ORIGINAL ARTICLE

# The $GABA_A$-Receptor γ2 (GABRG2) Gene in obsessive-compulsive disorder

## O gene do receptor $GABA_A$- γ2 (GABRG2) no transtorno obsessivo-compulsivo

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*Abstract*

***Objective:*** *The γ-aminobutyric acid type A ($GABA_A$) system may be implicated in obsessive-compulsive disorder, based on its major role in modulation of anxiety and its function as the principal inhibitory neurotransmitter system in the cortex. In addition, glutamatergic/GABAergic mechanisms appear to play a role in the pathophysiology of obsessive-compulsive disorder, making the $GABA_A$ receptor–$\gamma^2$ (GABργ2) gene a good candidate for susceptibility in this disorder.* ***Method:*** *118 probands meeting DSM-IV criteria for primary obsessive-compulsive disorder and their available parents were recruited for participation in this study and informed consent was obtained. An* NciI *restriction site polymorphism in the second intron was genotyped and data was analyzed using the Transmission Disequilibrium Test.* ***Results:*** *In total, 61 of the participating families were informative (i.e., with at least one heterozygous parent). No biases were observed in the transmission of either of the two alleles ($\chi^2$ = 0.016, 1 d.f., p = 0.898) to the affected probands in the total sample.* ***Conclusion/Discussion****: While these results do not provide support for a major role for the $GABA_A$ receptor–γ2 in obsessive-compulsive disorder, further investigations of this gene in larger samples are warranted.*

***Descriptors****: Obsessive-compulsive disorder; Genetics; Linkage disequilibrium; Receptors, GABA; Allelic imbalance*

*Resumo*

***Objetivo:*** *O sistema gabaérgico tipo A ($GABA_A$) pode estar implicado no transtorno obsessivo-compulsivo devido ao seu grande papel na modulação da ansiedade e da sua função como o principal neurotransmissor inibidor no córtex. Além disso, mecanismos glutamatérgicos/gabaérgicos parecem desempenhar um papel na fisiopatologia do transtorno obsessivo-compulsivo, tornando o gene do receptor $GABA_A$–γ2 (GABRG2) um bom gene candidato para a suscetibilidade genética a este transtorno.* ***Método:*** *118 probandos que preencheram os critérios do DSM-IV para transtorno obsessivo-compulsivo primário e seus pais (quando disponíveis) foram recrutados para a participação neste estudo; consentimento informado foi obtido. Um polimorfismo no sítio de restrição da enzima* NciI*, localizado no íntron 2, foi genotipado e os dados foram analisados utilizando-se o Teste de Desequilíbrio de Transmissão.* ***Resultados:*** *No total, 61 das famílias participantes foram informativas (ou seja, com pelo menos um progenitor heterozigoto). Não foi observado desequilíbrio de transmissão de qualquer um dos dois alelos ($\chi^2$ = 0,016, 1 g.l., p = 0,898) aos probandos afetados.* ***Conclusão/Discussão:*** *Apesar de estes resultados não fornecerem suporte para um papel importante para o gene $GABA_A$–γ2 no transtorno obsessivo-compulsivo, novas investigações desse gene em amostras maiores são justificadas.*

***Descritores:*** *Transtorno obsessivo-compulsivo; Genética; Desequilíbrio de ligação; Receptor de GABA; Desequilíbrio alélico*

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## Introduction

Obsessive-compulsive disorder (OCD) is characterized by recurrent unwanted thoughts (obsessions), usually accompanied by repetitive behaviours (compulsions) intended to alleviate anxiety.[1] Insight is generally preserved into the senseless nature of the symptoms. OCD is a relatively common disorder, with a lifetime prevalence of 2-3%.[2-3] Psychosocial morbidity of this chronic condition is extremely high, and can render the individual completely debilitated in some cases.

