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Mapping structural covariance networks of facial emotion recognition in early psychosis: A pilot study

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ABSTRACT

People with psychosis show deficits recognizing facial emotions and disrupted activation in the underlying neural circuitry. We evaluated associations between facial emotion recognition and cortical thickness using a correlation-based approach to map structural covariance networks across the brain. Fifteen people with an early psychosis provided magnetic resonance scans and completed the Penn Emotion Recognition and Differentiation tasks. Fifteen historical controls provided magnetic resonance scans. Cortical thickness was computed using CIVET and analyzed with linear models. Seed-based structural covariance analysis was done using the mapping anatomical correlations across the cerebral cortex methodology. To map structural covariance networks involved in facial emotion recognition, the right somatosensory cortex and bilateral fusiform face areas were selected as seeds. Statistics were run in SurfStat. Findings showed increased cortical covariance between the right fusiform face region seed and right orbitofrontal cortex in controls than early psychosis subjects. Facial emotion recognition scores were not significantly associated with thickness in any region. A negative effect of Penn Differentiation scores on cortical covariance was seen between the left fusiform face area seed and right superior parietal lobule in early psychosis subjects. Results suggest that facial emotion recognition ability is related to covariance in a temporal-parietal network in early psychosis.

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1. Introduction

Social cognition is defined as the mental processes involved in understanding, observing, and interpreting information in one's social environment. Research has established that people with psychosis show difficulties in social cognition, most prominently in recognizing facial emotions (Kohler et al., 2010). These deficits are present at all stages of the illness including the first-episode (Barkl et al., 2014) and are related to poorer social and occupational functioning (Couture et al., 2006; Fett et al., 2011; Irani et al., 2012).

Functional magnetic resonance imaging (fMRI) studies in non-clinical subjects have shown that processing of emotional faces in humans activates a network of regions that includes visual (fusiform face area), limbic (amygdala), temporal-parietal, and prefrontal brain areas (Fusar-Poli et al., 2009). Evidence from lesion studies (Adolphs

et al., 2000; Adolphs et al., 2003) and experiments using transcranial magnetic stimulation (Pitcher et al., 2008) have demonstrated that the face region of the right somatosensory cortex is also critical for accurate facial emotion recognition. A growing literature indicates that people with psychosis show abnormal activation in these brain regions when making judgements about facial emotional expressions, and these deviant activation patterns are thought to contribute to impairments in recognizing facial emotions (Gur et al., 2007; Li et al., 2010; Pinkham et al., 2011). However, the relationship between facial emotion recognition ability and neural structure in people with psychosis is largely understudied, and should be investigated using sophisticated imaging analyses and at differing illness stages such as soon after the onset of a psychosis. Functional imaging data suggests that the “face network” may have developed atypically in this population, which may also be reflected in aberrant structure or structural networks.

Recent developments in structural imaging analyses provide an opportunity to study associations between neuroanatomy and behavioral measures, including cognition (Dziobek et al., 2010; Lerch et al., 2006). Cortical thickness measures can be extracted through a fully-automated

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measurement of magnetic resonance (MR) images at a subvoxel resolution, and are believed to primarily reflect morphometric gray matter features such as the size, density or arrangement of cells. (Lerch and Evans, 2005; Parent and Carpenter, 1995). Structural covariance analysis of MR-based cortical thickness data can be used to further map inter-regional anatomical networks. This approach allows measurement of cortical thickness/gray matter volume in which areas of the cortex correlate with one another, allowing evaluation of anatomical relationships in the context of large-scale networks. Covariations in gray matter are thought to result from mutually trophic and maturational influences, and have been shown to partially reflect underlying white matter tracts and functional connectivity networks (Alexander-Bloch et al., 2013; Mechelli et al., 2005; Raznahan et al., 2011). A combined approach involving cortical thickness and structural covariance network analyses has the potential to provide information about underlying patterns of structure and network relationships that are associated with facial emotion recognition abilities in people with psychosis, which is lacking in the current literature.

The aims of the current study were fourfold. Our first aim was to compare cortical thickness in an early psychosis sample to a historical control group. In line with meta-analytic results (Bora et al., 2011) we hypothesized reduced cortical thickness in early psychosis subjects compared to controls in frontal and temporal regions. Our second aim was to assess structural covariance within intrinsic networks of facial emotion recognition, using the right somatosensory cortex (Pitcher et al., 2008) and bilateral fusiform face areas (Fusar-Poli et al., 2009) as seed regions of interest, in early psychosis subjects vs. controls. We hypothesized that early psychosis subjects would show alterations in network properties compared with controls. Our third aim was to evaluate associations between facial emotion recognition and cortical thickness across the cortical mantle in the early psychosis group, using the right somatosensory cortex and bilateral fusiform face regions as seeds. In line with functional imaging data showing that poorer facial emotion abilities are associated with altered activation in widespread cortical regions in this population (Gur et al., 2007), we hypothesized that early psychosis subjects would show different patterns of associations between cortical thickness and facial emotion recognition ability than controls. Our fourth aim was to evaluate the modulation of facial emotion recognition on structural covariance between thickness in right somatosensory cortex and bilateral fusiform face area seeds and thickness across the brain in early psychosis subjects. Given the limited published research on structural covariance analyses, aim four was exploratory and no hypothesis was put forth.

