizophrenia; thus, it is unclear whether findings are specific to the schizophrenia spectrum and risk for schizophrenia or if they occur similarly in other populations, such as those at risk for affective psychoses.

Range of Emotional Stimuli and Experimental Method

Understanding of emotion perception and the experience of emotion would be advanced through incorporating stimuli in a range of modalities (eg, words, pictures, film clips) levels of intensity/subtlety, as well as through including valence and arousal as factors. In addition, increased use of experience-sampling methods might allow for greater generalizability of findings. In terms of biological correlates, though the number of studies that incorporate psychophysiology and neuroimaging in at-risk populations is gradually increasing, the vast majority of studies to date have focused on cognition[70] and the development of studies that specifically target emotion is warranted.

Avenues of Treatment

Treatment for emotion-processing abnormalities might come in a variety of forms and is an important area of future research. Psychotherapy, such as cognitive behavior therapy aimed at reducing negative affect and stress and addressing cognitive distortion (eg, paranoia), is an increasing approach with patients with established schizophrenia and could be implemented with persons at risk who have such symptoms. Increasing the number and salience of positive experiences might be helpful. In addition, improving emotion perception and understanding of emotional and social cues might be gained through cognitive training and structured peer support groups. Family groups using a psychoeducational approach about the cognitive and emotional difficulties of the individual may be helpful by reducing stress within families. Finally, as symptoms increase, psychotropic medications may be indicated. Such strategies are already underway in persons who are putatively prodromal,[50,112–116] and might be cautiously applied to other HR groups who are treatment-seeking but less severely symptomatic.

Conclusions

Modern experimental methods have permitted a closer examination of the observations made by Kraepelin and Bleuler on the aberrant emotion processing that is part of the pathophysiology of schizophrenia. Through the study of emotion processing in those considered at risk, a picture emerges largely without confounds associated with the effects of illness and treatment. Knowledge of which emotion abnormalities place one at increasing risk may lead to the development of therapeutic targets for early intervention.

Additional experiments that incorporate a range of methodologies are needed to clarify and refine knowledge on the nature and degree of abnormalities, their impact on goal attainment and aspects of social functioning (eg, social problem solving, social skills, self representation, theory of mind, volition), and their utility in predicting future conversion to psychosis.

Emotion-processing abnormalities have widespread impact across all areas of functioning. Intact emotion processing is fundamental to profitably navigating one's environment and to social success. It has been suggested that intact emotion processing facilitates the

operation of reason.[117] Those with schizophrenia and those considered at risk demonstrate abnormalities across multiple components of emotion processing that are similar to those experienced by people with schizophrenia, making these components candidate markers of increased vulnerability and potential fruitful targets of future research and early intervention.

