[原　著]

司法に関連する外傷後ストレス障害（PTSD）
—類型化の試み—

橋爪きょう子[*1]・小西聖子[*2]・柑本美和[*3]・中谷陽二[*1]

これまで，わが国における司法に関連した外傷後ストレス障害（posttraumatic stress disorder；PTSD）が包括的に扱われた研究が少ないため，本研究では事例を調査しその類型化を試みた．刑事事件においては責任能力などの要件としてPTSDを主張するもの，被害者のPTSDが傷害罪・致死罪などを構成すると主張するもの，加害者に不利な情状として被害者のPTSDを主張するものの3つに分類された．刑事事件以外では，不法行為において損害としてPTSDを主張するもの，PTSDに対する補償と年金の請求，DVや虐待，難民において保護を目的にPTSDを主張するものに分類された．それぞれの類型において，精神科医がPTSDの評価を行う際の留意点に注目して考察を加えた．

Key Words　外傷後ストレス障害（PTSD），司法，裁判，補償

はじめに

DSM-IIIに外傷後ストレス障害（posttraumatic stress disorder；以下PTSD）が登場して以来，PTSDに関連した訴訟が多い米国においては事例の類型化が行われ，対応や問題点が吟味されている．わが国でも司法の場でPTSDが問題となる頻度が増加し，法学，精神医学の立場それぞれで議論がなされている．本研究では，わが国の司法に関連した領域でPTSDが関与した事例を包括的に調査し類型化を試みる．

先行研究—米国での類型と論点

米国の司法領域でPTSDが関与する領域はおおむね5つに分類される[28,33]．①犯罪の完全なまたは部分的な抗弁または刑罰減軽，②民事裁判における不法行為に対する損害賠償，③障害による機能不全に対する保障や年金，④被虐待児やDV（domestic violence；以下DV）被害者の保護，⑤宗教に関連したものである．

①については，精神障害を理由とする抗弁（insanity defense）としてPTSDが用いられることへの議論がある[2,29,30]．当初PTSDはベトナム帰還兵の犯す暴力的な犯罪に対して用いられたが，後に非暴力的な犯罪，さらにはDVを受けていた女性がバタラー（虐待男性）を殺害した際などにも用いられるようになった[8,25]．また，これとは別に，刑事事件の事実認定において，PTSDの症状があるから外傷的出来事（traumatic event）があったのだと主張する症候群証拠（syndrome evidence）についても議論がなされている[11]．たとえばレイプ被害において加害者がその性交渉は被害者の合意に基づいていたと主張した際に，被害者のPTSDを主張することで，性交渉が合意のない暴力的な行為であったことを示すような場合である[2,34]．

②は，行為者の故意または過失の結果としてのPTSDに対して損害賠償を求めるものである[26]．

（受理日　2005年11月29日）
＊1　筑波大学大学院人間総合科学研究科
〒305-0006　茨城県つくば市天王台1-1-1筑波大学総合研究棟D棟
＊2　武蔵野大学大学院人間関係学部
＊3　国立精神・神経センター精神保健研究所司法精神医学研究部

交通事故などの不慮の事故，食中毒，暴力など，様々な事柄に対してPTSDが主張される可能性がある．この際，外傷的出来事が被害者の症状の直接の原因かどうかという因果関係について精神科医は意見を求められる[22,23,27]．

③については，米国で問題となっているものとして戦闘復員兵を含めた労働災害補償[23]，民間障害保険の問題などがある[22]．労働災害を訴える多くのケースでは，不当な解雇やハラスメントが原因として主張されており，外傷が明白でないことが多い[9]との指摘もある．

④については，離婚を請求する際にDVを受けている被害者のPTSD[17]，子どもの保護監督権の裁定に際して親の暴力性や不適切さの証明であるとして子どものPTSDが主張される[22]．PTSDによる虐待の主張は，特に性的虐待において“false memory”の問題がつきまとう[16]．

⑤については，離婚した人や刑罰を受けた人が，裁判所やカトリックの司教管区の法廷でPTSDに罹患していることが認められると，厳格な規律を持つカトリック教会でその後の立場を保つのに有効であるという場合である．

わが国の司法に関連するPTSD事例の類型化の試み

わが国でPTSDに関連した67の事例を，判例雑誌，判例マスター[11]，最高裁判所判例データベース，インターネットの一般データベースを用いて収集し，類型化を試みた．事例の内訳について刑事事件関連を**表1**，民事事件・その他に関連したものを**表2**に示す．ここに示されたように，様々な分野と出来事においてPTSDが扱われていることがわかる．これを，手続きの違いによって区別すれば，刑事事件，民事事件，行政事件といったように分類がなされるであろう．今回は前掲の米国の分類にならい，これらの事例をPTSDが主張される目的によって類型化を試み，精神科医がPTSDを診断する際に留意すべき点について検討することを目的とした．

表1　刑事事件，少年事件（内カッコが少年事件例数）

事　件	加害者のPTSDが問題となったもの	被害者のPTSDが問題となったもの
殺　人	2（1）	2
傷害致死	1	−
傷　害	−	6
監　禁	−	1
放　火	1	1
計	4例（うち少年1例）	10例

表2　民事事件・その他の事例

交通事故関連	29
セクシャルハラスメント	7
暴　行	5
監　禁	1
交通事故以外の事故	2
DV関連（離婚請求，保護）	2
子の監護に関するもの	1
難民に関連するもの	4
労務災害	2
計	53例

類型化するにあたっては，PTSD診断が刑罰に影響を与える刑事事件とその他を区別した．前者はPTSDが主張される対象が加害者であるか被害者であるかで分類し，被害者対象のものはさらに傷害や致傷罪の成立が問題となっているものとそうでないものを区別した．後者は不法行為に関係したもの，年金や補償に関連したもの，DVや虐待の被害者・難民の保護の3つに分類した．以下，実際の事例を提示して類型を示し若干の検討を加える．

1．責任能力関連型：責任能力などの要件としてPTSDを主張

〈事例1〉東京地判1998年4月17日判例タイムズ（以下，判タ）989号77頁

家庭内暴力があった14歳の長男を父親が金属バットで殴打して殺害．弁護人は犯行当時に被告人がいわゆる複雑性PTSDの状態であり心神耗弱の状態にあったと主張．判決では犯行の状況などから心神耗弱の状態にあったとは認められないとした．

考　察：この型では刑事事件において加害者のPTSDが責任能力と関連して主張される．日本では筆者が知る範囲では，現在のところPTSDで心神喪失や心神耗弱が認められた例はない．米国においては，責任無能力の主張は少ないとされてお

り[2,20,29]，PTSDは限定能力（diminished capacity）を主張する際に用いられることが多い．Sparr[30]はPTSDによる限定能力が認められる可能性として解離などの条件を提示しており，今後わが国で加害者のPTSDの評価の際に参考になるだろう．なお少年事件における責任能力と保護処分の決定については議論がある[17]．虐待被害後のPTSDは責任能力と関連していないとされた事例もあり（東京家判1999年9月7日家月52巻3号72頁）（ただしこの事例ではPTSDの治療必要性が考慮されて保護処分が決定された），少年事件で加害少年のPTSDが取り上げられる場合もこの型に含まれると考えられる．

2．傷害罪・致傷罪型：被害者のPTSDが傷害罪・致傷罪などを構成すると主張

〈事例2〉富山地判2001年4月19日判タ1081号291頁

交際相手の男性が以前交際していた女性に約3年半にわたって嫌がらせ電話をかけ続けたことで，被害者にPTSDの傷害を負わせたとして傷害罪で起訴．判決ではPTSDが傷害にあたると認定した．

〈事例3〉福岡高判2000年5月9日判例時報（以下，判時）1728号159頁

被告人が通りがかりの小学生と女性に暴行．被害者2人はPTSDと診断され被告人は傷害罪で起訴．判決では，診断に疑問があることなどから傷害罪にあたらないとした．

考　察：PTSDに傷害罪・致傷罪を認めるか否かについては司法の中で議論があるところである[10,31]．PTSDがわが国の裁判例に登場する以前には，たび重なる嫌がらせによって被害者がうつ病に罹患したことが傷害罪と認められた例がある（名古屋地裁1994年1月18日判タ858号272頁）．事例2はこの既存の「心理的ストレスを与えることを目的とした行為への傷害罪の適用」に対して，新たに登場したPTSDが利用されるかたちである．事例3では「いわゆる犯罪の被害者として恐怖による二次的かつ一般的なストレス状態を超えたものとは認めがたい」とPTSDを否定する記載が判決文に見られる．被害者は多かれ少なかれ精神的な被害を被っており，それがどのような場合に傷害罪や致傷罪と認められるかは今後判例の蓄積が待たれる．

3．情状型：加害者に不利な情状として被害者のPTSDを主張

〈事例4〉福井地判2004年9月1日最高裁判所データベース

加害男性が内縁の妻の娘Aの交際相手をAの目の前で殺害．判決ではAがPTSDおよび解離性障害などを発症していることが考慮されて量刑が決定された．

考　察：類型2においてはPTSDか否かが大きな論点となる傾向にあり，PTSDという診断によって傷害罪などの成否が分かれる可能性があるが，この型においては，加害者の刑の量定を重くするために，被害者のPTSDが不利な情状として主張されている．事例4の加害者は殺人罪で起訴されているが，その罪名には現れない“事件によって生じたAの精神的な苦痛”が刑の決定に影響を及ぼしている．このように，情状としてPTSDが主張される場合，評価をする精神科医に求められることは，診断の確定だけではなく被害者の精神医学的・心理学的な状態を丁寧に説明することであろう．

4．不法行為型：損害としてPTSDを主張

〈事例5〉東京地判2000年3月10日判時1734号140頁

原告女性が上司からセクハラ被害を受けたとして提訴．判決では原告がPTSDの診断を受けていることが考慮され損害賠償が認められた．

〈事例6〉横浜地判1998年6月8日判タ1002号221頁

交通事故で外傷を負い，5年後より不眠，頭痛，錯乱状態などが出現しPTSDと診断．判決では，PTSDの存在とその交通事故との因果関係が認められ後遺障害第7級に認定．

考　察：故意・過失による他人の権利の侵害（不法行為）によって損害を被った際には損害賠償を請求することができるが，この型ではPTSDが損害として主張される．PTSDの診断には，原因

となる出来事の存在とその出来事に関連した症状の存在が必要となる．司法においては，このような診断（出来事の存在と症状の存在）が因果関係を内包していると捉えられてPTSDが用いられることが多いといわれている[18]．しかし一方精神医学分野においては，評価に際して精神科医が安易に因果関係を証明することは避けるべきであると[13,23]する意見が優勢であるようだ．

