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Orbitofrontal cortex volume and intrinsic religiosity in non-clinical psychosis

Andrea Pelletier-Baldelli^{a,b,*}, Derek J. Dean^a, Jessica R. Lunsford-Avery^a, Ashley K. Smith Watts^{a,c}, Joseph M. Orr^{a,d}, Tina Gupta^a, Zachary B. Millman^a, and Vijay A. Mittal^{a,b}

^aDepartment of Psychology and Neuroscience, University of Colorado Boulder, Boulder, CO, USA

^bCenter for Neuroscience, University of Colorado Boulder, Boulder, CO, USA

^cInstitute for Behavioral Genetics, University of Colorado Boulder, Boulder, CO, USA

^dInstitute of Cognitive Science, University of Colorado Boulder, Boulder, CO, USA

Abstract

Research indicates that religiosity plays a complex role in mental illness. Despite this link, little work has been done to clarify the role of religiosity in persons exhibiting non-clinical psychosis (NCP, individuals experiencing fleeting psychotic-like symptoms in the absence of a formal psychotic disorder). Further, there are no NCP investigations into whether abnormalities exist in brain structures that are associated with religiosity. Understanding these relationships in NCP is important to clarify the role of religiosity and brain structural anomalies in psychosis. Twenty individuals experiencing NCP and twenty controls were assessed for intrinsic religiosity (IR; motivation/commitment to religious beliefs and/or practices) using a well-validated self-report scale. Structural magnetic resonance imaging was used to determine volumes of the orbitofrontal cortex (OFC), a critical region that has been associated with increased religiosity. Results indicate that IR is elevated in the NCP group, and that these individuals exhibit bilateral volume reduction in both the lateral and medial OFC. Sample-wide correlations are non-significant, but show notable relationships between smaller OFC regions and increased IR. Significant negative relationships were found between OFC volume and depressive and negative symptoms. Overall, results suggest that brain abnormalities associated with NCP may also confer a heightened susceptibility for religiosity.

Keywords

Psychosis continuum; Psychotic-like experiences; Psychotic symptoms; Psychosis risk; Gray matter volume; Magnetic resonance imaging (MRI)

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Corresponding Author: Andrea Pelletier-Baldelli, Department of Psychology and Neuroscience, University of Colorado at Boulder, 345 UCB, Boulder, Colorado 80309-0345, Phone: 252.670.2571.

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1. Introduction

A body of evidence suggests that psychosis occurs across a continuum (Verdoux and van Os, 2002; Mittal et al., 2011; Pelletier et al., 2013a). Research supports the idea of a continuous phenotype by indicating that individuals in the general population can exhibit fleeting psychotic-like symptoms (van Os et al., 2009). These experiences, occurring in the absence of formal psychiatric illness, are often referred to as non-clinical psychosis (NCP) (Mittal et al., 2012a). Individuals experiencing NCP represent approximately 5–8% of the general population (van Os et al., 2009), and this group is also at an increased risk of developing psychosis (Poulton et al., 2000; Hanssen et al., 2005; Welham et al., 2009). There is a growing body of literature linking NCP with a variety of risk factors commonly seen in formal psychosis, such as trauma, ethnicity, immigrant status, cannabis use, low socio-economic status, urban residence, unemployment, and prenatal complications (Kelleher and Cannon, 2011). One important component that is not investigated in the NCP population (and only minimally investigated in formal psychosis) is religion. Religion is commonly understood to reflect one's beliefs, practices, or behaviors surrounding supernatural agents (Kapogiannis et al., 2009a). Related to the concept of religion, religiosity is defined as psychological and/or behavioral traits associated with religious beliefs (Kapogiannis et al., 2009a). Because religion may often be a driving force in an individual's life that may pervade and affect all other beliefs, attitudes and behaviors (Suhail and Ghuari, 2010), the study of religion and religiosity warrants empirical attention.