2. Materials and methods

2.1. Participants

Fifteen participants with a early psychosis were recruited through the Early Psychosis Treatment Service at Foothills Hospital in Calgary, Alberta, Canada, and all provided MR scans. For this study an early psychosis was defined as being within the first 3 years of receiving an initial diagnosis of psychosis, which was confirmed through chart records. Exclusion criteria were history of neurological disorder, loss of consciousness for more than 5 min, or presence of metal in the body. Twelve participants were taking anti-psychotic medications at the time of the study and three were unmedicated.

Although a control group was not recruited for this study, data was available for 15 historical controls from previous studies conducted at the University of Calgary in the research program of the senior author (J.A.). Control subjects could not meet criteria for any prodromal syndrome, any current or past psychotic disorder or a Cluster A personality disorder diagnosis, not have a family history (in first-degree relatives) of any psychotic disorder or any other disorder involving psychotic symptoms. They could not be currently using psychotropic medication. The historical control group was matched to the early psychosis group

based on age first and secondly on sex. Unfortunately, the dataset that the historical control group was drawn from was comprised mostly of females over the age of 18 and males under the age of 18. Because we elected to first match on age, this resulted in an over-representation of females in the historical control group. MR data of controls was used in the current study to compare cortical covariance with our early psychosis patients.

All participants provided written informed consent and the study was approved by the University of Calgary Conjoint Health Research Ethics Board.

2.2. Measures

Demographics recorded included age, sex, years of educations and handedness. Antipsychotic dosage was recorded and computed as chlorpromazine equivalent dosage. Symptom severity was assessed using the positive and negative subscales of the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987). IQ was assessed with a 2-subtest form of the Wechsler Abbreviated Scale of Intelligence comprising the Vocabulary and Block Design subtests (Wechsler, 1999). Facial emotion recognition was assessed with the Penn Emotion Recognition task (ER40; Gur et al., 2002) and the Penn Emotion Differentiation task (EDF40; Silver et al., 2002). In these tasks, pictures representing facial expressions are shown in color, with an equal number of male and female faces, and four races represented (Caucasian, African-American, Asian and Hispanic). In the ER40, faces are presented one at a time and participants choose the emotion that is represented from a list of five possibilities (anger, fear, neutral, happy and sad). In the EDF40, two faces are shown and participants indicate which shows an emotion (either happiness or sadness) more intensely. The ER40 yields a total score ranging from 0 to 40, and individual sub-scores for happy, sad, angry, fearful and neutral facial expressions. The EDF40 provides a total score ranging from 0 to 40, and two sub-scores for happy and sad facial expressions. For the current manuscript, we report only total accuracy scores for each of these tasks.

2.3. Study procedures

PANSS ratings were conducted by experienced research clinicians. MR scans were performed on the same day that ER40/EDF40 task performance was collected. Participants received monetary remuneration for their participation.

2.4. MRI acquisition

MRI scanning was conducted on a 3 Tesla GE Signa scanner with an 8-channel head coil at the Seaman Family MR Research Centre at the University of Calgary. All participants underwent a high-resolution anatomical scan (3D SPGR, 180 slices, FOV = 25.6 cm, 1 × 1 × 1 mm, flip angle = 12°).

2.5. Measurement of cortical thickness

A quality control (QC) procedure was carried out by one rater on all raw T1-weighted images to ensure no visible motion artefacts or poor resolution of gray/white matter contrast. The high quality MRIs were then submitted to the CIVET processing pipeline (Version 2.0.0) (<http://www.bic.mni.mcgill.ca/ServicesSoftware/CIVET>) (Ad-Dab'bagh et al., 2006; Zijdenbos et al., 2002), using the CBRAIN platform (Sherif et al., 2014). Native T1-weighted images were first registered to the ICBM152 template using a linear transformation (Collins et al., 1994; Grabner et al., 2006) and simultaneously corrected for non-uniformity artefacts using N3 (Sled et al., 1998). The transformed images were then segmented into gray matter, white matter, cerebral spinal fluid and background using a neural net classifier (INSECT) (Zijdenbos et al., 2002). Gray matter and white matter surfaces were extracted

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