また，民事訴訟では原告側に損害の要因があると認められる場合は被告の賠償責任を減ずることが認められている(素因減額)．この理論がPTSDに適用されて，PTSD発症前後の環境要因や性格要因が素因とされて賠償の減額が認められた判例も存在する．精神科医が原告の素因について尋ねられることもあり，出来事チェックリストやCAPS[3]などを利用しながら事件以外の要因[1,4]を提示する必要がある．しかし，この過程で被害者のプライバシーが明らかになることがあるためPTSDは諸刃の剣であるとも言われている[22]．加害者の精神鑑定において倫理的な配慮が必要とされる[6]と同様，精神科医はこの点について被害者に説明することなどが必要であろう．

なお，交通事故ではPTSDに関連した損害賠償請求が数多くあるが，賠償額の算定に用いる後遺障害の基準は以下で述べる労務災害と共通しているため，評価における留意点が⑤と共通することを付け加える．

5．補償・年金型：PTSDに対する補償と年金の請求

〈事例7〉2004年1月29日読売新聞データベース

暴力団員が飲食店に手投げ弾を投げ込み従業員を暴行．事件後に生じたPTSDが労災認定された．

考　察：この型では事故や災害による障害の補償を求めてPTSDが主張され，保険金や年金の請求がこれに含まれる．年金や労務災害は厳密いうと裁判で問題となったものではないが，関連したものとして一類型とする．

これまではこの領域においては，PTSDが後遺障害の何級に該当するか，労働能力の喪失の程度はどれほどなのかといった論争がなされてきた[14,15,31]．これらの問題は精神医学的な側面で解釈する場合，機能障害の問題と予後の問題として捉えられる．機能障害については，診断名そのものが機能障害のレベルを暗示するわけではないと指摘され[23]，米国においてはGAF[7]などを用いて，評価者が異なっても均質性のある評価がなされるような，また経時的な変化を比較できるような評価を用いることが勧められている．わが国においても普遍的で客観的な機能障害の評価法が広く用いられることが求められる．一方，予後はまだ一定の見解が得られていないのが現状である．

6．被害者保護型：被害者を保護する根拠としてPTSDを主張

〈事例8〉福岡家1999年12月1日家月52巻6号66頁

父親からの身体的虐待，心理的虐待が疑われた女児に対して，児童福祉法28条により，児童相談所所長が申立人となり児童養護施設への入所を申し立てた．精神科医が今後PTSDに発展する可能性が高いことを指摘し施設入所が認められた．

〈事例9〉東京高判2001年12月18日最高裁判所データベース

外国人男性が東京入国管理局に収容．以前からあったPTSDなどの精神状態が収容によって増悪しているとして収容停止を求めた．判決では，収容がPTSDを増悪させているとはいえないとして執行停止はなされなかった．

考　察：この型では被虐待児やDV被害者，難民を現状から保護するためにPTSDが主張される．児童の保護に際して，虐待の影響を示すために精神医学的な診断が用いられることがある．被虐待児はPTSDや解離性障害の罹患率が高いことが知られており，保護の際にもこれらの診断名が用いられる機会は多いと考えられる．Wendyら[32]は，ケースワーカーや警察，検察，医療スタッフがチームを組むことで子どもへの負担や情報の混乱が減少すると述べており，わが国でも子どもの司法評価のためのシステムの確立が必要であるといわれている[21]．また，DVにおいては精神的な苦痛を訴えて離婚を申し立てる際や，子どもの親権を争ったり，面接交渉を行う際にPTSD

が主張される．DV加害者である元夫の子どもへの面接交渉で，母親がPTSDの加療中であることが考慮されて面接が不適切とされた判例（東京家裁2002年5月21日家月54巻11号76頁）は一例である．難民については，難民申請の際や入国管理局への収容中止を求めて母国の迫害によるPTSDを主張することがある．難民の示す精神症状にはPTSDを含めて様々であるとされており[19]，その人の文化特有の症状の表出の特徴も考慮すると評価はさらに困難となると考えられる．

虐待やDV，母国での迫害といった被害は外界から閉ざされた環境で行われ，被害の存在を証明することが困難である．このため，PTSD症状が存在することを示すことで被害があったのだという，事実認定に有利な効果を期待する側面があることも否定できない．Slovenko[24]は被害者のPTSD症状の存在から逆行性に出来事の存在を主張する症候群証拠の問題を指摘している．精神科医が精神症状の評価を行い，保護に関わっていくことは必要で重要なことであると考えられるが，自ら法的な事実認定をするのではなく，裁判官が事実認定をする際の根拠を提供する[12]という意識を常に持つべきであると考えられる．

おわりに

わが国におけるPTSDに関連した事例を調査し類型化を試み，それぞれの類型で生じやすい問題点について検討を加えた．これらに加えて，すべてに共通する問題としてPTSDの診断の適切さの問題があると考えられる．司法の場ではこれまで述べてきたような様々な影響が生じるため，厳密な評価が必要とされる．しかし診察時間が限られた日常診療の中で，構造化面接を含めた詳細な評価を行う環境にある医師は多くない．また厳密にPTSDと診断される患者と診断には症状が少し足りない患者に対する治療方針はほとんど変わらない．このような理由から，精神科医がPTSD類縁疾患をPTSDと診断して治療を行っていることもあると思われるが，このように治療の目的で用いたPTSDという診断名が後に司法の場で取り上げられ問題となることもある．これらの事情を踏まえると，精神科医は精査前の診断は“PTSD疑い”などの暫定診断を用い，後に確定診断を行うといった慎重さが必要になるかもしれない．また正確な評価を行うためのガイドラインが混乱解消の一助になるだろう．司法関係者には，医療機関での診断はあくまで治療を目的としたものであり，司法の場で用いるには精査が必要との認識を求めたい．

一方，司法関係者の間ではPTSDの診断がもっぱら重大な関心事になっており，他の精神疾患よりもこの診断を重要視しているように見える．しかし，PTSDはあくまで被害後に心因反応として生じる精神障害の一つにすぎず，病状もPTSDであるから重いということは一概にはいえない（外傷体験の後にPTSDを発症せずにうつ病になった場合，その病態が軽いとはいえない）．PTSDか否かといった限定された議論は，PTSD以外の様々な症状を表出しうる被害者が法的な援助を得る機会を減らす可能性がある．PTSDのみが過大に取り上げられる状況は，精神科医が司法精神医学的関与を行うことに消極的になる要因にもなると考えられる．

被害者擁護の機運が高まる中，今後も司法に関連したPTSDの事例に関して注意を向けることは必要なことである．精神科医は，その診断が患者や加害者にどのような影響を与えうるのかを踏まえて正確な診断を行うことが必要であり，司法に対してPTSD以外の精神症状についての理解を求めていく努力を続けていく必要があるだろう．

文　献

1）Acierno, R., Resnick, H., Kilpatrick, D. G., et al.: Risk factors for rape, physical assault, and posttraumatic stress disorder in women; Examination of defferential multivariate relationships. J. Anxiety Disord., 13; 541-563, 1999.

2）Appelbaum, P. S., Jick, R. Z., Griss, T., et al.: Use of posttraumatic stress disorder to support an insanity defense. Am. J. Psychiatry, 150(2); 229-234, 1993.

3）Blake, D. D., Wethers, F. W., Nagy, L. M., et al.: The development of clinician-administred PTSD scale. J. Traum. Stress, 8; 75-90, 1995.

4）Breslou, N., & Davis, G. G.: Posttraumatic stress disorder in an urban population of young

adults; Risk factors for chronicity. Am. J. Psychiatry, 149(5); 671-675, 1992.
5) Brewin, C. R., Andrews, B., Valentine, J. D.: Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. J. Consult. Clin. Psychol., 68; 748-766, 2000.
6) Carson, D., Eastman, N., Gudjonsson, G., et al.: Psychiatric reports for legal purposes in the United Kigdom: (ed.), Gunn, J., Taylor, P. J. Forensic psychiatry clinical, legal & ethical issues, Butterworth Heinemann, London, p.826-856, 1993.
7) Diagnostic and Statistical Manual of Mental Disorders. 4th edition(DSM-IV). APA, Washington, D. C., 1994.
8) Dutton, M. A., & Goodman, L. A.: Posttraumatic stress disorder among battered women; Analysis of legal implications. Behav. Sci. Law, 12; 215-234, 1994.
9) Gold, L. H.: PTSD in employment litigation: (ed.), Robert, I. S. PTSD in litigation, American Psychiatric Publishing, Washington, D. C. p.163-186, 2002.
10) 林美月子:PTSD と傷害. 神奈川法学, 36 (3); 219-243, 2004.
11) 判例マスター. 新日本法規, 名古屋
12) 岩井圭司:民事賠償裁判における精神的被害の評価. 精神科治療学, 17 (4); 417-424, 2002.
13) 黒木宣夫, 岡田幸之:PTSD の精神鑑定ガイドライン:金 吉晴編, 心的トラウマの理解とケア. じほう, 東京, p.229-234, 2001.
14) 黒木宣夫:PTSD 診断と賠償—臨床医による PTSD 診断と賠償及び補償の留意点. 海文堂出版, 東京, 2003.
15) 黒木宣夫:PTSD の労災認定. 精神療法, 30(5); 528-524, 2004.
16) Levy, B. J.: Plaintiff and defense expert witnesses in the sexual abuse case, Rebecca Rix; Sexual abuse litigation a practical resource for attorneys, clinicians and advocates. The Haworth Maltreatment & Trauma Press, New York, 2000.
17) 町野 朔:少年法の新たな展開—理論・手続き・処遇:猪瀬慎一郎 (編), 有斐閣, 東京, p.85-97, 2001.
18) 中谷陽二, 上原美樹:心的外傷後ストレス障害 (PTSD) の法的問題—最近の動向—. 法と精神科臨床, 4; 99-107, 2001.
19) 野田文隆:難民とトラウマ. PTSD とその周辺をめぐって. 臨床精神医学 (増刊号), 152-157, 2002.
20) 岡田幸之, 安藤久美子, 佐藤親次:司法精神医学と PTSD. PTSD とその周辺をめぐって. 臨床精神医学 (増刊号), 118-123, 2002.
21) 奥山眞紀子:日本における性的虐待への対応の現状と課題. 子供の虐待とネグレクト, 6 (2); 175-180, 2004.
22) Pitman, R. K., Sparr, L. K., Saunders, L. S.: Legal issues in posttraumatic stress disorder: (eds.), Bessel, A., van der Kolk. Traumatic stress. Guilfood Press, New York, 1996. (岡田幸之訳:外傷後ストレス障害における法的問題:西澤哲監訳, トラウマティックストレス. 誠信書房, 東京, p.426-451, 2001)
23) Simen, R. I.: Forensic psychiatric assessment of PTSD claiments: (ed.), Robert I. S. PTSD in litigation, American Psychiatric Publishing, Washington, D. C., p.41-90, 2002.
24) Slovenko, R.: Syndrome evidence in establishing a stressor. J. Psychiatry Law, 12; 443-467, 1984.
25) Slovenko, R.: Legal aspects of posttraumatic stress disorder. Psychiatr. Clin. North Am., 17(2); 439-446, 1994.
26) Sohouten, R.: Compensation for victims of trauma in the United States. 精神経誌, 104 (12); 1186-1197, 2002.
27) Sparr, L. F., Boehnlein, J. K.: Posttraumatic stress disorder in tort actions; Forensic minefield. Bull. Am. Acad. Psychiatry Law, 18(3); 283-302, 1990.
28) Sparr, L. F.: Legal aspects of posttraumatic stress disorder; Uses and abuses. PTSD: Etiology, phenomenology, and treatment. American Psychiatric Press, Washington, p.239-264, 1990.
29) Sparr, L. F., & Atkinson, R. H.: Posttraumatic stress disorder as an insanity defense; Medicolegal quicksand. Am. J. Psychiatry, 143(5); 608-612, 1986.
30) Sparr, L. F.: Mental defenses and posttraumatic stress disorder; Assessment of criminal intent. J. Trauma. Stress, 9; 405-425, 1996.
31) 杉田雅彦:日本における PTSD 民事・刑事訴訟. 精神経誌, 104 (12); 1207-1214, 2002.
32) Wendy, B., Raymond, B., Robin, F., et al.:藤川洋子, 小澤真嗣訳:子供の面接ガイドブック. 日本評論社, 東京, 2003.
33) Wilson, J. P., Moran, T. A.: Forensic/Clinical assessment of psychological trauma and PTSD in legal settings: (eds.), John, P. W., & Terence, M. K. Assessing psychological trauma and PTSD, 2nd edition. Guilford Press, New York, p.603-636, 2004.