The link between schizophrenia and religion is commonly recognized, but the exact nature of the relationship is not clearly understood and is often overlooked (Gearing et al., 2011). Research suggests that religion may act as both a risk and protective factor in regards to hallucinations and delusions (Gearing et al., 2011). For example, studies indicate that the subjective importance of religion may be positively related to the presence of religious delusions (Rudalevi et al., 2008). Research also suggests that having religious delusions is associated with poorer outcome in individuals with schizophrenia, and specifically, with less adherence to medication (Mohr et al., 2010). Further, it appears that differing religious appraisals (i.e., viewing God as benevolent versus God as punishing) of one's serious mental illness may also play a moderating role on prognosis (Phillips and Stein, 2007). Of note, there is some evidence to suggest that religious delusions are more likely to be held as fixed beliefs in comparison with other delusions (e.g., persecutory and body/mind control without a religious context) (Applebaum et al., 1999; Mohr et al., 2010). In individuals with a psychosis diagnosis, research indicates that the prevalence of religious delusions ranges anywhere from 6% to 36%, depending on the specific culture in question (Applebaum et al., 1999). Finally, in regards to having a more protective role, religion is associated with increased ability to cope with mental illness, and specifically with hallucinations and delusions (Mohr et al., 2006). Ultimately, although a relationship is apparent, it is not clear how religion may impact psychosis.

Research on religiosity also focuses more broadly on general psychological adjustment and other health outcomes (Hackney and Sanders, 2003; Koenig, 2008). To determine the role of religiosity in a variety of health outcomes, researchers have assessed a multitude of religious domains, including intrinsic religiosity (IR). IR is understood as the general spirituality or

devoutness of an individual, and refers to one's degree of motivation and commitment to a lifestyle influenced by the presence of God and/or the Devine (Koenig et al., 1997; Lucchetti et al., 2012). IR has been linked to less alcohol use, minority status, greater optimism, female gender, recent illness onset, less depression, and less anxiety (Rajagopal et al., 2002; Cotton et al., 2006). In general, IR provides a means of assessing religiosity more broadly and is a tool for elucidating relationships with relevant health variables.

One means of furthering our understanding of religiosity in NCP is through neuroimaging. Although research indicates that NCP individuals exhibit structural abnormalities that are similar to those seen in formal psychosis (Jacobson et al., 2010), there is a need for further research to better understand associations between brain structure in NCP and clinical/behavioral components of NCP. Additionally, the literature on the neuroimaging of religiosity in NCP is non-existent. Of the limited research investigating religiosity and the brain in the field more broadly, one study assessed cortical volume and its relationship to religiosity through magnetic resonance imaging (MRI) (Kapogiannis et al., 2009a). In a recent study of 40 healthy adults (Kapogiannis et al., 2009a), investigators found that key components of religiosity (having intimate relationship with God and religious behaviors, as well as fear of God) were associated with structural differences including a decrease in the left orbitofrontal cortex (OFC). This is particularly interesting as the OFC is integral to higher order cognitive function including emotional processing, motivation, decision-making, hedonic experience, and sensory-visceral multimodal experience (Öngür and Price, 2000; Kringelbach, 2005; Chakirova et al., 2010). Additionally, studies across the psychosis spectrum, including those assessing individuals at high risk, individuals with first-episode psychosis, and those with chronic schizophrenia have found decreased volumes in the OFC (Borgwardt et al., 2008; Chakirova et al., 2010; Jung et al., 2012).

The present study seeks to address gaps in the NCP literature, specifically in regards to religiosity and brain structure. Twenty NCP and 20 matched control participants were assessed for IR and OFC volume to determine (1) whether IR is more prevalent in those individuals experiencing NCP, (2) whether there are significant volumetric differences in the OFC between groups (left lateral OFC, right lateral OFC, left medial OFC, and right medial OFC), and (3) whether a specific directional relationship found in a previous study (Kapogiannis et al., 2009a) was present here (decreased left orbitofrontal cortex volume related to high religiosity). Given the emerging idea of a putatively significant role of religiosity and OFC volumetric abnormalities in disorders such as schizophrenia (Gearing et al., 2011; Chakirova et al., 2010), we believe the present data may help facilitate an understanding of a relationship between these two variables and the overarching implications for our comprehension of psychosis.