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References

1. Kraepelin E. *Dementia Praecox. Barclay E, Barclay S, trans.* New York, NY: Churchill Livingstone Inc.; 1919/1971.
2. Bleuler E. *Dementia Praecox or the Group of Schizophrenias. Zinkin H, trans.* New York, NY: International Universities Press; 1950. [German edition published in 1911].
3. Meehl PE. Schizotaxia, schizotypy, schizophrenia. *Am Psychol.* 1962;17:827–838.
4. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders DSM-IV-TR, Fourth Edition, Text Revision. Washington, DC. American Psychiatric Association, 2000.
5. Kring AM. Emotion in schizophrenia: old mystery, new understanding. *Curr Dir Psychol Sci.* 1999;8:160–163.
6. Bentall RP, Kaney S. Content specific information processing and persecutory delusions: an investigation using the emotional Stroop test. *Br J Med Psychol.* 1989;62:355–364.
7. Phillips L, Deldin P, Voglmaier M, Rabbitt S. Emotional Stroop performance predicts disorganization in schizophrenia. *Schizophr Res.* 2005;77:141–149.
8. Phillips ML, Senior C, David AS. Perception of threat in schizophrenics with persecutory delusions: an investigation using visual scan paths. *Psychol Med.* 2000;30:157–167.
9. Herbener ES, Rosen C, Khine T, Sweeney JA. Failure of positive but not negative emotional valence to enhance memory in schizophrenia. *J Abnorm Psychol.* 2007;116:43–55.
10. Hall J, Harris JM, McKirdy JW, Johnstone EC, Lawrie SM. Emotional memory in schizophrenia. *Neuropsychologia.* 2007;45:1152–1159.
11. Horan WP, Kring AM, Blanchard JJ. Anhedonia in schizophrenia: a review of assessment strategies. *Schizophr Bull.* 2006;32:259–273.
12. Docherty NM, Herbert AS. Comparative affective reactivity of different types of communication disturbances in schizophrenia. *J Abnorm Psychol.* 1997;106:325–330.
13. Burbridge JA, Barch DM. Emotional valence and reference disturbance in schizophrenia. *J Abnorm Psychol.* 2002;111:186–191.
14. Pinkham A, Penn DL, Perkins DO, Lieberman J. Implications for the neural basis of social cognition for the study of schizophrenia. *Am J Psychiatry*. 2003;160:815–824.
15. Hooker C, Park S. Emotion processing and its relationship to social functioning in schizophrenia patients. *Psychiatry Res.* 2002;112:41–50.
16. Keshavan MS. High-risk studies, brain development, and schizophrenia. In: Keshavan M, Kennedy J, Murray R, eds. *Neurodevelopment and Schizophrenia.* Cambridge, UK: Cambridge University Press; 2004.
17. Seidman LJ, Giuliano AJ, Smith CW, et al. Neuropsychological functioning in adolescents and young adults at genetic risk for schizophrenia and affective psychoses: results from the Harvard and Hillside Adolescent High Risk Studies. *Schizophr Bull.* 2006;32:507–524.
18. Berenbaum H, Oltmanns TF. Emotional experience and expression in schizophrenia and depression. *J Abnorm Psychol.* 1992;101:37–44.
19. Kring AM, Neale JM. Do schizophrenic patients show a disjunctive relationship among expressive, experiential, and psychophysiological components of emotion? *J Abnorm Psychol.* 1996;105:249–257.
20. Yung AR, McGorry PD. The prodromal phase of first-episode psychosis: past and current conceptualizations. *Schizophr Bull.* 1996;22:353–370.
21. McGlashan TH, Johannessen JO. Early detection and intervention with schizophrenia: rationale. *Schizophr Bull.* 1996;22:201–222.
22. Cannon TD, Cadenhead KS, Cornblatt B, et al. Prediction of psychosis in youth at high clinical risk: a multi-site longitudinal study in North America. *Arch Gen Psychiatry*. 2008;65:28–37.
23. Gottesman II. *Schizophrenia Genesis: The Origin of Madness.* New York, NY: Freeman; 1991.
24. Vollema MG, Sitskoorn MM, Appels MCM, Kahn RS. Does the Schizotypal Personality Questionnaire reflect the biological-genetic vulnerability to schizophrenia? *Schizophr Res.* 2002;54:39–45.
25. Kremen WS, Faraone SV, Seidman LJ, Pepple JR, Tsuang MT. Neuropsychological risk indicators for schizophrenia: a preliminary study of female relatives of schizophrenic and bipolar probands. *Psychiatry Res.* 1998;79:227–240.
26. Cornblatt BA, Green MF, Walker EF. Schizophrenia: etiology and neurocognition. In: Millon T, Blaney PH, Davis RD, eds. *Oxford Textbook of Psychopathology.* Oxford, England: Oxford University Press; 1999.
27. Faraone SV, Green AI, Seidman LJ, Tsuang M. 'Schizotaxia': clinical implications and new directions for research. *Schizophr Bull.* 2001;27:1–18.
28. Snitz BE, MacDonald AW, Carter CS. Cognitive deficits in unaffected first-degree relatives of schizophrenia patients:

a meta-analytic review of putative endophenotypes. *Schizophr Bull.* 2006;32:179–194.
29. Gottesman II. Erlenmeyer-Kimling L. Family and twin strategies as a head start in defining prodromes and endophenotypes for hypothetical early-intervention in schizophrenia. *Schizophr Res.* 2001;51:93–102.
30. Chapman LJ, Chapman JP, Raulin ML. Scales for physical and social anhedonia. *J Abnorm Psychol.* 1976;85:374–382.
31. Blanchard JJ, Gangestad SW, Brown SA, Horan WP. Hedonic capacity and schizotypy revisited: a taxometric analysis of social anhedonia. *J Abnorm Psychol.* 2000;109:87–95.
32. Raine A. The SPQ: a scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophr Bull.* 1991;17:556–564.
33. Kendler KS, Lieberman JA, Walsh D. The Structured Interview for Schizotypy (SIS): a preliminary report. *Schizophr Bull.* 1989;15:559–571.
34. Chapman LJ, Chapman JP, Raulin ML. Body-image aberration in schizophrenia. *J Abnorm Psychol.* 1978;87:399–407.
35. Eckblad M, Chapman LJ. Magical ideation as an indicator of schizotypy. *J Consult Clin Psychol.* 1983;51:215–225.
36. Kerns JG. Schizotypy facets, cognitive control, and emotion. *J Abnorm Psychol.* 2006;115:418–427.
37. Liddle PF. The symptoms of chronic schizophrenia: a reexamination of the positive-negative dichotomy. *Br J Psychiatry*. 1987;151:145–151.
38. Lenzenweger MF. Schizotypy: an organizing framework for schizophrenia research. *Curr Dir Psychol Sci.* 2006;4:162–166.
39. Horan WP, Reise SP, Subotnik KL, Ventura J, Nuechterlein K. The validity of Psychosis Proneness Scales as vulnerability indicators in recent-onset, schizophrenia patients. *Schizophr Res.* 2008;100:224–236.
40. Lenzenweger MF, Korfine L. Confirming the latent structure and base rate of schizotypy: a taxometric analysis. *J Abnorm Psychol.* 1992;101:567–571.
41. Baron M, Gruen R, Rainer JD, Kane J, Asnis L, Lord S. A family study of schizophrenia and normal control probands: implications for the spectrum concept of schizophrenia. *Am J Psychiatry*. 1985;142:447–455.
42. Miller P, Byrne M, Hodges A, Lawrie SM, Owens DG, Johnstone EC. Schizotypal components in people at high risk of developing schizophrenia: early findings from the Edinburgh high-risk study. *Br J Psychiatry*. 2002;179–184.
43. Kwapil TR. Social anhedonia as a predictor of the development of schizophrenia-spectrum disorders. *J Abnorm Psychol.* 1998;107:558–565.
44. Klosterkotter J, Hellmich M, Steinmeyer EM, Schultze-Lutter F. Diagnosing schizophrenia in the initial prodromal phase. *Arch Gen Psychiatry*. 2001;58:158–164.
45. Addington J, Cadenhead KS, Cannon TD, et al. North American Prodrome Longitudinal Study: a collaborative multisite approach to prodromal schizophrenia research. *Schizophr Bull.* 2007;33:665–672.
46. Yung AR, Phillips LJ, McGorry PD, et al. Prediction of psychosis: a step towards indicated prevention of schizophrenia. *Br J Psychiatry*. 1998;172(suppl 33):14–20.
47. Yung AR, Phillips LJ, Yuen HP. Psychosis prediction: 12-month follow up of a high-risk ('prodromal') group. *Schizophr Res.* 2003;60:21–32.
48. Cornblatt B, Lencz T, Obuchowski M. The schizophrenia prodrome: treatment and high-risk perspectives. *Schizophr Res.* 2002;54:177–186.