PTSD Concerned with Legal Setting in Japan

Kyoko Hashizume [*1], Takako Konishi [*2], Miwa Kojimoto [*3], Yoji Nakatani [*1]

*1 Graduate School of Comprehensive Human Sciences, University of Tsukuba, Japan
*2 Fuculty of Human Studies, Musashino University
*3 National Institute of Mental Health National Center of Neurology and Psychiatry

Posttraumatic stress disorder (PTSD) diagnosis in legal settings has growing importance in Japan. The number of cases the diagnosis is being used in is increasing. The purpose of this study is to present an over view of PTSD in Japanese legal settings and to classify these cases with the aim of using the diagnosis. PTSD is a concern in the Japanese legal settings in six major areas. 1. In criminal litigation, PTSD has been used as a complete or partial defense. 2. In criminal litigation, PTSD has been used to prosecute an offender on a charge of bodily injury. 3. In criminal litigation, victims' PTSD has been used as a circumstance to make defenders punish more severe. 4. In civil litigation, where in psychologically traumatizes individuals seek compensation for personal injury. 5. Disability claims. 6. Protective custody of a child, victims of domestic violence, and refugees. Psychiatrists must make trustworthy PTSD diagnosis because the penalty of defendants, the amount of compensation and victims' circumstances can change depending on the diagnosis.

Key words posttraumatic stress disorder (PTSD), psychological trauma, litigation, legal setting

Address: 1-1-1 Tennoudai Tukuba Ibaraki 305-0066 Japan

Available online at www.sciencedirect.com
SCIENCE DIRECT®
Schizophrenia Research xx (2006) xxx–xxx
SCHIZOPHRENIA RESEARCH
www.elsevier.com/locate/schres

Morphologic alterations of the parcellated superior temporal gyrus in schizophrenia spectrum

Tsutomu Takahashi [a,d,*], Michio Suzuki [a,d], Shi-Yu Zhou [a,d,e], Ryoichiro Tanino [a], Hirofumi Hagino [a], Yasuhiro Kawasaki [a,d], Mie Matsui [b,d], Hikaru Seto [c], Masayoshi Kurachi [a,d]

[a] *Department of Neuropsychiatry, University of Toyama, 2630 Sugitani, Toyama 930-0194, Japan*
[b] *Department of Psychology, University of Toyama, 2630 Sugitani, Toyama 930-0194, Japan*
[c] *Department of Radiology, University of Toyama, 2630 Sugitani, Toyama 930-0194, Japan*
[d] *Core Research for Evolutional Science and Technology, Japan Science and Technology Corporation, Tokyo, Japan*
[e] *Department of Psychiatry and Medical Psychology, Dalian Medical University, Dalian, China*

Received 2 November 2005; received in revised form 10 January 2006; accepted 10 January 2006

Abstract

Morphologic abnormalities of the superior temporal gyrus (STG) as well as its sub-regions such as Heschl's gyrus (HG) or planum temporale (PT) have been reported in schizophrenia patients, but have not been extensively studied in schizotypal subjects. In the present study, magnetic resonance images were acquired from 65 schizophrenia patients, 39 schizotypal disorder patients, and 72 healthy controls. Volumetric analyses were performed using consecutive 1-mm coronal slices on the temporal pole (TP) and superior temporal sub-regions [planum polare (PP), HG, PT, rostral STG, and caudal STG]. The HG was significantly smaller in schizophrenia patients compared with controls but not in schizotypal patients, while volume reductions of the left PT and bilateral caudal STG were common to both disorders. The TP gray matter was larger in female schizotypal patients compared with female schizophrenia patients. There were no significant group differences in the PP and rostral STG volume. In the subgroup of early phase schizophrenia patients (illness duration < 1.0 year), smaller volumes for the left PP and rostral STG were correlated with hallucinations and delusions. Our findings suggest that morphologic changes in the posterior regions of the STG are common to the schizophrenia spectrum, whereas less involvement of the HG, and possibly the PP and rostral STG might be related to the sparing of schizotypal patients from developing overt psychosis.

Keywords: Schizophrenia; Schizotypal disorder; Magnetic resonance imaging; Superior temporal gyrus; Temporal pole

* Corresponding author. Tel.: +81 76 434 2281; fax: +81 76 434 5030.
E-mail addresses: tsutomu@ms.toyama-mpu.ac.jp, tsutomu@med.u-toyama.ac.jp (T. Takahashi).

0920-9964/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.schres.2006.01.016

1. Introduction

Since the initial report of Barta et al. (1990) showing reduced superior temporal gyrus (STG) volume in schizophrenia, morphologic abnormalities of the STG have been repeatedly described in schizophrenia (reviewed by Shenton et al., 2001), and volume reduction of the STG, especially in the left hemisphere, has been correlated with various positive symptoms such as auditory hallucinations or thought disorder (reviewed by Rajarethinam et al., 2000). Based on recent development in magnetic resonance imaging (MRI)-based topographic parcellation, the focus of attention with regard to the STG abnormalities in schizophrenia has been directed to the changes in its functionally relevant anatomical sub-regions. Although the data are not entirely consistent (e.g., Shapleske et al., 2001), asymmetry anomaly (Barta et al., 1997; Petty et al., 1995) or left-sided volume reduction (Hirayasu et al., 2000; Kwon et al., 1999; Sumich et al., 2002; Yamasue et al., 2004) of the planum temporale (PT) and clinical correlations of these changes to the severity of thought disorder (Barta et al., 1997; Petty et al., 1995; Rossi et al., 1994) have been reported in schizophrenia. With regard to the volumes of the primary auditory cortex (Heschl's gyrus, HG), significant reduction (Hirayasu et al., 2000; Rojas et al., 1997) or inverse association with hallucinations and delusions (Sumich et al., 2005) was noted, while other studies failed to find significant results (Barta et al., 1997; Kwon et al., 1999; Sumich et al., 2002; Yamasue et al., 2004).

In contrast to these two sub-regions, less attention has been paid to morphologic changes in the other superior temporal sub-regions, i.e. the planum polare (PP) and the lateral portion of the STG. The PP is located anterior to the HG on the supratemporal plane and is considered as auditory association cortex, but has rarely been studied. The only volumetric MRI study on this region in schizophrenia revealed neither volume changes nor a correlation with clinical symptoms (Crespo-Facorro et al., 2004a). The lateral portion of the STG, which constitutes the upper bank of the superior temporal sulcus, is concerned with the biological basis for social interaction or mentalizing that is disturbed in schizophrenia (Frith and Frith, 1999). To our knowledge, however, only one volumetric MRI study has attempted a detailed examination of this specific sub-region in schizophrenia (Kim et al., 2003), where a smaller right posterior portion of the lateral STG and a negative correlation between the volume of the left anterior portion and psychotic symptoms were found in male patients. Thus, the structural brain changes of the superior temporal sub-regions and their clinical correlations in schizophrenia remain elusive.

Subjects with schizotypal features diagnosed as schizotypal disorder in ICD-10 (World Health Organization, 1992) or schizotypal personality disorder (SPD) in DSM-IV (American Psychiatric Association, 1994) share genetic, biological, and psychological commonalities with schizophrenia and are thought to be the prototype of schizophrenia spectrum disorders (Siever and Davis, 2004). Based on studies concerning cognitive characteristics and brain morphologic changes in schizotypal subjects (reviewed by Dickey et al., 2002a; Siever and Davis, 2004) and schizophrenia patients, it is hypothesized that while abnormalities in the temporal regions are common to both groups as a neurobiological basis for vulnerability factors as part of the schizophrenia spectrum, the preservation of frontal regions might contribute to the sparing of schizotypal patients from the development of prominent psychosis (Kurachi, 2003a,b; Siever and Davis, 2004). This view received support from a recent volumetric MRI study that examined the medial temporal and prefrontal cortices in schizotypal subjects (Suzuki et al., 2005).

Despite the current emphasis on the importance of the STG in schizophrenia, MRI studies of this region in schizotypal subjects are scarce. Although our previous voxel-based morphometric (VBM) study revealed a gray matter reduction of left STG region in schizotypal disorder patients (Kawasaki et al., 2004), results of volumetric analyses using anatomically defined region of interest (ROI) are controversial. Smaller left STG of the same degree as schizophrenia was reported in male subjects with SPD, but not observed in female subjects (Dickey et al., 1999, 2003). Downhill et al. (2001) noted a bilateral STG reduction in SPD subjects. Dickey et al. (2002b) also examined the HG and PT only in male subjects with SPD and found a significant volume reduction in the left HG compared with healthy controls. To our knowledge, however, no brain morphologic studies have examined changes in the other superior temporal

sub-regions such as the PP and lateral STG in schizotypal subjects.