2. Methods

2.1. Subjects

All participants were recruited through the Adolescent Development and Preventive Treatment (ADAPT) program at the University of Colorado Boulder (UCB), and the Institutional Review Board (IRB) approved all procedures. Study details were provided to all participants and written informed consent was obtained. To identify participants for NCP

group, individuals participating in the UCB Psychology Department undergraduate research pool ($n=1,285$) were screened using the Community Assessment of Psychic Experiences (CAPE) (Mittal et al., 2012b) positive symptom inventory. The option to participate in the study was made available to those scoring in the top 15th percentile on the CAPE positive domain (a score of 15 on the CAPE). The research pool is a volunteer research database in which undergraduate students taking an introduction to psychology course participate in research studies for course credit. Several studies recruit from this subject pool. Therefore, to limit potential sampling bias (i.e., individuals knowingly selecting studies for which they are most suited or in which they are most interested), available studies are listed as numbers without descriptions. From the possible 81 students invited, a total of 20 students selected to participate in this study; none of the students declined to participate after learning the study details.

Healthy control participants ($n = 20$) were recruited through flyers and newspaper announcements (advertised as a study of neuroimaging and healthy development for volunteers with no psychiatric symptoms and no family history of psychosis) and selected on the basis of demographic characteristics comparable to the NCP group in age, sex, and parental educational level (a proxy for social class). Due to the desire to maximize recruitment of a normative sample, we chose not to use an extreme low NCP group (scoring low on the CAPE) in order to avoid potentially superficially increasing variability and influencing findings (Mittal et al., 2011; Mittal et al., 2012a; Pelletier et al., 2013a). Therefore, screening with the CAPE positive domain was not an inclusion/exclusion criterion for the healthy control group.

2.2. Clinical symptoms

The CAPE is self-report questionnaire that measures the frequency of psychotic-like experiences on a four-item Likert scale including “Never,” “Sometimes,” “Often,” and “Nearly Always” (Mittal et al., 2012b). The positive, negative, and depressive frequency sections were administered to all participants. The positive symptom frequency section of the CAPE contains 20 items, the negative section includes 14 items, and the depressive section includes 8 items. The CAPE is one of the most widely used, reliable, and well-validated instruments for examining NCP (Johns, 2005; Barkus et al., 2007; Vellante et al., 2012).

The B module of Structured Clinical Interview for DSM-IV Disorders (SCID) (Overall and Gorham, 1976) was administered to participants in both groups to ensure that participants with clinical levels of psychosis would not be included, as their inclusion could potentially confound results (no participants were excluded based on this criterion). Previous studies show that the SCID yields valid and reliable diagnosis for a wide age range including adolescents and young adults (Weinstein et al., 1999). This measure has been demonstrated to have excellent inter-rater reliability in adolescent populations (Martin et al., 2000). Advanced psychology doctoral students and clinical psychologists conducted the SCID interviews, and reliability exceeded 0.90.

2.3. Religiosity

Religiosity was measured using the Duke University Religion Index (DUREL), a brief, five-item self-report scale created for epidemiological studies assessing religious involvement (Koenig and Büssing, 2010). The DUREL assesses multiple domains of religiosity including intrinsic religiosity (IR), organizational religious activity (e.g. religious service attendance), and non-organizational religious activity (e.g., time spent in prayer) (Koenig and Büssing, 2010). Two questions assess organized and non-organized religiosity (one question for each dimension), and three questions assess IR. In general, IR represents how committed or motivated an individual is to a lifestyle characterized by religiosity. Specifically, questions assess whether one experiences the presence of God or the Divine, if religion is a strong component of one's general approach to life, and whether religion is pervasive. Participants are asked to respond indicating whether the statement is (a) Definitely true of me, (b) Tends to be true, (c) Unsure, (d) Tends not to be true, or (e) Definitely not true. For the present study, higher scores indicate increased intrinsic religiosity. The DUREL has excellent psychometric properties including internal consistency (Cronbach's $\alpha = 0.78$ to 0.91), convergent validity ($r = 0.71$ – 0.86), and test-retest reliability (0.91) (Koenig and Büssing, 2010). Furthermore, the DUREL has been normed on almost 7,000 people, in both clinical and community populations (Koenig and Büssing, 2010).