49. McGorry PD. Back to the future: predicting and reshaping the course of psychotic disorder. *Arch Gen Psychiatry*. 2008;65:25–27.
50. Morrison AP, French P, Parker S, et al. Three-year follow-up of a randomized controlled trial of cognitive therapy for the prevention of psychosis in people at ultrahigh risk. *Schizophr Bull.* 2007;33:682–687.
51. Plutchik R. Emotions: a general psychoevolutionary theory. In: Scherer KR, Ekman P, eds. *Approaches to Emotion.* Hillside, NJ: Erlbaum; 1984:197–219.
52. Ekman P. Are there basic emotions? *Psychol Rev*. 1992;99:550–553.
53. Lang PJ, Bradley MM, Cuthbert BN. Emotion, motivation, and anxiety: brain mechanisms and psychophysiology. *Biol Psychiatry*. 1998;44:1248–1263.
54. Phillips ML, Drevets WC, Rauch SL, Lane R. Neurobiology of emotion perception I: the neural basis of normal emotion perception. *Biol Psychiatry*. 2003;54:504–514.
55. Phillips ML, Drevets WC, Rauch SL, Lane R. Neurobiology of emotion perception II: implications for major psychiatric disorders. *Biol Psychiatry*. 2003;54:515–528.
56. Williams LM, Das P, Harris AWF, et al. Dysregulation of arousal and amygdala-prefrontal systems in paranoid schizophrenia. *Am J Psychiatry*. 2004;161:480–489.
57. Grace AA. Gating of information flow within the limbic system and the pathophysiology of schizophrenia. *Brain Res Rev.* 2000;31:330–341.
58. Edwards J, Jackson HJ, Pattison PE. Emotion recognition via facial expression and affective prosody in schizophrenia: a methodological review. *Clin Psychol Rev.* 2002;22:789–832.
59. Bolte S, Poustka F. The recognition of facial affect in autistic and schizophrenic subjects and their first degree relatives. *Psychol Med.* 2003;33:907–915.
60. Toomey R, Seidman LJ, Lyons MJ, Faraone SV, Tsuang MT. Poor perception of nonverbal social-emotional cues in relatives of schizophrenic patients. *Schizophr Res.* 1999;40:121–130.
61. Bediou B, Krolak-Salmon P, Saoud M, et al. Facial expression and sex recognition in schizophrenia and depression. *Can J Psychiatry*. 2005;50:525–533.
62. van't Wout M, Aleman A, Bermond B, Kahn RS. No words for feelings: alexithymia in schizophrenia patients and first-degree relatives. *Compr Psychiatry*. 2007;48:27–33.
63. Cedro A, Kokoszka A, Popiel A. Alexithymia in schizophrenia: an exploratory study. *Psychol Rep.* 2001;89:95–98.
64. Katsanis J, Iacono W, Beiser M. Anhedonia and perceptual aberration in first-episode psychotic patients and their relatives. *J Abnorm Psychol.* 1990;99:202–206.
65. Glatt SJ, Stone WS, Faraone SV, Seidman LJ, Tsuang MT. Psychopathology, personality traits and social development of young first-degree relatives of patients with schizophrenia. *Br J Psychiatry*. 2006;189:337–345.
66. Curtis C, Lebow B, Lake DS, Katsanis J, Iacono WG. Acoustic startle reflex in schizophrenia patients and their first-degree relatives: evidence of normal emotional modulation. *Psychophysiology*. 1999;36:469–475.
67. Myin-Germeys I, Delespaul P, van Os J. Behavioral sensitization to daily life stress in psychosis. *Psychol Med.* 2005;35:733–741.
68. Walker E, Grimes KE, Davis DM, Smith AJ. Childhood precursors of schizophrenia: facial expressions of emotion. *Am J Psychiatry*. 1993;150:1654–1660.