In the present study, three-dimensional MRI was used to parcellate the STG into five sub-regions based on detailed tracing guideline (Kim et al., 2000): PP, HG, PT, rostral STG (anterior portion of lateral STG), and caudal STG (posterior portion of lateral STG). We measured the volumes of the temporal pole and these superior temporal sub-regions in schizophrenia patients, schizotypal disorder patients, and healthy controls to clarify the similarities and differences in the superior temporal morphology between these two disorders. Based on previous VBM findings (Kawasaki et al., 2004) and proposed hypotheses (Kurachi, 2003a,b; Siever and Davis, 2004), we predicted that schizotypal disorder patients would have STG abnormalities similar to those seen in overt schizophrenia. In addition, we examined the correlations between these volumetric measurements and the severity of positive symptoms in schizophrenia to replicate previous observations.

2. Methods

2.1. Subjects

Thirty-nine schizotypal disorder patients (24 males and 15 females) who met the ICD-10 criteria for research (World Health Organization, 1993) were examined. The sample characteristics of the clinic-based schizotypal disorder patients in our laboratory have been previously described (Kawasaki et al., 2004; Suzuki et al., 2004, 2005; Takahashi et al., 2002b, 2004, 2005; Yoneyama et al., 2003). They were recruited from patients who visited the clinics of the Department of Neuropsychiatry, Toyama Medical and Pharmaceutical University Hospital with schizotypal features accompanied by distress or associated problems in their lives and who needed to receive clinical care including medication with low-dose antipsychotics for these problems. Since schizotypal subjects rarely present themselves for clinical care, our clinic-based sample was considered to be more severely ill than schizotypal individuals among the general population. The mental condition of each subject was assessed by experienced psychiatrists to check for the emergence of overt psychotic symptoms, and none of the 39 patients has evolved into overt schizophrenia to date (mean follow-up period after MRI scanning=2.7 years, S.D.=2.2). All available clinical information and data obtained from a detailed review of the clinical records and structured interviews for Comprehensive Assessment of Symptoms and History (CASH) including the chapter on premorbid or intermorbid personality (Andreasen et al., 1992) were stored in a database. The subjects were diagnosed by consensus reached by at least two psychiatrists based on these data. Although all of the schizotypal subjects in this study also fulfilled the DSM-IV criteria of the SPD on Axis II, 10 subjects had experienced in the past transient quasi-psychotic episodes fulfilling a diagnosis of brief psychotic disorder on Axis I. At the time of MRI scanning, 34 of the 39 patients were treated with low-dose antipsychotics, of which eleven were treated with typical neuroleptics and twenty-three received atypical neuroleptics. The remaining five patients were neuroleptic-naive. Although the possibility cannot be excluded that in some of our schizotypal subjects the antipsychotic medication prevented the onset of their overt psychotic episodes, they were stable to show typical schizotypal features without developing overt psychosis during more than 2 years of clinical follow-up, and they may primarily constitute a distinct category from schizophrenia.

The schizophrenia group was composed of 65 patients with schizophrenia (35 males and 30 females). Each patient fulfilled the ICD-10 diagnostic criteria for research on schizophrenia (World Health Organization, 1993). All but one of the schizophrenia patients were on neuroleptic medication; 30 were being treated with typical neuroleptics and 34 were receiving atypical neuroleptics. Clinical symptoms of schizotypal disorder and schizophrenia patients were rated at the time of scanning using the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1984a) and the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1984b).

Seventy-two control subjects were healthy volunteers (38 males and 34 females) who were recruited from members of the community, hospital staff, and university students. They were given a questionnaire consisting of 15 items concerning tl eir family and past histories, as well as present illness. They did not have any personal or family history of psychiatric illness in their first-degree relatives. All controls were inter-

viewed and administered the Minnesota Multiphasic Personality Inventory (MMPI) by clinical psychologists to obtain a homogenous control group without eccentric profiles on the MMPI, and were excluded if they had an abnormal profile with any *T*-score for the validity scales or the clinical scales exceeding 70.

All subjects were physically healthy at the time of the study, and none had a lifetime history of serious head trauma, neurological illness or substance abuse disorder. The subjects were right-handed except for one female patient with schizotypal disorder of unknown handedness.

Table 1 shows the demographic and clinical data of the subjects. The subject overlap with our previous publication included 69/72 controls, 37/39 schizotypal patients, and 62/65 schizophrenia patients, where we reported bilateral volume reduction in the insular cortex for schizophrenia patients compared with schizotypal disorder patients and control subjects (Takahashi et al., 2005). The three groups were matched for age, height and parental education. Although there were more male than female schizotypal patients, the difference in the gender ratios among the three diagnostic groups was not significant (chi-square analysis, chi-square=0.85, $p=0.653$). The control subjects had attained a higher mean level of education than had the patients with either disorder [ANOVA, $F=25.52(2,173)$, $p<0.001$]. The total SAPS score for the schizophrenia patients was significantly higher than that for the schizotypal patients [ANOVA, $F=7.03(1,101)$, $p=0.009$]. There were significant differences in medication dosage [ANOVA, $F=17.95(1,102)$, $p<0.001$] and duration of neuroleptic medication [ANOVA, $F=4.06(1,102)$, $p=0.046$]. The patients with schizotypal disorder took significantly smaller amounts of neuroleptics than did the patients with schizophrenia.

Written informed consent was obtained from all subjects. This study was approved by the Committee on Medical Ethics of Toyama Medical and Pharmaceutical University.

2.2. Magnetic resonance imaging procedures

Magnetic resonance images were obtained by utilizing a 1.5-T Magnetom Vision (Siemens Medical System, Inc, Erlangen, Germany) with a three-dimensional gradient-echo sequence FLASH (fast low-angle shots) yielding 160–180 contiguous T1-weighted slices of 1.0-mm thickness in the sagittal plane. The imaging parameters were: repetition time=24 ms; echo time=5 ms; flip angle=40°; field of view=256 mm; and matrix size=256×256 pixels. The voxel size was $1.0\times1.0\times1.0\,mm^3$.

Image processing for volumetric analysis has been described in detail elsewhere (Takahashi et al., 2002a). Briefly, on a Unix workstation (Silicon Graphics, Inc, Mountain View, CA, USA), the image data were processed using the software package Dr View 5.3 (Asahi Kasei Joho System Co, Ltd, Tokyo,

Table 1
Clinical and demographic characteristics of normal control subjects, patients with schizotypal disorder, and patients with schizophrenia

	Control subjects ($n=72$)	Schizotypal patients ($n=39$)	Schizophrenia patients ($n=65$)
Male/female	38/34	24/15	35/30
Age (years)	23.9 ± 5.3 (range, 18–38)	25.7 ± 5.3 (range, 18–37)	25.8 ± 4.8 (range, 18–36)
Height (cm)	166.1 ± 7.9	165.2 ± 9.0	165.1 ± 7.6
Education (years)	15.7 ± 2.4	13.4[a] ± 1.9	13.4[a] ± 1.9
Parental education (years)	12.7 ± 2.3	12.1 ± 1.7	12.1 ± 2.1
Age at onset (years)	–	–	21.9 ± 4.3
Duration of illness (years)	–	–	4.0 ± 4.1
Duration of medication (years)	–	1.6 ± 3.2	2.9[b] ± 3.4
Drug (mg/day, haloperidol equiv.)[c]	–	4.3 ± 4.6	11.2[d] ± 9.5
Total SAPS score	–	16.6 ± 9.2	26.1[d] ± 21.0
Total SANS score	–	43.3 ± 23.0	47.5 ± 23.3

ANOVA followed by Scheffé's test was used. The value represent means±SDs. SANS, Scale for the Assessment of Negative Symptoms; SAPS, Scale for the Assessment of Positive Symptoms.

[a] $p<0.01$: compared to the controls.

[b] $p<0.05$: compared to the schizotypal patients.

[c] The different typical and atypical neuroleptic dosages were converted into haloperidol equivalents using the guideline by Toru (2001).

[d] $p<0.01$: compared to the schizotypal patients.

Japan). Brain images were realigned in three dimensions to standardize for differences in head tilt during image acquisition and were then reconstructed into entire contiguous coronal images, with a 1-mm thickness, perpendicular to the anterior commissure–posterior commissure line. The whole cerebrum was manually separated from the brainstem and cerebellum. The signal-intensity histogram distributions from the T1-weighted images across the whole cerebrum were then used to semi-automatically segment the voxels into gray matter, white matter, and cerebrospinal fluid. The intracranial volume (ICV) was measured to correct for differences in head size as previously described (Zhou et al., 2003).

2.3. Volumetric analyses of regions of interest (ROIs)

As presented in Fig. 1, the TP and superior temporal sub-regions (PP, HG, PT, rostral STG, and caudal STG) were manually traced on consecutive coronal 1-mm slices based on the tracing guidelines by Kim et al. (2000).

The TP was defined as the temporal cortex rostral to the first slice that contains the temporofrontal junction. The gray and white matter volumes of the TP were obtained using the abovementioned tissue segmentation procedure.