2.4. Structural imaging

Magnetic resonance imaging (MRI) of the brain was acquired on each subject using a Siemens 3-Tesla Magnetom TIM Trio MRI scanner (Siemens AG, Munich, Germany) with a 12-channel head coil. A T1-weighted 3D magnetization prepared rapid gradient multi-echo sequence (MPRAGE; sagittal plane; repetition time [TR] = 2530 ms; echo times [TE] = 1.64 ms, 3.5 ms, 5.36 ms, 7.22 ms, 9.08 ms; GRAPPA parallel imaging factor of 2; 1 mm³ isomorphic voxels, 192 interleaved slices; field of view [FOV] = 256 mm; flip angle = 7°; time = 6:03 min) covering the whole brain was acquired for anatomical segmentation. A turbo spin echo proton density (PD)/T2-weighted acquisition (TSE; axial oblique aligned with anterior commissure-posterior commissure line (AC-PC line); TR= 3720ms; TE=89ms; GRAPPA parallel imaging factor of 2; 0.9×0.9 mm voxels; FOV=240 mm; flip angle = 120°; 77 interleaved 1.5-mm slices; time = 5:14 min) was acquired to check for incidental pathology. The entire imaging protocol including localizing images, gradient echo field mapping, arterial spin labeling scan, and BOLD weighted resting state scan was about 30 min.

2.5. Image processing

The OFC volumes were delineated automatically on the MPRAGE using the Freesurfer suite of automated tools (Fischl et al., 2002). The processing stream involved motion correction, removal of non-brain tissue using a hybrid watershed/surface deformation procedure (Segonne et al., 2004), automated Talairach transformation, segmentation of the subcortical white matter and deep gray matter volumetric structures (Fischl et al., 2002; Fischl et al., 2004) intensity normalization (Fischl et al., 2004) tessellation of the gray matter/white matter boundary, automated topology correction (Sled et al., 1998; Fischl et al., 2001) and surface deformation following intensity gradients. This process optimally places the gray/

white and gray/cerebrospinal fluid borders at the location where the greatest shift in intensity defines the transition to the other tissue class (Segonne et al., 2007). Freesurfer returned separate volumes for lateral and medial orbitofrontal cortex, separately for each hemisphere (see Fig. 1). Freesurfer also returned values for each participant's total intracranial volume (TICV) (i.e., the sum of whole-brain gray matter +white matter+cerebrospinal fluid), and the individual OFC volume estimates were divided by the TICV to control for whole brain volume.

2.6. Statistical analysis

Demographics were analyzed to test for significant group differences using Pearson chi-square tests for categorical variables and independent *t*-tests for continuous variables. Group differences in positive, negative, and depressive symptoms were analyzed using independent *t*-tests. A Kolmogorov-Smirnov test revealed that the IR scale was not normally distributed; however, no outliers were present for the IR measure. Therefore, a Mann-Whitney *U*-test was used to assess group differences in IR. Group differences in OFC volume were assessed using separate linear regression models. Further, Spearman correlations were used to examine any potential relationship between the medial and lateral OFC and IR. The relationship between symptoms and OFC was an exploratory aim using Pearson correlations and was analyzed independently in each group due to the sampling strategy. Finally, associations between the IR and symptoms were also conducted using Spearman correlations in each group separately in order to provide clearer understanding regarding relationships between the OFC, IR, and psychosis.

3. Results

There were no significant differences between the NCP ($n=20$) and healthy control ($n=20$) groups on demographic characteristics including age, gender and parental education (see Table 1). The NCP group showed significantly higher scores for positive, negative, and depressive symptoms on the CAPE than the control group (positive symptoms: $t(38)=5.67$, $p=0.01$; negative symptoms: $t(38)=3.76$, $p=0.01$; depressive symptoms: $t(38)=3.12$, $p=0.01$).

3.1. Group difference in intrinsic religiosity

There were significant differences between groups with respect to levels of IR, such that the NCP group reported higher levels of this index on the DUREL ($U=111.5$, $z=-2.45$, $p=0.01$).

3.2. Orbitofrontal cortex volume

The NCP group showed significantly smaller volumes than the controls for both the left ($F(1,38)=6.16$, $p=0.018$) and right lateral OFC ($F(1,38)=7.14$, $p=0.011$). Analyses also revealed that the NCP group exhibited a significant decrease in volume in regards to the left ($F(1,38)=7.97$, $p=0.008$) and right medial OFC ($F(1,38)=9.25$, $p=0.004$) (see Table 1).