There is solid evidence for the involvement of genetic factors in the etiology of OCD.[4-9] Family studies have typically reported increased prevalence of OCD and related disorders amongst first-degree relatives of OCD probands, thus providing support for a genetic diathesis.[10-11] Furthermore, segregation analyses have been consistent with a single gene of major effect.[12-13]

The etiology of OCD is unclear. While it is widely accepted that serotonergic mechanisms are important in the neurobiology of OCD, other neurotransmitter systems may also be involved. Benzodiazepines (BDZ) have long been observed to be specifically helpful in augmentation of serotonin-reuptake inhibitor treatment of OCD, as well as non-specifically useful in modulating the intense anxiety, which is a core feature of this disorder.[14] BDZs pharmacologically act at the γ-aminobutyric acid (GABA)-benzodiazepine receptor complex, via positive allosteric modulation of the $GABA_A$ receptor-binding site.[15] The $GABA_A$ receptor is an oligomeric glycoprotein, which forms a pentameric chloride channel assembled from different genetic variants of 3 subunits of the following: alpha (α), beta (β), delta (δ), and gamma (γ), with $\alpha_2\beta_2\gamma$ being the most common pentamer in the brain; BDZs bind at the junction of the α and γ subunits.[16] The amino acid neurotransmitter, GABA, is the principal inhibitory neurotransmitter in the brain, and may also be functionally important in cortical disinhibition.[17] It may therefore be relevant to explore the potential role of GABAergic mechanisms, in particular the $GABA_A$ receptor, in OCD. The relevance of GABAergic mechanisms in OCD has also been supported by observations that the anticonvulsants, gabapentin and topiramate, may be effective in OCD.[18-23] Furthermore, cortical inhibition studies with short interval cortical inhibition (SICI) and the cortical silent period (CSP) assay have reported a decrease in patients with Tourette's syndrome and OCD,[24-26] likely reflecting dysfunction within common cortical-subcortical circuits.

The γ2 subunit of the $GABA_A$ receptor is widely distributed in all regions of the brain,[27] and enables BZD modulation of the activity of this receptor. Thus $GABA_A$ receptor-γ2 (GABRG2) is an intriguing functional candidate gene in OCD. The GABRG2 gene has been mapped to the 5q31.1-q33.1 chromosomal region.[28] A single nucleotide polymorphism (*Nci*I restriction site, rs211013) has been identified in the second intron of the GABRG2 gene, located 0.7 Kb downstream from the 8-amino-acid exon. We therefore tested this candidate gene in a sample of 118 OCD probands and 198 familial controls, using a restriction fragment length polymorphism (RFLP) downstream from the variably spliced exon as mentioned above.

## Method

### 1. Sample

A total of 118 adults with OCD were recruited from consecutive referrals to the Anxiety Disorders Clinic at the Centre for Addiction and Mental Health. All subjects were diagnosed with primary OCD by an experienced psychiatrist. OCD and other Axis I disorders were confirmed using the Structured Clinical Interview for DSM-IV (SCID-IV).[29] All subjects had one or more first-degree biological relatives (parent or sibling) willing to participate in the study. Probands with a history of neurologic or metabolic diseases, bipolar or psychotic disorder, or current substance dependence were excluded. In total, 198 first-degree relatives participated; all participants provided written informed consent. For demographic details, see Table 1. This study was approved by the Centre for Addiction and Mental Health Research Ethics Board.

**Table 1 - Demographic data**

| Descriptors | Mean (S.D.) |
|---|---|
| Age | 41 (10.57) |
| Gender | 58 female |
| Ethnicity | 88% Caucasian; remainder comprised of African American; East Indian; East Asian |
| Age of onset | 14.7 (9.699) |
| YBOCS Score | 21.31 (7.73) (n = 70 with current YBOCS data)<br>27.67 (6.439) (n = 27 with lifetime YBOCS data) |

### 1. Genetic typing

Genomic DNA was extracted from whole blood using a non-enzymatic procedure.[30] Polymerase chain reactions were used to amplify the segment of genomic DNA containing a polymorphic restriction site in the GABRG2 gene. The PCR reaction was performed in a 25μl volume containing: 150ng genomic DNA, 1´ GeneAmp PCR Buffer II (Applied Biosystems, Foster City), 2.5mM $MgCl_2$, 160μM each of dATP, dTTP, dCTP, dGTP, 0.8μM of each primer [F: 5' – AGA AAT TTA CCA ACT GGT CTA GCC GG – 3' and R: 5' – AAA TCA AAT ATT GTG TCA TGC TTA GT – 3'], and 0.04 Unit of *Taq* polymerase (Applied Biosystems, Foster City). The reaction mixture was first denatured at 95°C for 5 minutes, followed by 40 cycles of 95°C for 30 seconds, 68°C for 30 seconds, and 72°C for 30 seconds. A final extension step was added at 72°C for 4 minutes. Ten microlitres of PCR product was digested with 5 Units of *Nci*I (NEB), 1´ PCR buffer (NEB4), 2x BSA (NEB), and $ddH_2O$ to a volume of 15μl. The *Nci*I digested PCR fragments were detected by 3.0% agarose gel electrophoresis at 100V for 1.5 hours. The fragment size of the uncut product, which has the A allele (allele 1), is 287bp and the cut product sizes (G allele, allele 2) are 263bp and 24bp after digested with *Nci*I.