Before tracing each sub-region, the whole STG was delineated on the segmented gray matter images. The first coronal plane showing the temporofrontal junction and the coronal plane containing the posterior end of the posterior horizontal limb of the sylvian fissure were chosen as anterior and posterior boundaries, respectively. On each coronal slice, the whole STG was bounded superiorly by the sylvian fissure and inferiorly by the superior temporal sulcus. The whole STG was then segmented into supratemporal and lateral portions by the lateral limb of the supratemporal plane, and the supratemporal portion was further subdivided into PP, HG, and PT. The HG was

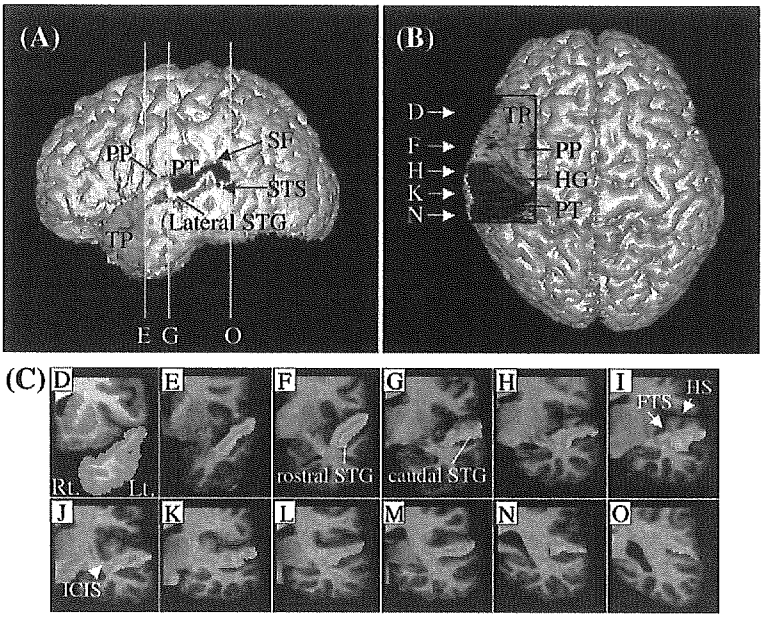

Fig. 1. Regions of interest (ROIs) manually traced in this study. (A) The reference coronal lines are marked on the lateral view of the three-dimensional reconstructed image. The coronal line G corresponds to panel G, a coronal slice containing the anterior end of the HS. The coronal lines E and O represent the most anterior (E) and most posterior (O) slices of the whole STG, respectively. (B) Top–down view of the reconstructed image of the supratemporal plane. The frontal and parietal lobes are partially cut off. (C) The sample coronal slices (panel D–O) show delineations of each ROI, which are labeled with the same colours as panels (A) and (B). The position of each coronal slice is also marked on the panel (B). The lateral STG (yellow) was further subdivided into rostral STG and caudal STG by plane G. Abbreviations: FTS = first transverse sulcus; HG = Heschl's gyrus; HS = Heschl's sulcus; ICIS = inferior circular insular sulcus; PP = planum polare; PT = planum temporale; SF = sylvian fissure; STG = superior temporal gyrus; STS = superior temporal sulcus; TP = temporal pole.

Table 2
Intracranial volume (ICV) and absolute volumes for each region of interest in the control subjects, patients with schizotypal disorder, and patients with schizophrenia

Brain region	Controls		Schizotypal patients		Schizophrenia patients		Analysis of covariance[a]					
	(Male 38, Female 34)		(Male 24, Female 15)		(Male 35, Female 30)		Group		Side		Group × Side	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	$F(2,167)$	p	$F(1,170)$	p	$F(2,170)$	p
ICV (cm^3)	1487	144	1516	150	1487	147	1.06	0.348	–	–	–	–
Temporal pole GM (mm^3)							4.19	0.017	53.64	<.001	0.03	0.972
Left	12598	2077	13188	2043 (+4.7%)	12201	2081 (−3.2%)						
Right	11709	2032	12221	1785 (+4.4%)	11359	1832 (−3.0%)						
Temporal pole WM (mm^3)							1.09	0.340	159.24	<.001	0.67	0.514
Left	1672	683	1679	656 (+0.4%)	1656	52 8(−1.0%)						
Right	2353	886	2209	572(−6.1%)	2322	797 (−1.3%)						
Whole STG (mm^3)							36.48	<.001	85.29	<.001	6.43	0.002
Left	12641	1670	10029	1580 (−20.7%)	10505	1868 (−16.9%)						
Right	10917	1465	9418	1324 (−13.7%)	9354	1499 (−14.3%)						
Planum polare (mm^3)							2.07	0.129	12.19	<.001	2.20	0.114
Left	1443	462	1349	351 (−6.5%)	1363	384 (−5.5%)						
Right	1672	461	1513	426 (−9.5%)	1399	502 (−16.3%)						
Heschl's gyrus (mm^3)							3.62	0.029	84.24	<.001	1.00	0.369
Left	2083	540	1889	529 (−9.3%)	1835	569 (−11.9%)						
Right	1587	458	1529	394 (−3.7%)	1430	449 (−9.9%)						
Planum temporale (mm^3)							10.33	<.001	89.59	<.001	3.79	0.025
Left	3047	705	2407	600 (−21.0%)	2435	609 (−20.1%)						
Right	2285	655	1987	584 (−13.0%)	1984	567 (−13.2%)						
Rostral STG (mm^3)							0.77	0.466	2.61	0.108	0.83	0.438
Left	1240	767	1175	591 (−5.2%)	1255	755 (+1.2%)						
Right	1213	636	1057	495 (−12.9%)	1039	675 (−14.3%)						
Caudal STG (mm^3)							31.80	<.001	6.50	0.012	6.99	0.001
Left	4827	1087	3209	850 (−33.5%)	3615	1088 (−25.1%)						
Right	4158	1026	3330	700 (−19.9%)	3499	861 (−15.8%)						

Abbreviations: GM, gray matter; STG, superior temporal gyrus; WM, white matter.
The numbers in parentheses indicate percent differences from the controls.
For the results of the post hoc tests, see text.
[a] The main effect of gender was not significant for any region. Gender-by-group interaction was observed only for the temporal pole gray matter.

traced from posterior to anterior, beginning with the plane showing the appearance of the Heschl's sulcus (HS), which forms a lateral border of the gyrus, and ending anteriorly with the plane including the most anterior point of HS or the sulcus intermedius (SI) if it existed [plane G (Fig. 1)]. The deepest point of the sylvian fissure, inferior circular insular sulcus or the first transverse sulcus formed the medial boundary of the HG. When two convolutions originated separately from the retroinsular regions, only the most anterior gyrus was regarded as HG. When they originated medially from a common stem, however, both were defined as HG (Kasai et al., 2003a); the lateral border of the HG was changed to the SI after the HS disappeared into the surface or lateral limb of the supratemporal plane while Kim et al. (2000) changed

the lateral border to the SI immediately after it appeared. After tracing the HG that takes a diagonal course on the supratemporal plane, the regions lying anteromedial and posterolateral to the HG within the remaining gray matter of the supratemporal plane were regarded as the PP and PT, respectively (Fig. 1). In the anterior–posterior direction, plane G bounded the PP and PT. The lateral portion of the whole STG was also divided into rostral and caudal portions (rostral and caudal STG) by plane G.

All volumetric data reported here were measured by one rater (TT) who was blinded to the subjects' identity, gender, and diagnosis. The volumes of the temporal pole and superior temporal sub-regions in a subset of five randomly selected brains were measured independently by two raters (TT and RT), and each volume was then remeasured after at least 4 weeks by the first rater; both intra- and inter-rater intraclass correlation coefficients for each ROI measurement were over 0.88.

2.4. Statistical analysis

Statistical analyses were performed using repeated measures multivariate analysis of variance with age, ICV, and dosage of neuroleptic medication as covariates (MANCOVA) for each ROI, with group (schizophrenia patients, schizotypal disorder patients, and controls) and gender (male and female) as between-subject factors, and side (left and right) as a within-subject variable. The relative volumes for each ROI [(absolute volume/ICV) × 100] were also analyzed using the same model but with only age and dosage of neuroleptic medication as covariates. The statistical analyses for group comparisons reported here are based on the absolute volumes, but the results were considered significant only when the results with both absolute and relative volumes reached significance. For the comparison of ICV, age, height, and daily medication dosage were treated as covariates; the groups did not significantly differ in their ICV volumes (Table 2). In the case of significant volume changes in a particular sub-region, the absolute volume was also analyzed by using MANCOVA with age, daily medication dosage, and whole STG volume as covariates for each hemisphere with group and gender as between-subject variables to further expose sub-regional effects. The asymmetry index of volume for each region was calculated by the following formula: 2 × (left − right/left + right); it was then analyzed by two-factor (group, gender) analysis of covariance (ANCOVA) with age as a covariate. The post hoc Scheffé's test was employed to follow up the significant main effects or interactions yielded by these analyses.

For the schizophrenia group, Spearman's rho was calculated to explore correlations between the relative volumes of TP gray matter, PP, HG, PT, rostral STG, and caudal STG in the left/right hemisphere and scores for the subscales of SAPS (hallucinations, delusions, bizarre behavior, positive formal thought disorder). To prevent possible Type I error due to multiple comparisons, we limited the analyses to the severity of positive symptoms based on previous findings. Correlational analyses were not performed for schizotypal disorder patients because of the very low scores for these subscales.

To examine the effects of neuroleptic medication, correlations between the relative volumes for each region and daily medication dosage and duration of neuroleptic medication were analyzed by using Spearman's rank correlation coefficients. For the patients with schizophrenia, the correlations between the relative volumes for each region and duration of illness and age of onset were also analyzed. For 62 schizophrenia patients and 69 control subjects overlapped with our previous study on the insula (Takahashi et al., 2005), Spearman's correlations for relative values were analyzed to test whether the volume changes in the insular cortex are correlated with the changes in the superior temporal sub-regions reported in this study. For these analyses, statistical significance was defined as $p < 0.05$.

3. Results

3.1. Volumes of ROIs

Table 2 shows the absolute volumes for each ROI in the three groups.

MANCOVA of the whole STG revealed significant main effects for the group and side and a significant group-by-side interaction. The whole STG was significantly reduced in the schizophrenia ($p < 0.001$) and schizotypal ($p < 0.001$) patients compared with the control subjects bilaterally, but there was no difference between both disorders ($p = 0.659$). Leftward asymmetry was found for the controls ($p < 0.001$) and schizophrenia patients ($p < 0.001$) but not for the schizotypal patients ($p = 0.352$).

For the planum polare (PP), MANCOVA revealed a significant main effect for the side, where the PP in the right hemisphere was larger than that in the left for all diagnostic groups ($p=0.001$).

For the Heschl's gyrus (HG), MANCOVA revealed significant main effects for the group and side; schizophrenia patients had a significantly smaller HG than control subjects ($p=0.007$), and the HG was significantly asymmetrical (left>right) in all groups ($p=0.001$). The HG volume of the schizotypal patients did not significantly differ from those of schizophrenia patients ($p=0.524$) or controls ($p=0.292$). When covarying for whole STG volume, the main effect for the group was not significant for both left [$F=1.72(2,167)$; $p=0.181$] and right [$F=2.37(2,167)$; $p=0.097$] hemispheres.

For the planum temporale (PT), MANCOVA revealed significant main effects for group and side and a significant group-by-side interaction. While the left PT volume was significantly smaller in the schizophrenia patients ($p<0.001$) and schizotypal patients ($p<0.001$) compared with the control subjects, there was no difference between both disorders ($p=0.992$). The PT was larger in the left than in the right hemisphere for all diagnostic groups ($p<0.001$). MANCOVA of the left PT covarying for left whole STG volume showed a significant group-by-gender interaction [$F=3.90(2,167)$; $p=0.022$]; the left PT was smaller in the schizophrenia patients (male, $p<0.001$; female, $p=0.002$) and male schizotypal patients ($p<0.001$) compared with the controls.