3.3. Orbitofrontal cortex and intrinsic religiosity

Sample-wide correlational analyses revealed no significant associations between regions of the OFC and IR. It may be that with a larger sample size, relationships could become stronger. For example, although not significant, results suggest that perhaps IR may be

negatively related to the right lateral OFC ($r_s=-0.21$, $p=0.10$), left medial OFC ($r_s=-0.23$, $p=0.08$), and right medial OFC ($r_s=-0.20$, $p=0.12$). There was no significant relationship between IR and the left lateral OFC ($r_s=-0.09$, $p=0.30$) (see Table 2).

3.4. Psychotic-like symptoms and orbitofrontal cortex

As an exploratory aim, symptom associations were assessed in conjunction with OFC volume. In the control group, no significant associations were found. For the NCP group alone, results indicated significant relationships with OFC regions and depressive and negative symptoms. The left and right lateral OFC regions were negatively related to negative symptoms ($r=-0.43$, $p=0.03$ and $r=-0.41$, $p=0.04$, respectively), indicating that smaller lateral OFC volumes were associated with higher negative symptoms. Similarly, a decrease in gray matter volume was related to higher frequency of depressive symptoms for the right lateral OFC ($r=-0.53$, $p=0.008$).

3.5. Psychotic-like symptoms and intrinsic religiosity

In the control group, there was a significant association between positive symptoms and IR, such that higher religiosity corresponded to greater symptoms ($r=0.47$, $p=0.021$). For the NCP group alone, there were no significant correlations between IR and positive, negative, or depressive symptoms. Although not significant, correlations in the NCP were in an interesting direction, suggesting a positive relationship with positive symptoms and a negative association with negative and depressive symptoms (positive, $r_s=0.175$, $p=0.230$; negative, $r_s=-0.158$, $p=0.253$; depressive, $r_s=-0.226$, $p=0.169$) that could be further evaluated in a larger sample.

4. Discussion

To the authors' knowledge, this is the first study to assess religiosity and its relationship to brain structure in a NCP sample. In doing so, the present investigation expands upon the sparse literature on structural findings and religiosity, and it lends support to previous research in both domains. Findings regarding elevated IR, reduced OFC volumes, and associations between increased IR and reduced OFC volumes provide further clarification on the phenomenon of religiosity in psychosis.

The group differences in IR suggest that those exhibiting NCP are more committed to having the presence of God/the Divine in their lives. This finding is in line with previous research involving psychotic populations, which suggests that individuals experiencing illnesses such as schizophrenia exhibit increased religiosity (Suhail and Ghauri, 2010). Thus, the observation of heightened religiosity in NCP represents one of the first attempts to clarify how religion may present across the psychosis continuum.

The current investigation examined the OFC primarily due to research suggesting that the OFC may contribute to schizophrenia symptomatology (Chakirova et al., 2010). Research involving first-episode patients indicates orbitofrontal abnormalities (Nakamura et al, 2007), and studies suggest decreases in gray matter volume in the OFC in other at-risk populations along the psychosis spectrum (Pantelis et al., 2003; Borgwardt et al., 2008). More specifically, research on high-risk samples demonstrates a specific progressive reduction in

OFC volume over time (Jung et al., 2012). However, the literature on this topic is somewhat mixed; for example, one study that assessed structural abnormalities in an NCP population reported no decrease in OFC volume (Jacobson et al., 2010). These differences may reflect heterogeneous methodologies as the noted study assessed a sample aged 11–13 years and used voxel-based morphometry to determine gray matter volume (Jacobson et al., 2010). The present findings, showing decreased volume in the lateral and medial OFC regions for those individuals experiencing NCP relative to healthy controls, provide evidence that NCP constitutes a lower end of a psychosis continuum.

Although not significant, results were notable between the OFC and religiosity as this is the first study to assess this relationship in an NCP population. The link between the OFC and IR is consistent with another structural study that reported that smaller OFC volumes were related to higher levels of religiosity in healthy individuals. Of note, the present study was suggestive of associations in the OFC bilaterally, while the earlier study reported a relationship in the left OFC only. This contrast in results may be due to the slightly different measures of religiosity used in the present study. For example, the current investigation assesses IR, whereas the former study assessed a more specific type of relationship with God (i.e., fear of God) (Kapogiannis et al., 2009a). Future research will need to incorporate a large sample size to determine whether the potential links noted in the present study become significant and help clarify any relationship.