### 3. Statistical analysis

We tested for the presence of transmission disequilibrium between the GABRG2 gene *Nci*I RFLP polymorphism and OCD using the Transmission Disequilibrium Test (TDT).[31] McNemar chi-square tests ($\chi^2$) were performed on the sample of informative trios (n = 61 in total), i.e. those with one or more heterozygous relative. Power for TDT was determined with the Genetic Power Calculator.[32] In this study, the statistical analyses were significant based on $p < 0.05$.

## Results

The genotype frequencies were in Hardy-Weinberg equilibrium using PedStats.[33] The frequency of allele 1 (A allele) in our total was 0.544 and allele 2 (G allele) was 0.456. The genotype distribution was: 0.270 for A/A, 0.547 for A/G, and 0.182 for G/G. We did not detect biased transmission of alleles from parents to their affected offspring in our informative sample ($\chi^2 = 0.016$, 1 df, $p = 0.898$) (Table 2).

## Discussion

Our results from this study do not provide support for the hypothesis of linkage disequilibrium between the $GABA_A$ receptor-γ2 gene and OCD.

**Table 2 - TDT results**

| Allele | Transmission | Non-transmission |
|---|---|---|
| 1 (A) | 31 | 30 |
| 2 (G) | 30 | 31 |

The role of the neurotransmitter GABA in OCD is unclear. Evidence implicating the $GABA_A$-BDZ receptor in this disorder is mainly derived from suggestions that BDZ may play a useful role in the management of this condition.[34-35] However, this literature has been generally based on studies of clonazepam, a 7-nitro-benzodiazepine derivative that in addition to binding with the $GABA_A$–BDZ receptor, it uniquely impacts on serotonin synthesis and upregulates cortical serotonin binding sites.[36] Thus it is not clear that the possible therapeutic effects of clonazepam are in fact mediated by alteration in GABA neurotransmission, but may rather relate to its serotonergic effect. Alternately, BDZ may also modulate anxiety via binding with the peripheral BDZ receptor. Additionally, observations of the potential anxiolytic effects of the anticonvulsants gabapentin and topiramate also suggest a role for GABA neurotransmission in OCD. Topiramate has been shown to have anti-obsessional benefits in two OCD studies,[22-23] and the GABA analogue, gabapentin, has been reported helpful in OCD in a few case reports.[18-21] However, the mechanism of action of gabapentin is unclear, and potentially may not directly involve GABAergic mechanisms.

This study is clearly limited by the small size of the sample available. Although a total of 118 families were tested, only 61 were actually informative. Nonetheless, this sample had a power of 93% to detect a relative risk as low as 1.5 due to the high variant frequency of 0.456. However, only one polymorphism was tested. The *Nci*1 RFLP polymorphism is itself silent, but is located 0.7kB downstream from an alternately spliced 8 nucleotide long exon implicated in alcohol effects.[37] Thus this negative finding for this one polymorphism does not rule out the possibility of linkage disequilibrium elsewhere in this gene.

To our knowledge, this is the first published study of the GABRG2 gene in obsessive-compulsive disorder. While this analysis does not clearly support a major role for this gene, further investigations utilizing larger samples are warranted.

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| Writting group member | Employment | Research grant[1] | Other research grant or medical continuous education[2] | Speaker's honoraria | Ownership interest | Consultant/ Advisory board | Other[3] |
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** Modest*
*** Significant*
**** Significant. Amounts given to the author's institution or to a colleague for research in which the author has participation, not directly to the author.*
*For more information, see Instructions for authors.*

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