For the rostral STG, MANCOVA showed no main effects or interactions among the factors. MANCOVA of the caudal STG revealed significant main effects for group and side and a significant group-by-side interaction. Post hoc analyses showed the caudal STG to be significantly reduced in schizophrenia ($p<0.001$) and schizotypal ($p<0.001$) patients as compared with the control subjects bilaterally. No significant differences in the caudal STG volume emerged between the schizophrenia and schizotypal patients ($p=0.181$). The caudal STG volume showed asymmetry with the left side being larger than the right for the control subjects ($p<0.001$), whereas this asymmetry was not significant for the schizophrenia ($p=0.983$) or schizotypal ($p=0.997$) patients. When covarying for the whole STG volume, a significant effect for group in MANCOVA was revealed in the left [$F=3.34(2,167)$; $p=0.038$], but not in the right caudal STG [$F=1.28(2,167)$; $p=0.279$]. Post hoc analyses showed that the left caudal STG was significantly reduced in both schizophrenia ($p<0.001$) and schizotypal disorder ($p<0.001$) patients. This indicates the prominent sub-regional effects of the left caudal STG among the superior temporal sub-regions.

MANCOVA of the temporal pole (TP) gray matter revealed significant main effects for group and side and a significant group-by-gender interaction [$F=3.11(2,167)$; $p=0.047$]. Post hoc tests showed the TP gray matter of female schizotypal patients to be larger than that of female schizophrenia patients ($p=0.022$), but there were no differences between the control subjects and schizophrenia ($p=0.335$) or schizotypal ($p=0.164$) patients. The TP gray matter was larger in the left than in the right hemisphere for all groups ($p<0.001$). For the TP white matter, MANCOVA showed no main effect for group but the main effect for side was significant; the TP white matter volume was larger in the right than in the left hemisphere ($p<0.001$).

3.2. Laterality effects

Asymmetry indices of the regions are presented in Table 3. ANCOVAs for the asymmetry index of the whole STG and caudal STG revealed significant main effect for diagnosis; the schizotypal disorder patients had significantly reduced leftward asymmetry of the whole STG volume than the controls (post hoc test, $p=0.017$), and both schizophrenia (post hoc test, $p=0.033$) and schizotypal disorder (post

Table 3
Asymmetry indices of regions of interest in the control subjects, patients with schizotypal disorder, and patients with schizophrenia

Brain region	Controls (Male 38, Female 34)		Schizotypal patients (Male 24, Female 15)		Schizophrenia patients (Male 35, Female 30)		Analysis of covariance Diagnosis effect	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	$F(2,169)$	p
Whole STG	0.146	0.139	0.060[a]	0.145	0.112	0.158	3.30	0.039
Planum polare	−0.152	0.382	−0.106	0.332	0.004	0.384	2.53	0.083
Heschl's gyrus	0.272	0.352	0.199	0.314	0.236	0.279	0.73	0.483
Planum temporale	0.295	0.290	0.199	0.319	0.207	0.324	1.24	0.291
Rostral STG	−0.039	0.852	0.052	0.790	0.240	0.907	1.53	0.220
Caudal STG	0.153	0.271	−0.051[b]	0.328	0.011[c]	0.368	4.07	0.019

STG, superior temporal gyrus.
The asymmetry index of volume for each region was calculated by the following formula: 2 × (left − right/left + right).
[a,c] $p<0.05$: compared to the controls.
[b] $p<0.01$: compared to the controls.

hoc test, $p=0.008$) patients were significantly less lateralized for the caudal STG volume than the control subjects. There was no significant main effect for gender or group-by-gender interaction in these ANCOVAs.

3.3. Correlational analysis

There was a negative correlation between the relative volume of the left rostral STG and the score for delusions of the SAPS (rho = −0.390, $p=0.001$) in the schizophrenia group. When the analysis was made for the subgroup of early phase schizophrenia patients (illness duration < 1.0 year, 12 males and 8 females), negative correlations were found between the relative volume of the left PP and the scores for hallucinations (rho = −0.577, $p=0.008$) and delusions (rho = −0.596, $p=0.006$) and between the relative volume of the left rostral STG and the scores for hallucinations (rho = −0.541, $p=0.014$) and delusions (rho = −0.680, $p<0.001$). The correlation between the left rostral STG volume and the severity of delusions in the early phase group remained significant even after Bonferroni correction for multiple comparisons [six ROIs in the left/right hemisphere by four symptom ratings; $p<0.001$ (0.05/48)].

For schizophrenia patients, the relative volumes for each ROI were not correlated with the illness duration, age at onset, medication dosage or duration of neuroleptic medication. For the schizotypal disorder patients, the relative volumes for the TP gray matter (left, rho = −0.374, $p=0.019$; right, rho = −0.430, $p=0.006$), right HG (rho = −0.387, $p=0.015$) and right caudal STG (rho = −0.318, $p=0.049$) were negatively correlated with the dosage of neuroleptic medication, and the relative volume for the left HG was negatively correlated with the duration of medication (rho = −0.385, $p=0.015$).

In control subjects, the insular cortex was positively correlated with all of the superior temporal sub-regions that significantly reduced in schizophrenia patients (bilateral HG, left PT, and bilateral caudal STG) for both hemispheres (rho = 0.264 to 0.499, $p=0.028$ to <0.001), but there were no such correlations in schizophrenia. This might suggest the altered connections between cortical regions in schizophrenic brains.

4. Discussion

To our knowledge, this is the first volumetric MRI study to report similarities and differences in the morphology of the reliably parceled superior temporal sub-regions including the lateral portion of STG between schizophrenia and schizotypal disorder. Compared with the controls, volumes of the bilateral caudal STG and left PT were comparably reduced in both disorders, whereas volume reduction in the HG was found only in the schizophrenia patients.

In this study, volumes of the superior temporal sub-regions were mostly reduced in the schizophrenia patients compared to the controls with the exception of the PP and rostral STG, but these regions also showed approximately 15% volume reductions in the right hemisphere. Our results of left-lateralized PT volume reduction, bilateral volume reduction of the HG, and no significant volume change of the PP were generally in line with previous MRI findings for schizophrenia (Crespo-Facorro et al., 2004a; Hirayasu et al., 2000; Kwon et al., 1999; Sumich et al., 2002; Yamasue et al., 2004). On the other hand, the present finding showing bilateral volume reduction of the caudal STG in schizophrenia did not accord with previous study suggesting right-sided volume reduction of caudal STG in schizophrenia (Kim et al., 2003). The reason for this discrepancy is unclear because we basically used the same parcellation strategies for subdividing the STG (Kim et al., 2000). However, it may be worth noting that we found marked volume changes in the left caudal STG for schizophrenia even after controlling for whole STG volume. Although its functional significance has not yet been established, the caudal STG is a region activated during auditory speech perception (Price, 2004) and also during "mentalizing" tasks (Gallagher and Frith, 2003). Deficit in mentalizing (interpretation of the mental states of others) abilities may account for the varying range of symptoms in schizophrenia (Brüne, 2005; Frith and Frith, 1999). It would be worthwhile to further study the functional and structural abnormalities of the caudal STG in relation to language- or sociality-related functions in schizophrenia patients.

The principal focus of this study is on the similarities and differences in the superior temporal morphology between schizophrenia and schizotypal patients. Consistent with previous VBM study (Kawasaki et al., 2004), we found in this volumetric MRI study that the STG volume is significantly reduced as a whole in both schizophrenia and schizotypal disorder patients, especially in the left hemisphere. In previous volumetric MRI studies, Dickey et al. (1999, 2003) reported a smaller left STG to the same degree as schizophrenia in male but not female SPD subjects who were recruited from community. We found no gender effects on whole STG in contrast to these reports, but our findings may be partly limited by the relatively small sample size of

female schizotypal patients. Thus, the issue of gender on STG morphology in schizotypal subjects needs to be further studied. Another MRI study on clinic-based SPD subjects found that the gray matter reduction of the STG in both hemispheres was greater than that in schizophrenia patients (Downhill et al., 2001). Taken together, these previous and present studies support the notion that the abnormalities in temporal regions are a common neurobiological basis for schizophrenia spectrum (Kurachi, 2003a,b; Siever and Davis, 2004). For the superior temporal sub-regions, we found that the HG was relatively preserved in the schizotypal patients, while volume reductions of the left PT and caudal STG were common to both disorders. These findings did not accord with a previous report by Dickey et al. (2002b), who examined the volumes of the HG and PT in male SPD subjects and found a significant volume reduction only in the left HG compared with healthy controls. These inconsistencies may be due in part to the different sample characteristics of the schizotypal subjects among reports as discussed elsewhere (Takahashi et al., 2005); our cohort may have included subjects who were more severely ill than SPD individuals among the general population. Although further replication is required, our findings suggest that morphologic changes of the HG may partly represent the liability to develop positive psychotic symptoms in schizophrenia spectrum patients. This view is consistent with a previous functional imaging study that found direct evidence of the involvement of HG in auditory hallucination (Dierks et al., 1999).

In this study, we found significant group-by-side interaction particularly for the caudal STG volume; the left-greater-than-right laterality seen in the normal controls was remarkably reduced in schizophrenia patients and even reversed in schizotypal patients. As first clearly recognized by Crow (1990), anomalous cerebral asymmetry is one of the most characteristic features of the brain in schizophrenia (reviewed by DeLisi et al., 1997) and probably represents the genetic/developmental abnormalities in the disease (Crow et al., 1989; Crow, 1990; Sharma et al., 1999). Our findings support the altered laterality hypothesis of Crow (1990) and suggest that both schizophrenia and schizotypal disorder patients share at least in part the same cerebral asymmetry abnormalities, possibly reflecting a pathophysiologic process common to both disorders.

We also investigated the morphology of the TP, a component of the olfactocentric paralimbic circuit along with the orbitofrontal cortex and the insula (Mesulam, 2000). Consistent with a previous MRI study (Crespo-Facorro et al., 2004b) but not with a study by Kasai et al. (2003b) who reported left TP reduction in schizophrenia patients, we found no volume changes in the TP between the schizophrenia patients and the controls. On the other hand, we found the TP gray matter to be significantly larger in the female schizotypal patients compared with the female schizophrenia patients. Interestingly, evidence suggests that the insula, the other main component of the paralimbic structures, is also even larger in schizotypal patients than in control subjects (Takahashi et al., 2005). Dysfunction of these paralimbic structures may lead to the disturbances in various cognitive and emotional functions that can partly account for the symptomatology in schizophrenia (Crespo-Facorro et al., 2004b; Kasai et al., 2003b). It thus may be assumed that increased volumes of some paralimbic structures in schizotypal subjects reflect a compensatory mechanism, which has also been suggested in the prefrontal cortex of schizotypal subjects (Siever and Davis, 2004; Suzuki et al., 2005).