Although we cannot conclusively infer causality from the present study, an accumulating body of evidence suggests an important role for the OFC in religiosity. Both structural and functional studies have implicated the OFC as a region involved in religious beliefs (Kapogiannis et al., 2009a; Kapogiannis et al., 2009b) in healthy individuals. More broadly, research indicates that the OFC is a hub for the integration of sensory input, and is involved in learning, autonomic responses, decision making, and emotional behaviors (Kringelbach, 2005). Further, the OFC functions in conjunction with other notable brain regions and structures including the medial prefrontal cortex, hypothalamus, and amygdala, among others (Kringelbach, 2005). The idea that religiosity also may be processed in the OFC (which functions in regards to an extensive list of processes and is linked to various other regions) is plausible. This is especially plausible in the present study, in which religiosity was defined by the pervasiveness of religion in one's life.

Although the OFC was chosen as a focus in this particular study, there are additional brain regions implicated in religiosity. Studies note that activation involved in religiosity comprises networks commonly associated with social cognition, such as the inferior frontal gyrus, temporal parietal gyrus, and precuneus (Kapogiannis et al., 2009b). Additionally, regions such as the temporal lobes, ventromedial prefrontal cortex, and medial parietal regions have also been implicated in religious belief through functional MRI and single photon emission tomography (Puri et al., 2001; Azari and Slors, 2007; Harris et al., 2009). Future studies using multi-modal imaging will add to the growing understanding of religion as a complex construct that recruits a variety of cognitive and emotional processes (Beauregard, 2012).

To expand our understanding of the relationship between religiosity and psychosis, we examined symptom associations with the OFC and symptom relationships with IR. Based on past research, there have been established links between psychotic symptoms (i.e., ideas of reference, magical thinking, suspiciousness) and volumetric abnormalities in the OFC (Chakirova et al., 2010). Another study suggested a relationship between OFC anomalies and both positive and negative symptoms (Nakamura et al., 2007). Similarly, the present study supports previous research in suggesting an association between psychotic symptomatology and the OFC. The significant relationship with the OFC and both negative and depressive symptoms in the NCP group is an informative finding, in that elevations in these specific symptom domains are associated with decreases in gray matter volume. The significant relationship between the right lateral OFC and depressive symptoms supports a recent finding connecting lower trait neuroticism (which included depression) and increased volume in the right OFC (Kapogiannis et al., 2012). Additionally, the present finding of an association between depressive and negative symptoms and the OFC is particularly relevant for high-risk research as this relationship was only present in the NCP group and not controls. As depressive and negative symptoms are likely to appear before the onset of positive symptoms for individuals at ultra-high risk for psychosis (Yung and McGorry, 1996; Pelletier and Mittal, 2013b), the relationship between the OFC and these specific symptoms may be of use in furthering our ability to enhance early identification efforts. Finally, results regarding relationships between symptoms and IR are notable. Specifically, for the NCP group, the directionality of the findings suggests that examining these relationships in a larger sample would be useful and perhaps provide clarification as to the role of psychosis as both a protective and risk factor. Furthermore, more nuanced religious scales may help provide more variability, which would allow for statistical approaches associated with more power (e.g., parametric) to help address questions surrounding the link between psychosis and religiosity.

Normatively smaller OFC volumes have been associated with increased religiosity in healthy individuals (Kapogiannis et al., 2009a). Because this region is affected in schizophrenia (i.e., patients with formal psychosis show smaller volumes) (Borgwardt et al., 2008; Chakirova et al., 2010; Jung et al., 2012) and the current findings also indicate smaller OFC in NCP (i.e., the volumes are smaller in the clinical group and associated with symptoms), it is possible that pathogenic factors confer a heightened religiosity across the psychosis spectrum. While the current results may begin to elucidate relationships between the OFC, religiosity, and symptomatology when considered in the context of the existing literature, future longitudinal studies will be critical in determining if this heightened susceptibility to religion may paradoxically serve as a protective factor, or further exacerbate existing vulnerabilities. Without doubt, a host of mitigating factors relating to the self, family, culture, and a specific given religion will also affect this relationship.