69. Goldstein JM, Faraone SV, Chen WJ, Tsuang MT. Genetic heterogeneity may in part explain sex differences in the familial risk for schizophrenia. *Biol Psychiatry*. 1995;38: 808–813.
70. MacDonald AW, Thermenos HW, Barch DM, Seidman LJ. Imaging genetic liability to schizophrenia: Review of fMRI studies of patients' non-psychotic relatives. Schizophr Bull June 12, 2008; doi:10. 1093/schbul/sbn053.
71. Van Rijn S, Aleman A, Swaab H, Kahn RS. Neurobiology of emotion and high risk for schizophrenia: role of the amygdala and the X-chromosome. *Neurosci Biobehav Rev.* 2005;29:385–397.
72. Seidman LJ, Pantelis C, Keshavan MS, et al. A review and new report of medial temporal lobe dysfunction as a vulnerability indicator for schizophrenia: a magnetic resonance imaging morphometric family study of the parahippocampal gyrus. *Schizophr Bull.* 2003;29:803–830.
73. Boos HBM, Aleman A, Cahn W, Hulshoff H, Kahn RS. Brain volumes in relatives of patients with schizophrenia: a meta-analysis. *Arch Gen Psychiatry*. 2007;64:297–304.
74. Steel RM, Whalley HC, Miller P, Best JJK, Johnstone EC, Lawrie SMU. Structural MRI of the brain in presumed carriers of genes for schizophrenia, their affected and unaffected siblings. *J Neurol Neurosurgery Psychiatry*. 2002; 72:455–458.
75. Blackwood DHR, Glabus MF, Dunan J, O'Carroll RE, Muir WJ, Ebmeier KP. Altered cerebral perfusion measured by SPECT in relatives of patients with schizophrenia: correlations with memory and P300. *Br J Psychiatry*. 1999; 175:357–366.
76. Seidman LJ, Thermenos HW, Poldrack RA. Altered brain activation in dorsolateral prefrontal cortex in adolescents and young adults at genetic risk for schizophrenia: an fMRI study of working memory. *Schizophr Res.* 2006; 85:58–72.
77. Callicott JH, Egan MF, Mattay VS, et al. Abnormal fMRI response of the dorsolateral prefrontal cortex in cognitively intact siblings of patients with schizophrenia. *Am J Psychiatry*. 2003;160:709–719.
78. Thermenos H, Seidman LJ, Breiter H, et al. Functional magnetic resonance imaging during auditory verbal working memory in nonpsychotic relatives of persons with schizophrenia: A pilot study. *Biol Psychiatry*. 2004;55:490–500.
79. Habel U, Martina K, Shah NJ. Genetic load on amygdala hypofunction during sadness in nonaffected brothers of schizophrenia patients. *Am J Psychiatry*. 2004;161: 1806–1813.
80. Raine A. Schizotypal personality: neurodevelopmental and psychosocial trajectories. *Annu Rev Clin Psychol.* 2006;2: 291–326.
81. Waldeck TL, Miller SL. Social skills deficits in schizotypal personality disorder. *Psychiatry Res.* 2000;93:237–246.
82. Shean G, Bell E, Cameron CD. Recognition of nonverbal affect and schizotypy. *J Psychol.* 2007;141:281–291.
83. Williams B, Henry JD, Green MJ. Facial affect recognition and schizotypy [abstract]. *Early Interv Psychiatry*. 2007;1: 177–182.
84. van't Wout M, Aleman A, Kessels RPC, Laroi F, Kahn RS. Emotional processing in a non-clinical psychosis-prone sample. *Schizophr Res.* 2004;68:271–281.
85. Berenbaum H, Snowhite R, Oltmanns TF. Anhedonia and emotional responses to affect evoking stimuli. *Psychol Med.* 1987;17:677–684.
86. Kotsaftis A. Emotion in schizotypal personality disorder: a study of the relationship between emotional indicators. *Dissertation Abstracts International: Section B: The Sciences and Engineering, Vol. 55(11-B)*. Ann Arbor, MI: ProQuest Information and Learning; 1995:5075.
87. Kerns JG. Positive schizotypy and emotion processing. *J Abnorm Psychol.* 2005;114:392–401.
88. Berenbaum H, Boden TM, Baker JP, Dizen M, Thompson RJ. Emotional correlates of the different dimensions of schizotypal personality disorder. *J Abnorm Psychol.* 2006;115:359–368.
89. Ferguson ML, Katkin ES. Visceral perception, anhedonia, and emotion. *Biol Psychol.* 1996;42:131–145.
90. Leung WW. Experience and expression of emotion in social anhedonia: an examination of film-induced social affiliative state in schizotypy. *Dissertation Abstracts International: Section B: The Sciences and Engineering*.Vol. 67(6-B). Ann Arbor, MI: ProQuest Information and Learning; 2006: 3457.
91. Horan WP, Brown SA, Blanchard JJ. Social anhedonia and schizotypy: the contribution of individual differences in affective traits, stress, and coping. *Psychiatr Res.* 2007;149: 147–156.
92. Gooding D, Davidson RJ, Putnam KM, Tallent KA. Normative emotion-modulated startle response in individuals at risk for schizophrenia-spectrum disorders. *Schizophr Res.* 2002;57:109–120.
93. Prince JD, Berenbaum H. Alexithymia and hedonic capacity. *J Res Pers.* 1993;27:15–22.
94. Fernandes LOL, Miller GA. Compromised performance and abnormal psychophysiology associated with the Wisconsin scales of Psychosis Proneness. In: *The Behavioral High-Risk Paradigm in Psychopathology.* New York, NY: Springer; 1995:47–87.
95. Dickey CC, McCarley RW, Shenton ME. The brain in schizotypal personality disorder: a review of structural MRI and CT findings. *Harv Rev Psychiatry*. 2002;10:1–15.
96. Siever LJ, Koenigsberg HW, Harvey P, et al. Cognitive and brain function in schizotypal personality disorder. *Schizophr Res.* 2002;54:157–167.
97. Dickey CC, McCarley RW, Xu ML, et al. MRI Abnormalities of the hippocampus and cavum septi pellucidi in females with schizotypal personality disorder. *Schizophr Res.* 2007;89:49–58.
98. Kawasaki Y, Suzuki M, Nohara S, et al. Structural brain differences in patients with schizophrenia and schizotypal disorder demonstrated by voxel-based morphometry. *Eur Arch Psychiatry Clin Neurosci.* 2004;254:406–414.
99. Buchsbaum MS, Nenadic I, Hazlett EA, et al. Differential metabolic rates in prefrontal and temporal Brodmann areas in schizophrenia and schizotypal personality disorder. *Schizophr Res.* 2002;54:141–150.
100. Koenigsberg HW, Buchsbaum MS, Buchsbaum BR, et al. Functional MRI of visuospatial working memory in schizotypal personality disorder: a region-of-interest analysis. *Psychol Med.* 2005;35:1019–1030.
101. Mohanty A, Herrington JD, Koven NS. Neural mechanisms of affective interference in schizotypy. *J Abnorm Psychol.* 2005;114:16–27.
102. Fisher J, Mohanty A, Herrington JD. Neuropsychological evidence for dimensional schizotypy: implications for creativity and psychopathology. *J Res Pers.* 2004;38: 24–31.