In this study, the severity of hallucinations or delusions within the early phase schizophrenia patients was negatively correlated with the volumetric measures of the left PP and the left rostral STG. These findings are consistent with the findings that the volume reduction of anterior STG, especially in the left hemisphere, is associated with the severity of hallucinations in schizophrenia (Barta et al., 1990; Flaum et al., 1995; Kim et al., 2003; Levitan et al., 1999; Rajarethinam et al., 2000). However, our results do not support previous MRI studies that implicate the posterior STG, which includes the PT or caudal STG, in thought disorder (Barta et al., 1997; Menon et al., 1995; Petty et al., 1995; Rajarethinam et al., 2000; Rossi et al., 1994; Shenton et al., 1992). It is possible that this discrepancy arises from the differences in the sample characteristics between the reports; our early phase schizophrenia group was probably not suitable for exploring the morphologic changes related to thought disorder because of their very low score for the positive formal thought disorder of the SAPS [mean score=0.8 ± 1.8 (S.D.) (range, 0–7)]. Functional neuroimaging studies suggested that delusions or hallucinations are related to abnormalities in brain areas such as the left inferior frontal cortex, ventral

striatum, temporal gyrus, and parahippocampal regions (Liddle et al., 1992, 2000; McGuire et al., 1995; Shergill et al., 2000, 2004; Silbersweig et al., 1995; Suzuki et al., 1993), but the structural brain changes underlying these symptoms remain elusive, and they may not be related to a single site of the brain (Suzuki et al., 2005). However, our results suggest that structural brain changes in the left PP and left rostral STG may represent part of a disturbed neural network that generates or modulates hallucinations or delusions. Although not directly supported by the present morphologic findings in schizotypal patients, the less severe involvement of these regions may be related to the decreased magnitude in symptomatology for schizotypal disorder relative to schizophrenia.

Some limitations of the present study should be mentioned. First, a significant difference in medication dosage between the schizophrenia and schizotypal patients might have affected the volumetric results. We therefore used the daily medication dosage as a covariate for all MANCOVA analyses to control for the differences in medication status between both disorders. A second limitation is related to the anatomical definition of the rostral STG. Although each ROI was traced based on the intrinsic anatomical landmarks, there was little rostral STG volume when the anterior end of the Heschl's sulcus or the sulcus intermedius if present was positioned very close to the temporofrontal junction. However, the frequencies of such cases were similar in all diagnosis groups at 5–10%, and the exclusion of these cases did not change the statistical conclusions.

In conclusion, changes in the STG, especially the left posterior regions, might represent a common neurobiological basis for schizophrenia spectrum. However, the volume of the HG is relatively preserved in schizotypal disorder and the less severe involvement of this region and possibly of the PP and rostral STG might be related to the sparing of schizotypal patients from the development of overt psychosis.

Acknowledgements

This study was supported in part by a Grant-in-Aid for Young Scientists 16790678 from the Ministry of Education, Culture, Sports, Science and Technology, Japan, and a Research Grant (11-3) for Nervous and Mental Disorders from the Ministry of Health and Welfare, Japan.

References

American Psychiatric Association, 1994. Diagnostic and Statistical Manual of Mental Disorders, 4th ed. American Psychiatric Press, Washington, DC.

Andreasen, N.C., 1984a. The Scale for the Assessment of Negative Symptoms (SANS). The University of Iowa, Iowa City, IA.

Andreasen, N.C., 1984b. The Scale for the Assessment of Positive Symptoms (SAPS). The University of Iowa, Iowa City, IA.

Andreasen, N.C., Flaum, M., Arndt, S., 1992. The comprehensive assessment of symptoms and history (CASH): an instrument for assessing diagnosis and psychopathology. Arch. Gen. Psychiatry 49, 615–623.

Barta, P.E., Pearlson, G.D., Powers, R.E., Richards, S.S., Tune, L.E., 1990. Auditory hallucination and smaller superior temporal gyrus volume in schizophrenia. Am. J. Psychiatry 147, 1457–1462.

Barta, P.E., Pearlson, G.D., Brill II, L.B., Royall, R., McGilchrist, I.K., Pulver, A.E., Powers, R.E., Casanova, M.F., Tien, A.Y., Frangou, S., Petty, R.G., 1997. Planum temporale asymmetry reversal in schizophrenia: replication and relationship to gray matter abnormalities. Am. J. Psychiatry 154, 661–667.

Brüne, M., 2005. "Theory of mind" in schizophrenia: a review of the literature. Schizophr. Bull. 31, 21–42.

Crespo-Facorro, B., Kim, J.J., Chemerinski, E., Magnotta, V., Andreasen, N.C., Nopoulos, P., 2004a. Morphometry of the superior temporal plane in schizophrenia: relationship to clinical correlates. J. Neuropsychiatry Clin. Neurosci. 16, 284–294.

Crespo-Facorro, B., Nopoulos, P.C., Chemerinski, E., Kim, J.J., Andreasen, N.C., Magnotta, V., 2004b. Temporal pole morphology in males with schizophrenia. Psychiatry Res. Neuroimaging 132, 107–115.

Crow, T.J., 1990. Temporal lobe asymmetries as the key to the etiology of schizophrenia. Schizophr. Bull. 16, 433–443.

Crow, T.J., Ball, J., Bloom, S.R., Brown, R., Bruton, C.J., Colter, N., Frith, C.D., Johnstone, E.C., Owens, D.G., Roberts, G.W., 1989. Schizophrenia as an anomaly of development of cerebral asymmetry. A postmortem study and a proposal concerning the genetic basis of the disease. Arch. Gen. Psychiatry 46, 1145–1150.

DeLisi, L.E., Sakuma, M., Kushner, M., Finer, D.L., Hoff, A.L., Crow, T.J., 1997. Anomalous cerebral asymmetry and language processing in schizophrenia. Schizophr. Bull. 23, 255–271.

Dickey, C.C., McCarley, R.W., Voglmaier, M.M., Niznikiewicz, M.A., Seidman, L.J., Hirayasu, Y., Fischer, I., Teh, E.K., Van Rhoads, R., Jakab, M., Kikinis, R., Jolesz, F.A., Shenton, M.E., 1999. Schizotypal personality disorder and MRI abnormalities of temporal lobe gray matter. Biol. Psychiatry 45, 1393–1402.

Dickey, C.C., McCarley, R.W., Shenton, M.E., 2002a. The brain in schizotypal personality disorder: a review of structural MRI and CT findings. Harv. Rev. Psychiatry 10, 1–15.

Dickey, C.C., McCarley, R.W., Voglmaier, M.M., Frumin, M., Niznikiewicz, M.A., Hirayasu, Y., Fraone, S., Seidman, L.J.,

Shenton, M.E., 2002b. Smaller left Heschl's gyrus volume in patients with schizotypal personality disorder. Am. J. Psychiatry 159, 1521–1527.

Dickey, C.C., McCarley, R.W., Voglmaier, M.M., Niznikiewicz, M.A., Seidman, L.J., Demeo, S., Frumin, M., Shenton, M.E., 2003. An MRI study of superior temporal gyrus volume in women with schizotypal personality disorder. Am. J. Psychiatry 160, 2198–2201.

Dierks, T., Linden, D.E., Jandl, M., Formisano, E., Goebel, R., Lanfermann, H., Singer, G., 1999. Activation of Heschl's gyrus during auditory hallucinations. Neuron 22, 615–621.

Downhill Jr., J.E., Buchsbaum, M.S., Hazlett, E.A., Barth, S., Lees Roitman, S., Nunn, M., Lekarev, O., Wei, T., Shihabuddin, L., Mitropoulou, V., Silverman, J., Siever, L.J., 2001. Temporal lobe volume determined by magnetic resonance imaging in schizotypal personality disorder and schizophrenia. Schizophr. Res. 48, 187–199.

Flaum, M., O'Leary, D.S., Swayze II, V.W., Miller, D.D., Arndt, S., Andreasen, N.C., 1995. Symptom dimensions and brain morphology in schizophrenia and related psychotic disorders. J. Psychiatr. Res. 29, 261–276.

Frith, C.D., Frith, U., 1999. Interacting minds—a biological basis. Science 286, 1692–1695.

Gallagher, H.L., Frith, C.D., 2003. Functional imaging of 'theory of mind'. Trends Cogn. Sci. 7, 77–83.

Hirayasu, Y., McCarley, R.W., Salisbury, D.F., Tanaka, S., Kwon, J.S., Frumin, M., Snyderman, D., Yurgelun-Todd, D., Kikinis, R., Jolesz, F.A., Shenton, M.E., 2000. Planum temporale and Heschl gyrus volume reduction in schizophrenia: a magnetic resonance imaging study of first-episode patients. Arch. Gen. Psychiatry 57, 692–699.

Kasai, K., Shenton, M.E., Salisbury, D.F., Hirayasu, Y., Onitsuka, T., Spencer, M.H., Yurgelun-Todd, D.A., Kikinis, R., Jolesz, F.A., McCarley, R.W., 2003a. Progressive decrease of left Heschl gyrus and planum temporale gray matter volume in first-episode schizophrenia. Arch. Gen. Psychiatry 60, 766–775.

Kasai, K., Shenton, M.E., Salisbury, D.F., Onitsuka, T., Toner, S.K., Yurgelun-Todd, D., Kikinis, R., Jolesz, F.A., McCarley, R.W., 2003b. Differences and similarities in insular and temporal pole MRI gray matter volume abnormalities in first-episode schizophrenia and affective psychosis. Arch. Gen. Psychiatry 60, 1069–1077.

Kawasaki, Y., Suzuki, M., Nohara, S., Hagino, H., Takahashi, T., Matsui, M., Yamashita, I., Chitnis, X.A., McGuire, P.K., Seto, H., Kurachi, M., 2004. Structural brain differences in patients with schizophrenia and schizotypal disorder demonstrated by voxel-based morphometry. Eur. Arch. Psychiatry Clin. Neurosci. 254, 406–414.

Kim, J.J., Crespo-Facorro, B., Andreasen, N.C., O'Leary, D.S., Zhang, B., Harris, G., Magnotta, V.A., 2000. An MRI-based parcellation method for the temporal lobe. NeuroImage 11, 271–288.

Kim, J.J., Crespo-Facorro, B., Andreasen, N.C., O'Leary, D.S., Magnotta, V., Nopoulos, P., 2003. Morphology of the lateral superior temporal gyrus in neuroleptic naive patients with schizophrenia: relationship to symptoms. Schizophr. Res. 60, 173–181.