The present study benefits from several methodological strengths, including sampling for a healthy control group exhibiting a range of PLEs, including a formal psychosis screener, using a well-validated measure of religiosity, and employing a gold standard NCP assessment. However, the findings should be viewed as preliminary due to the relatively small sample size, which may have limited statistical power, and perhaps contributed to the non-significant findings. Furthermore, the study's utilization of an undergraduate population

and its cross-sectional design may limit generalizability of the results. Future studies should assess religiosity using a whole brain analysis in conjunction to studying OFC volume longitudinally to determine if the relationships evident in the present investigation remain constant. Additionally, future research would benefit from a more in-depth measure of religiosity, and perhaps a specific measure assessing religious coping to explore whether religion acts as a protective or risk factor in NCP. Investigations into religiosity may also be improved by including additional brain networks implicated in other studies. Finally, there is a need to research religiosity's impact on psychosis symptomology at other stages in the psychosis continuum, such as those deemed to be at clinical high risk. Such investigations stand to clarify any potential benefits or effects that may exist through the use of religious practice among individuals on the psychosis continuum.

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Figure 1.
Sagittal (A) and horizontal (B) view of Lateral (green) and Medial (red) Orbitofrontal Cortex

Table 1

Demographics, symptoms, religiosity, and brain volumes

NCP (N=20)		Controls (N=20)	Grand Total (N=40)	χ^2	p	
<u>Gender n(%)</u>	9(45.0)	8(40.0)	17(42.5)	0.102	0.749	
Males						
	Mean(SD)	Mean(SD)	Mean(SD)	t	p	
<u>Age</u>	18.6(0.76)	18.4(1.6)	18.5(1.2)	0.378	0.707	
<u>Parent Education</u>	15.7(1.9)	15.6(3.3)	15.6(2.6)	0.147	0.884	
<u>CAPE</u>						
* Positive	10.4(4.8)	3.3(2.7)	6.9(5.3)	5.67	0.000	
* Negative	5.1(2.2)	2.8(1.5)	3.9(2.2)	3.76	0.001	
* Depressive	9.7(5.4)	5.2(3.3)	7.5(5.0)	3.12	0.003	
	Mean(SD)	Mean(SD)	U	z	p	
<u>DUREL</u>						
* IR	7.2(3.7)	4.0(4.2)	5.6(4.2)	111.5	-2.45	0.014
	NCP Mean(SD)	Control Mean(SD)	F	p		
<u>Orbitofrontal Cortex (% of TICV)</u>						
* Lateral LH	0.51(0.05)	0.55(0.06)	6.16	0.018		
* Lateral RH	0.47(0.04)	0.50(0.05)	7.14	0.011		
* Medial LH	0.33(0.03)	0.35(0.04)	7.97	0.008		
* Medial RH	0.34(0.03)	0.38(0.05)	9.25	0.004		
	NCP Raw Mean(SD)	Control Raw Mean(SD)				
<u>Orbitofrontal Cortex</u>						
* Lateral LH	8303(1093)	8107(840)				
* Lateral RH	7639(857)	7466(753)				
* Medial LH	5323(704)	5233(543)				

	NCP Raw Mean(SD)	Control Raw Mean(SD)
* Medial RH	5563(488)	5635(777)
TICV	1633446(155639)	1487031(176379)

* indicates significant group differences at p<0.05.

Non-clinical psychosis symptoms were derived from the Community Assessment of Psychic Experiences (CAPE). Positive symptom frequency values range from 0–60, negative from 0–42, and depressive from 0–32. IR (intrinsic religiosity) is a subscale of religiosity from the Duke University Religiosity Index (DUREL). For the IR measure, Skewness=−0.073, Kurtosis= −1.51. Brain volumes represent % of total intracranial volume (TICV). Raw brain volume and TICV for group is provided in mm^3.

Table 2

Sample-Wide Correlations between Intrinsic Religiosity and Orbitofrontal Cortex *p < .12; **p < 0.05. Intrinsic Religiosity is a subscale from the Duke University Religion

	Left Medial Orbitofrontal Cortex	Right Medial Orbitofrontal Cortex	Left Lateral Orbitofrontal Cortex	Right Lateral Orbitofrontal Cortex
Intrinsic Religiosity	−0.23*	−0.20*	−0.09	−0.21*

Index (DUREL).