103. Hambrecht M, Lammertink M, Klosterkotter J, Matuschek E, Pukrop R. Subjective and objective neuropsychological abnormalities in a psychosis prodrome clinic. *Br J Psychiatry*. 2002;181(suppl 43):s30–s37.
104. Meyer SE, Bearden CE, Lux SR, et al. The psychosis prodrome in adolescent patients viewed through the lens of DSM-IV. *J Child Adolesc Psychopharmacol.* 2005;15: 434–451.
105. Häfner H, Maurer K, Löffler W. Modeling the early course of schizophrenia. *Schizophr Bull.* 2003;29:325–340.
106. Krabbendam L, Myin-Germeys I, Hanssen M, et al. Development of depressed mood predicts onset of psychotic disorder in individuals who report hallucinatory experiences. *Brit J Clin Psychol.* 2005;44:113–125.
107. Pantelis C, Velakoulis D, McGorry P, et al. Neuroanatomical abnormalities before and after onset of psychosis: a cross-sectional and longitudinal MRI comparison. *Lancet*. 2003;361:281–288.
108. Earnst KS, Kring AM, Kadar MA. Facial expression in schizophrenia. *Biol Psychiatry*. 1996;40:556–558.
109. Loughland CM, Williams LM, Gordon E. Schizophrenia and affective disorder show different visual scanning behavior for faces: a trait versus state-based distinction? *Biol Psychiatry*. 2002;52:338–348.
110. Adolphs R, Gosselin F, Buchanan TW, Tranel D, Schyns P, Damasio AR. A mechanism for impaired fear recognition after amygdala damage. *Nature*. 2005;433:68–72.
111. Brunet-Gouet E, Decety J. Social brain dysfunctions in schizophrenia: a review of neuroimaging studies. *Psychiatry Res.* 2006;148:75–92.
112. Cornblatt BA, Lencz T, Smith CW, et al. Can antidepressants be used to treat the schizophrenia prodrome? Results of a prospective, naturalistic treatment study of adolescents. *J Clin Psychiatry*. 2007;68:546–557.
113. McGorry PD, Yung AF, Phillips LJ, et al. Randomized controlled trial of interventions designed to reduce the risk of progression to first-episode psychosis in a clinical sample with subthreshold symptoms. *Arch Gen Psychiatry*. 2002;59:921–928.
114. Woods SW, Breier A, Zipursky RB, et al. Randomized trial of olanzapine versus placebo in the symptomatic acute treatment of the schizophrenic prodrome. *Biol Psychiatry*. 2003;54:453–464.
115. Woods SW, Tully EM, Walsh BC, et al. Aripiprazole in the treatment of the psychosis prodrome: an open label pilot study. *Br J Psychiatry*. 2007;191(suppl 51):s96–s101.
116. Morrison AP, French P, Walford L, et al. Cognitive therapy for the prevention of psychosis in people at ultra-high risk. Randomized controlled trial. *Br J Psychiatry*. 2004;184: 291–297.
117. Damasio AR. A second chance for emotion. In: Lane RD, Nadel L, eds. *Cognitive Neuroscience of Emotion.* New York, NY: Oxford University Press, Inc.; 2000:12–23.