Kurachi, M., 2003a. Pathogenesis of schizophrenia: Part I. Symptomatology, cognitive characteristics and brain morphology. Psychiatry Clin. Neurosci. 57, 3–8.

Kurachi, M., 2003b. Pathogenesis of schizophrenia: Part II. Temporo-frontal two-step hypothesis. Psychiatry Clin. Neurosci. 57, 9–16.

Kwon, J.S., McCarley, R.W., Hirayasu, Y., Anderson, J.E., Fischer, I.A., Kikinis, R., Jolesz, F.A., Shenton, M.E., 1999. Left planum temporale volume reduction in schizophrenia. Arch. Gen. Psychiatry 56, 142–148.

Levitan, C., Ward, P.B., Catts, S.V., 1999. Superior temporal gyrus volumes and laterality correlates of auditory hallucinations in schizophrenia. Biol. Psychiatry 46, 955–962.

Liddle, P.F., Friston, K.J., Frith, S.R., Hirsch, S.R., Jones, T., Frackowiak, R.S.J., 1992. Patterns of cerebral blood flow in schizophrenia. Br. J. Psychiatry 160, 179–186.

Liddle, P.F., Lane, C.J., Ngan, E.T.C., 2000. Immediate effects of risperidone on cortico–striato–thalamic loops and the hippocampus. Br. J. Psychiatry 177, 402–407.

McGuire, P.K., Silbersweig, D.A., Wright, I., Murray, R.M., David, A.S., Frackowiak, R.S., Frith, C.D., 1995. Abnormal monitoring of inner speech: a physiological basis for auditory hallucinations. Lancet 346, 596–600.

Menon, R.R., Barta, P.E., Aylward, E.H., Richards, S.S., Vaughn, D.D., Tien, A.Y., Harris, G.J., Pearlson, G.D., 1995. Posterior superior temporal gyrus in schizophrenia: grey matter changes and clinical correlates. Schizophr. Res. 16, 127–135.

Mesulam, M.M., 2000. Behavioral neuroanatomy: large-scale networks, association cortex, frontal syndromes, the limbic system, and hemispheric specializations. In: Mesulam, M.M. (Ed.), Principles of Behavioral and Cognitive Neurology, 2nd ed. Oxford Univ. Press, New York, pp. 1–120.

Petty, R.G., Barta, P.E., Pearlson, G.D., McGilchrist, I.K., Lewis, R.W., Tien, A.Y., Pulver, A., Vaughn, D.D., Casanova, M.F., Powers, R.E., 1995. Reversal of asymmetry of the planum temporale in schizophrenia. Am. J. Psychiatry 152, 715–721.

Price, C., 2004. An overview of speech comprehension and production. In: Frackowiak, R.S.J., Friston, K.J., Frith, C.D., Dolan, R.J., Price, D.J., Zeki, S., Ashburner, J., Penny, W. (Eds.), Human Brain Function, 2nd ed. Elsevier Academic Press, California, pp. 517–545.

Rajarethinam, R.P., DeQuardo, J.R., Nalepa, R., Tandon, R., 2000. Superior temporal gyrus in schizophrenia: a volumetric magnetic resonance imaging study. Schizophr. Res. 41, 303–312.

Rojas, D.C., Teale, P., Sheeder, J., Simon, J., Reite, M., 1997. Sex-specific expression of Heschl's gyrus functional and structural abnormalities in paranoid schizophrenia. Am. J. Psychiatry 154, 1655–1662.

Rossi, A., Serio, A., Stratta, P., Petruzzi, C., Schiazza, G., Mancini, F., Casacchia, M., 1994. Planum temporale asymmetry and thought disorder in schizophrenia. Schizophr. Res. 12, 1–7.

Shapleske, J., Rossell, S.L., Simmons, A., David, A.S., Woodruff, P.W., 2001. Are auditory hallucinations the consequence of abnormal cerebral lateralization? A morphometric MRI study of the sylvian fissure and planum temporale. Biol. Psychiatry 49, 685–693.

Sharma, T., Lancaster, E., Sigmundsson, T., Lewis, S., Takei, N., Gurling, H., Barta, P., Pearlson, G., Murray, R., 1999. Lack of normal pattern of cerebral asymmetry in familial schizophrenic patients and their relatives—the Maudsley family study. Schizophr. Res. 40, 111–120.

Shenton, M.E., Kikinis, R., Jolesz, F.A., Pollak, S.D., LeMay, M., Wible, C.G., Hokama, H., Martin, J., Metcalf, D., Coleman, M., McCarley, R.W., 1992. Abnormalities of the left temporal lobe and thought disorder in schizophrenia: a quantitative magnetic resonance imaging study. N. Engl. J. Med. 327, 604–612.

Shenton, M.E., Dickey, C.C., Frumin, M., McCarley, R.W., 2001. A review of MRI findings in schizophrenia. Schizophr. Res. 49, 1–52.

Shergill, S.S., Brammer, M.J., Amaro, E., Williams, S.C., Murray, R.M., McGuire, P.K., 2004. Temporal course of auditory hallucinations. Br. J. Psychiatry 185, 516–517.

Shergill, S.S., Brammer, M.J., Williams, S.C., Murray, R.M., McGuire, P.K., 2000. Mapping auditory hallucinations in schizophrenia using functional magnetic resonance imaging. Arch. Gen. Psychiatry 57, 1033–1038.

Siever, L.J., Davis, K.L., 2004. The pathophysiology of schizophrenia disorders: perspective from the spectrum. Am. J. Psychiatry 161, 398–413.

Silbersweig, D.A., Stern, E., Frith, C., Cahill, C., Holmes, A., Grootoonk, S., Seaward, J., McKenna, P., Chua, S.E., Schnorr, L., Jones, T., Frackowiak, R.S.J., 1995. A functional neuroanatomy of hallucinations in schizophrenia. Nature 378, 176–179.

Sumich, A., Chitnis, X.A., Fannon, D.G., O'Ceallaigh, S., Doku, V.C., Falrowicz, A., Marshall, N., Matthew, V.M., Potter, M., Sharma, T., 2002. Temporal lobe abnormalities in first-episode psychosis. Am. J. Psychiatry 159, 1232–1235.

Sumich, A., Chitnis, X.A., Fannon, D.G., O'Ceallaigh, S., Doku, V.C., Faldrowicz, A., Sharma, T., 2005. Unreality symptoms and volumetric measures of Heschl's gyrus and planum temporal in first-episode psychosis. Biol. Psychiatry 57, 947–950.

Suzuki, M., Yuasa, S., Minabe, Y., Murata, M., Kurachi, M., 1993. Left superior temporal blood flow increases in schizophrenic and schizophreniform patients with auditory hallucination: a longitudinal case study using ^{123}I-IMP SPECT. Eur. Arch. Psychiatry Clin. Neurosci. 242, 257–261.

Suzuki, M., Zhou, S.Y., Hagino, H., Takahashi, T., Kawasaki, Y., Nohara, S., Yamashita, I., Matsui, M., Seto, H., Kurachi, M., 2004. Volume reduction of the right anterior limb of the internal capsule in patients with schizotypal disorder. Psychiatry Res. Neuroimaging 130, 213–225.

Suzuki, M., Zhou, S.Y., Takahashi, T., Hagino, H., Kawasaki, Y., Niu, L., Matsui, M., Seto, H., Kurachi, M., 2005. Differential contributions of prefrontal and temporolimbic pathology to mechanisms of psychosis. Brain 128, 2109–2122.

Takahashi, T., Kawasaki, Y., Kurokawa, K., Hagino, H., Nohara, S., Yamashita, I., Nakamura, K., Murata, M., Matsui, M., Suzuki, M., Seto, H., Kurachi, M., 2002a. Lack of normal structural asymmetry of the anterior cingulate gyrus in female patients with schizophrenia: a volumetric magnetic resonance imaging study. Schizophr. Res. 55, 69–81.

Takahashi, T., Suzuki, M., Kawasaki, Y., Kurokawa, K., Hagino, H., Yamashita, I., Zhou, S.Y., Nohara, S., Nakamura, K., Seto, H., Kurachi, M., 2002b. Volumetric magnetic resonance imaging study of the anterior cingulate gyrus in schizotypal disorder. Eur. Arch. Psychiatry Clin. Neurosci. 252, 268–277.

Takahashi, T., Suzuki, M., Zhou, S.Y., Hagino, H., Kawasaki, Y., Yamashita, I., Nohara, S., Nakamura, K., Seto, H., Kurachi, M., 2004. Lack of normal gender differences of the perigenual cingulate gyrus in schizophrenia spectrum disorders: a magnetic resonance imaging study. Eur. Arch. Psychiatry Clin. Neurosci. 254, 273–280.

Takahashi, T., Suzuki, M., Zhou, S.Y., Hagino, H., Tanino, R., Kawasaki, Y., Nohara, S., Yamashita, I., Seto, H., Kurachi, M., 2005. Volumetric MRI study of the short and long insular cortices in schizophrenia spectrum disorders. Psychiatry Res. Neuroimaging 138, 209–220.

Toru, M., 2001. Psychotropic Manual, 2nd ed. Igaku-Shoin, Tokyo.

World Health Organization, 1992. The ICD-10 Classification of Mental and Behavioral Disorders: Clinical Descriptions and Diagnostic Guidelines. World Health Organization, Geneva.

World Health Organization, 1993. The ICD-10 Classification of Mental and Behavioural Disorders: Diagnostic Criteria for Research. World Health Organization, Geneva.

Yamasue, H., Yamada, H., Yumoto, M., Kamio, S., Kudo, N., Uetsuki, M., Abe, O., Fukuda, R., Aoki, S., Ohtomo, K., Iwanami, A., Kato, N., Kasai, K., 2004. Abnormal association between reduced magnetic mismatch field to speech sounds and smaller left planum temporale volume in schizophrenia. NeuroImage 22, 720–727.

Yoneyama, E., Matsui, M., Kawasaki, Y., Nohara, S., Takahashi, T., Hagino, H., Suzuki, M., Seto, H., Kurachi, M., 2003. Gray matter features of schizotypal disorder patients exhibiting the schizophrenia-related code types of the Minnesota Multiphasic Personality Inventory. Acta Psychiatr. Scand. 108, 333–340.

Zhou, S.Y., Suzuki, M., Hagino, H., Takahashi, T., Kawasaki, Y., Nohara, S., Yamashita, I., Seto, H., Kurachi, M., 2003. Decreased volume and increased asymmetry of the anterior limb of the internal capsule in patients with schizophrenia. Biol. Psychiatry 54, 427–436.